Handbook of Research on

# New Media, Training, and Skill Development for the Modern Workforce

Dominic Mentor

IGI Global
PUBLISHER of TIMELY KNOWLEDGE

# Handbook of Research on New Media, Training, and Skill Development for the Modern Workforce

Dominic Mentor
*Teachers College, Columbia University, USA*

A volume in the Advances in Multimedia and Interactive Technologies (AMIT) Book Series

IGI Global
PUBLISHER of TIMELY KNOWLEDGE

Published in the United States of America by
IGI Global
Business Science Reference (an imprint of IGI Global)
701 E. Chocolate Avenue
Hershey PA, USA 17033
Tel: 717-533-8845
Fax: 717-533-8661
E-mail: cust@igi-global.com
Web site: http://www.igi-global.com



Library of Congress Cataloging-in-Publication Data

Names: Mentor, Dominic, 1968- editor.
Title: Handbook of Research on new media, training, and skill development for the modern workforce / Dominic Mentor, editor.
Description: Hershey, PA : Business Science Reference, [2022] | Includes bibliographical references and index. | Summary: "The forced abrupt shift to online learning during the COVID pandemic revealed needs for the adoption and use of new media, virtual training, as well as online skill development for the modern workforce and this book a variety of tools to help readers to rapidly incorporate new media tools into their teaching and learning environments"-- Provided by publisher.
Identifiers: LCCN 2022003090 (print) | LCCN 2022003091 (ebook) | ISBN 9781668439968 (hardcover) | ISBN 9781668439982 (ebook)
Subjects: LCSH: Employees--Training of. | Web-based instruction. | Computer-assisted instruction. | Educational technology.
Classification: LCC HF5549.5.T7 N4724 2022 (print) | LCC HF5549.5.T7 (ebook) | DDC 658.3/124--dc23/eng/20220126
LC record available at https://lccn.loc.gov/2022003090
LC ebook record available at https://lccn.loc.gov/2022003091

This book is published in the IGI Global book series Advances in Multimedia and Interactive Technologies (AMIT) (ISSN: 2327-929X; eISSN: 2327-9303)

British Cataloguing in Publication Data
A Cataloguing in Publication record for this book is available from the British Library.

All work contributed to this book is new, previously-unpublished material. The views expressed in this book are those of the authors, but not necessarily of the publisher.

For electronic access to this publication, please contact: eresources@igi-global.com.

# Advances in Multimedia and Interactive Technologies (AMIT) Book Series

Joel J.P.C. Rodrigues
Senac Faculty of Ceará, Fortaleza-CE, Brazil; Instituto de Telecomunicações, Portugal

ISSN:2327-929X
EISSN:2327-9303

## Mission

Traditional forms of media communications are continuously being challenged. The emergence of user-friendly web-based applications such as social media and Web 2.0 has expanded into everyday society, providing an interactive structure to media content such as images, audio, video, and text.

The **Advances in Multimedia and Interactive Technologies (AMIT) Book Series** investigates the relationship between multimedia technology and the usability of web applications. This series aims to highlight evolving research on interactive communication systems, tools, applications, and techniques to provide researchers, practitioners, and students of information technology, communication science, media studies, and many more with a comprehensive examination of these multimedia technology trends.

## Coverage

- Digital Images
- Digital Games
- Multimedia Streaming
- Digital Communications
- Gaming Media
- Audio Signals
- Internet Technologies
- Digital Watermarking
- Digital Technology
- Multimedia Technology

IGI Global is currently accepting manuscripts for publication within this series. To submit a proposal for a volume in this series, please contact our Acquisition Editors at Acquisitions@igi-global.com or visit: http://www.igi-global.com/publish/.

The Advances in Multimedia and Interactive Technologies (AMIT) Book Series (ISSN 2327-929X) is published by IGI Global, 701 E. Chocolate Avenue, Hershey, PA 17033-1240, USA, www.igi-global.com. This series is composed of titles available for purchase individually; each title is edited to be contextually exclusive from any other title within the series. For pricing and ordering information please visit http://www.igi-global.com/book-series/advances-multimedia-interactive-technologies/73683. Postmaster: Send all address changes to above address. 

## Titles in this Series

*For a list of additional titles in this series, please visit: www.igi-global.com/book-series*

***Handbook of Research on New Media Applications in Public Relations and Advertising***
Elif Esiyok (Atilim University, Turkey)
Information Science Reference • © 2021 • 572pp • H/C (ISBN: 9781799832010) • US $265.00

***Multidisciplinary Perspectives on Narrative Aesthetics in Video Games***
Deniz Denizel (Bahcesehir University, Turkey) and Deniz Eyüce Şansal (Bahcesehir University, Turkey)
Information Science Reference • © 2021 • 300pp • H/C (ISBN: 9781799851103) • US $195.00

***Recent Advances in 3D Imaging, Modeling, and Reconstruction***
Athanasios Voulodimos (University of West Attica, Athens, Greece) and Anastasios Doulamis (National Technical University of Athens, Athens, Greece)
Information Science Reference • © 2020 • 396pp • H/C (ISBN: 9781522552949) • US $195.00

***Handbook of Research on Recent Developments in Image Processing and Applications***
Suresh Kumar Nagarajan (VIT University, India) and R. Mohanasundaram (VIT University, India)
Information Science Reference • © 2020 • 1700pp • H/C (ISBN: 9781799802228) • US $565.00

***Graphical Thinking for Science and Technology Through Knowledge Visualization***
Anna Ursyn (University of Northern Colorado, USA)
Information Science Reference • © 2020 • 374pp • H/C (ISBN: 9781799816515) • US $225.00

***New Media and Visual Communication in Social Networks***
Serpil Kır (Hatay Mustafa Kemal University, Turkey)
Information Science Reference • © 2020 • 345pp • H/C (ISBN: 9781799810414) • US $195.00

***Handbook of Research on Media Literacy Research and Applications Across Disciplines***
Melda N. Yildiz (New York Institute of Technology, USA) Minaz Fazal (New York Institute of Technology, USA) Meesuk Ahn (New York Institute of Technology, USA) Robert Feirsen (New York Institute of Technology, USA) and Sebnem Ozdemir (Istinye University, Turkey)
Information Science Reference • © 2019 • 433pp • H/C (ISBN: 9781522592617) • US $265.00

***Cases on Immersive Virtual Reality Techniques***
Kenneth C.C. Yang (The University of Texas at El Paso, USA)
Engineering Science Reference • © 2019 • 349pp • H/C (ISBN: 9781522559122) • US $215.00

IGI Global
PUBLISHER of TIMELY KNOWLEDGE

701 East Chocolate Avenue, Hershey, PA 17033, USA
Tel: 717-533-8845 x100 • Fax: 717-533-8661
E-Mail: cust@igi-global.com • www.igi-global.com

# List of Contributors

**Acquaro, Paul Evan** / *FOM Hochschule, Germany* ..... 1
**Bednar, Edward** / *Columbia University, USA* ..... 67
**Casale, Regina** / *Film and Educational Research Academy, USA* ..... 210
**Chan, Monica Miaoxia** / *Teachers College, Columbia University, USA* ..... 21
**Chan, Simon C. H.** / *The Hong Kong Polytechnic University, Hong Kong* ..... 287
**Chelliq, Ikram** / *Abdelmalek Essaâdi University, Morocco* ..... 234
**Cho, Anna** / *Teachers College, Columbia University, USA* ..... 110
**Darni, Rizqarossaa** / *Cambridge University, UK* ..... 110
**De Smidt, Juley** / *University of the Western Cape, South Africa* ..... 187
**Donald, William E.** / *University of Southampton, UK & Ronin Institute, USA* ..... 47
**Erradi, Mohamed** / *Abdelmalek Essaâdi University, Morocco* ..... 234
**Harris, Brennan M.** / *Teachers College, Columbia University, USA* ..... 133
**Hartel, Tammy Charlene** / *University of the Western Cape, South Africa* ..... 187
**Khaldi, Mohamed** / *Abdelmalek Essaâdi University, Morocco* ..... 234
**Ko, Stephen** / *The Hong Kong Polytechnic University, Hong Kong* ..... 287
**Krenn, Jamie L.** / *Teachers College, Columbia University, USA* ..... 21
**Leach, Lloyd** / *University of the Western Cape, South Africa* ..... 150, 305
**Mentor, Dominic** / *Columbia University, USA* ..... 110, 210, 262, 305, 351
**Oelofse, Andre** / *University of the Western Cape, South Africa* ..... 187
**Pychtin, Peter** / *GradSift, Australia* ..... 47
**Ras, Jaron** / *University of the Western Cape, South Africa* ..... 150
**Rayford, Christyn** / *South Holland Public Library, USA* ..... 133
**Reid, Jason D.** / *Teachers College, Columbia University, USA* ..... 335
**Ruipérez-Valiente, José A.** / *University of Murcia, Spain* ..... 89
**Sahin, Fusun** / *American Institutes for Research, USA* ..... 351
**Strukova, Sofia** / *University of Murcia, Spain* ..... 89
**Wang, Keying** / *Teachers College, Columbia University, USA* ..... 21

# Table of Contents

# Detailed Table of Contents

This chapter uncovers the opportunities that online media portals like content sharing and consumption sites or photography sites have for informal and formal learning. The authors explored online portals that can provide evidence of evaluating, inferring, measuring skills, and/or contributing to the development of competencies and capabilities of the 21st century with two case studies. The first one is focused on identifying data science topical experts across the Reddit community. The second one uses online Flickr data to apply a model on the photographs to rate them as aesthetically attractive and technically sound, which can serve as a base for measuring the photography capabilities of Flickr users. The presented results can serve as a base to replicate these methodologies to infer other competencies and capabilities across online portals. This novel approach can be an effective alternative evaluation of key 21st century skills for the modern workforce with multiple applications.



This chapter reports on a sustainable model created to increase engagement, success, and retention in a MOOC for learning computer programming within a United States-based national vocational program. The training organization was one of 10 national and regional organizations awarded scholarships by American-based information and telecommunications companies to participate in a MOOC to introduce and learn computer programming. The curriculum was informed and designed by multinational software technology corporations to address the dearth of computer programming talent in the USA. The academic unit set out to convert the poor state of MOOC completion rates, to convert the online opportunity into an active, supportive, and an engaging virtual space with a view to increase completion. Theoretical frameworks of scaffolding the learning and leveraging zones of proximal development were employed with precursor courses to help ramp up knowledge of an unknown subject area and skill. Social connectedness methods were also used to create teaching and learning communities (TLC) of support.



This chapter examines how a public library in the Midwestern USA adapted to the COVID-19 pandemic. Staff employed the research skills learned in their library science education to explore minimal-contact programming, through virtual and hybrid formats, and continued to provide library services to the community with minimal disruption. Following naturalistic observation of the library in its hybrid state and semi-structured interviews with its staff, the experiences of the librarians and community are considered through the theoretical lenses of social connectedness, the technology adoption model, and learning theory. Unique benefits of the public library, as a physical space, as a virtual destination, and as a hybrid between them are discussed.

Firefighters are required to maintain all aspects of their health and wellness in order to sustain their fitness for duty. Heart rate variability (HRV) has been used as a reliable tool when assessing the stressors placed on firefighters, be it physical, emotional, or psychological. This review determined the usefulness of using HRV as a tool to determine the physical, physiological, and psychological health of firefighters at a more regular and frequent scale. HRV is a versatile technology with a plethora of uses, particularly in monitoring the cardiovascular strain as a result of firefighting and recovery post-fire suppression. In addition, the literature showed that HRV could be used to successfully monitor physical fitness, physiological stress, psychological stress, decision making, risk taking behavior and recovery in firefighters. The use of mobile technology measuring HRV may be used to successfully assess firefighter occupational performance. In future research, longitudinal studies investigating HRV use in firefighters are warranted.



There is an increasing prevalence of cardiovascular risk factors in children, specifically in low socioeconomic regions where children are exposed to several factors as early as the fetal stage, increasing their risk of developing cardiovascular disease (CVD) later in life. However, atherosclerosis develops silently from early childhood, long before the manifestation of cardiovascular risk factors. The aim of the chapter is to provide insights on the advances in pediatric research using non-invasive ultrasound technology for the detection of subclinical atherosclerosis in children and to explore the acceptance and distribution of ultrasound technology. The use of ultrasound technology is increasing in developing countries, and many universities are offering training courses for health professionals. Therefore, the adoption of low-cost, portable ultrasound machines, training of medical staff, together with teleradiology can drastically improve healthcare access, cardiovascular risk identification in pediatrics, and prevent the development of CVD in high-risk populations.



This chapter revisits the creation and results of cultivating mobile journalism and film making skills with middle and high schoolers in Long Island. The youth digital film production effort was in response to a hate crime. An immigrant was killed by a group of young males after a suspected spree of other attacks. After the murderous incident, immigrant parents and students of the local schools feared for their lives. Working towards narrative goals, the organizers set out to teach students how to use mobile and computer technologies for filmmaking. Using themes of human rights, they also focused on responding to hate crimes and immigration issues. The chapter offers further key discoveries, lessons, and positive outcomes

criteria based on learning theories and literature on m-assessment. These criteria organized important features of m-apps under three categories: 1) general user experience, 2) learning experience, and 3) practice test-experience. The authors also evaluate the features of m-assessment apps found in the app spaces using the criteria. Results communicate how the examined apps perform against the criteria and emphasize different ways that these features can help learners. The chapter concludes with future directions based on the updated requirements of the project management certification exam and the need for more apps that implement theoretically supported features.

# Foreword

At my company, we center much of our work around emerging, necessary skills for today's worker. These include being effective with in-person, entirely online and hybrid audiences (e.g., team members, customers, partners); being able to facilitate both live and asynchronous collaborative experiences for those audiences; having an expansive toolkit of communication approaches using media (in our case, mostly visualization media).

These represent important areas for the modern workforce and thus lead to questions of identifying new media, how to train people on new skills in using such media, and how to continue developing and ultimately mastering those skills after they have been introduced. This edited volume serves an important purpose in bringing timely research and insights on topics and phenomena that have not only recently emerged but have already taken on new forms, largely because of the ongoing health pandemic at the time of the writing and publication.

At the Columbia University School of Professional Studies, I teach a course on Organizational Strategy and Learning. One of the questions I encourage students to ask in the context of achieving strategic goals is "Who needs to learn what?" The "who" is often employees, customers, shareholders, prospective hires, partners. The "what" can range from new skills to market understanding to changed internal processes, and so on. Living and working in a pandemic era has amplified certain global trends including global supply chain, remote and flexible work arrangements, automation, and generational differences (for example, younger generations may not plan on working at any institution for more than a few years). These trends make it critical to not only speak to the "who" and the "what" but also to the "when" and "how."

After engaging in this collection of scholarship proposed and edited by Dr. Dominic Mentor, you might feel more prepared to answer an expanded version of the aforementioned prompt: "Who needs to learn what, and when and how should they learn it?"

The connections to the "how and when" parts of the questions are evident in each and every chapter:

- The Selection of Online Learning Tools for Higher Education: Lessons Learned During the COVID-19 Pandemic Applicable to Numerous Learning Contexts
- Managing Work from Home With Young Children: A Realistic and Technology-Enhanced Guide
- Librarianship Through Every Occasion: Staying Open and Online During a Pandemic
- Libraries Creating Opportunities Before and During Crises: The Evolving Role of Libraries before and during the COVID-19 Pandemic Around the World
- Teaching and Learning Communities for MOOCs Teaching Computer Programming
- Use of Mobile Technology in Assessing Occupational Performance and Stress in Firefighters

- Advances in Pediatric Research Using Non-Invasive Technology-Showing Precursors of Cardiovascular Disease Occurring Later in Life
- A Primer for Developing Computer-Mediated Solutions for the Modern Workforce: Using Artificial Intelligence for Situationally Aware Human-Computer Interaction
- Using Online Digital Data to Infer Valuable Skills for the Modern Workforce
- Optimization of Job Boards and the Graduate Recruitment Process: Advancing HRM Strategies for the Acquisition of Early Careers Talent
- Digital Film Making Response to a Hate Crime: Narratives of Immigrant Youth
- Educational Online Video in Adaptive E-Learning
- The Rising Battle for the Planet of the Apps: Moving From an L-Class to M-Class Planet
- A Review of Personal Response Systems in Higher Education: A Theoretical Model and Future Research Directions
- Experiential Learning for Telehealth in Sports Science and Allied Health
- Mobile Assessment Applications and Training for Professional Examinations: The Case of Project Management Certifications

It is clear that in the many spaces where we engage learners of any age with computer technology, we increase dynamic opportunities for learning. Once the importance and prevalence of new media for education are better understood, we can further harness the potential of computer and mobile technologies for teaching and learning, personal and organizational development as well as transformation. Your takeaways from this book will not only be a comprehensive overview of computer and mobile mediated learning, but also thought processes and practical methods to help apply new media technologies for mediated learning in training programs, schools, colleges and workplace contexts.

I first met Dr. Dominic Mentor, the editor and contributor to this book, when I took his Mobile Learning course at Teachers College, Columbia University. Both at the time and still to this day, this course has been a leading edge experience at the intersection of mobile technology and learning, educating masters and doctoral students at the cusp of innovative educational practices. The course was incredibly popular – I was on the waitlist for two semesters before finally getting a seat! So much of what I learned and experienced there shaped my own doctoral work and continues to be a part of my teaching and professional practice. He has always been a pioneering scholar in the field of new media and teaching, and this book is another important contribution to the field of research that academics and business professionals, schools and industries will all benefit from.

*Reshan Richards*
*Columbia University School of Professional Studies, USA & Explain Everything, USA*

# Preface

The COVID-19 pandemic and its varying lockdown restrictions hastened and advanced the adoption of online learning and new media technologies for education and training in various sectors of society. The pandemic impacted education and training in emergency fashion for some, but also richly expanded the use of online and new media technologies. Allowing for the continuation and enhancements of teaching, training, and learning through computer 'media-ted' engagement. Many who had resisted online learning with a strong preference for in-person engagement, found themselves forced to use new media technologies to engage with their young and adult learners. Meanwhile, many libraries and librarians had already adopted digital engagement, and many were well poised to continue to serve the public. Some were more astutely and creatively as others, but libraries were far better positioned to continue to operate amidst pandemic lockdown restrictions than many schools, yet again being a shining beacon of hope, enlightenment, and refuge for society.

The editor was asked once by a co-author of textbooks where his intellectual journey started. This question evoked memories of a mother reading to her children and taking her children to the library weekly to twice weekly to borrow books. Being one of three children at the time, we took turns during our bedtime story reading moments to sit either side of her, and one of us had the good fortune of hanging around her neck with arms clasped firmly to lean over to see the words come alive as she read to us. Libraries were a saving grace for so many reasons for this editor, but a mother planting the seeds of libraries as a resource center helped shape and inspire cognitive development in so many innumerable ways. Thanks to libraries and their ability to stay abreast with the digital times, it helped to develop the editor's intellectual journey and was able to do so for many of its constituents during the pandemic lockdown. While this book offers only two chapters that speak to the superhero efforts of libraries to continue to stay open and serve the public, the entire book and its chapters would not have been possible if not for libraries being able to offer its services amidst the most challenging of times. Similarly, during COVID lockdown restrictions in many countries, teachers had to adjust and quickly adopted new media technologies to engage their students, and at the same time learning new online learning technologies to serve their students.

The pandemic created and catered for more opportunities where teachers of young learners and workplace trainers of adults had to switch to online engagement and in many cases had to do so daily. Those who had embraced online learning and new media technologies prior to the pandemic, were able to seamlessly continue their teaching, training, and learning work depending on the infrastructure that was in place to support the online efforts. However, for many in the education and training field, the pandemic contexts of forced adoption of online teaching and learning was a difficult transition. This book offers many examples about the use of new media technologies for training and skill development as well as lessons to both the early and new adopters of online learning.

The projects researched, lessons learned shared in this book come from various industries ranging from Library Science, Higher Education, K-12 or primary, secondary, or school contexts, corporate, medical, emergency services, and sport sciences. The book proudly hosts two chapters on the superhero librarians that managed to creatively keep libraries open and functioning during the pandemic lockdowns. While the selection of Learning Management Systems like the library chapters in this book, similarly, offers lessons from before, during, and post pandemic contexts. The book also provides ideas on optimizing job boards and the graduate recruitment process, parents managing work from home with young children with realistic and balanced technology-enhanced recommendations. Additionally, the book offers valuable insights into how the use of mobile technology for firefighter fitness tracking could also be replicated and applied to other civil servants, emergency responders, ambulance workers and others in similar demanding fields. The capturing of digital narratives of immigrant youth after a series of hate crimes can also be utilized in formal educational, co-curricular contexts or reducing gender-based violence programs. While blended, hybrid and online learning offers valuable learning data analytics, this book includes a chapter on personal response systems that have moved to mobile phones, tablet devices and web access because many educational institutions rely on personal response systems for tracking in class cognitive engagement or remote class participation as well as to track students' learning. The book also covers the ever-growing varieties of Massively Open Online Courses (MOOCs) as well as ways and means to create opportunities for successful participation in MOOCs.

Furthermore, the book also presents advances in pediatric research using non-invasive technology with the valuable ability to pick-up and reveal precursors of infant cardiovascular disease that could occur later in life. While another chapter speaks to how we can use online digital data from social media networking sites to acquire and infer valuable skills needed by the modern workforce. Finally, experiential learning for sports science via computer-mediated and mobile learning engagement is also addressed, but of course, many of these book chapters would not have been possible if the researchers, authors, and the editor did not have access to libraries.

The research and projects included in this book as chapters offer easy and helpful methods with practices and activities that can blend seamlessly and unobtrusively into the online teaching and learning life of educators, trainers, and learners. Furthermore, the chapters offer methods and solutions where users are not just the recipients of education, but rather the drivers, contributors to, and owners of their learning, while making them active agents in their learning. Leveraging the hypermedia capabilities of online learning allows for learning to be naturally pursued and expanded for the benefit of both the individual and the community of learning, as can be seen in the following summaries of the chapters.

The first chapter offers valuable research and insight into the selection of digital Learning Management Systems (LMSes) for higher education with lessons learned from and during the COVID-19 pandemic. While these lessons came from the higher education context, the lessons learned are highly transferable to K-12, young workforce development contexts, and adult corporate training and learning contexts. While many higher education institutions already have LMSes in place, quite a few worldwide, including K-12 primary and secondary schools, had to quickly adapt and shift to a new online learning demand and transfer their learning environment to online platforms. There is now full recognition that we have moved from an ad-hoc adoption of online learning to an emergency adoption that has now morphed into an expectation of leveraging the richness and benefits of online learning beyond the pandemic. Many are predicting that during the post-pandemic times we will be seeing staggering rollouts and adoption of online tools amidst a move back to in-person educational engagement. But with a need to continue to select and implement online platforms and tools to move beyond just supporting online learning, but to effectively leverage LMSes for hybrid and blended learning. Not just because of the unpredictability of possibly being forced to go back online with social distancing requirements given COVID-19 permutations, but also because of the benefits and advantages noticed from the emergency adoption of LMSes. The chapter on selecting LMSes offers to find the right balance between choice of LMS, pedagogy, training, support, data security and privacy, and ensuring ease of use from better User Interfaces and User Experiences (UI/UX) that might have previously confounded the efforts to provide an effective online learning environment. This chapter re-examines the results of a study on LMSes as an online learning tool choice done pre-pandemic and offers reviews of lessons learned from literature on emergency online learning adoption to offer how teachers, instructional designers and online Learning Management System administrators who serve as decision makers, can better select online learning tools for use within their institutions to benefit both teachers and learners.

The COVID-19 pandemic has shifted the way people work, including caretakers and parents. It left many working parents having to care for their young children due to school shutdowns and limited access to childcare services. Another group that has been impacted by the shift to online work has been parents who had to navigate working from home with their children. In many ways, a chapter focusing on parents working from home covers an underserved, or rather somewhat, under researched, group of people. The chapter on parents and caregivers working from home with children present, explores ways in which parents can continue pursuing their careers without jeopardizing parenthood in these split attention situations. The authors offer a variety of angles and strategies where parents and caretakers can build an effective work-from-home lifestyle while caring for their children. This includes possible methods to reinforce work-life integration from strategies to culture, tips for managing both work and children successfully, providing activities parents and caregivers can do with their child to improve productivity, and utilizing technology to boost daily efficiency and organization. In this chapter, as with other chapters in this book, the authors leverage theories in a practical manner and tap into behaviorism, constructionism, and social connectedness theories to outline and support the successful use of various strategies with positive results for both parents and children. As shared before, parents introducing libraries to children, offered both parents and children connectedness to the community and the resources available in the library, but also, stimulation, refuge, and development of independence.

Libraries play such an important role in our communities and society, but the breadth of services and the information they provide, as well as their social contributions are often overlooked and taken for granted. With the world reeling in response to the COVID-19 pandemic, many businesses and institutions were compelled to close their doors for the sake of public safety. In this time of uncertainty, the public's need for information increased while access to the institutions that provide that information decreased, and so, reopening learning and information institutions, such as public libraries, became a high priority. This book chapter highlights the significant role that libraries play in our lives and uses naturalistic observation and semi-structured interviews to examine one suburban public library as it learned to navigate online and hybrid formats to deliver its programming safely and effectively. By leveraging modern technology, the library quickly restored many of its much-needed services to its community and engaged its patrons in brand new ways. The Librarianship Through Every Occasion: Staying Open and Online During a Pandemic chapter offers many useful examples that other libraries around the world could use and add to their service delivery, during and post-pandemic period. Additionally, the book also hosts another chapter on how libraries created opportunities before and during the COVID-19 pandemic crises. Moreover, the chapters on libraries in this book also show how the evolving role of libraries before and during the COVID-19 pandemic around the world helped to combat misinformation, continued to be resourceful havens of information, offered temporary escapism and recreation through reading, and offered other appealing programs through innovative digital engagements.

While COVID-19 has impacted many organizations and individuals, one group significantly impacted by the pandemic are universities and recent graduate students. As these students are preparing to transition and trying to navigate this new world that the pandemic has shifted, they are confronted by the prospect of their next transition. This book offers a chapter that aims to provide insights on how organizations can optimize their use of job boards and the graduate recruitment process. The authors of the chapter collected data from 321 university students and recent graduates from Australia and examined their views and feedback on their lived experience of utilizing the job boards while undergoing the graduate recruitment process during the COVID-19 pandemic. The results and recommendations elucidate how higher education and organizations can optimize opportunities of the recruitment process which includes removing unnecessary stages or duplication of efforts that would help reduce the investment of time per application, increasing clarity of requirements, as well as providing timely and constructive feedback. Further implications of the chapter offer how the human resource strategy for early career talent acquisition could be better informed. The chapter regarding online job boards shows optimizing these job board processes can offer competitive advantages, create cost savings, and promote organizational sustainability. Furthermore, with the prospects of students getting employed at a higher rate by streamlining and optimizing job board processes, an organization could increase a significant success metric of which they are increasingly being measured against other organizations.

The chapter on developing computer-mediated solutions for situated workforce learning examines the present digital work context as well as the present and future of technologically enriched work environments. The chapter interrogates how contemporary computer-mediation approaches using artificial intelligence and machine learning can be utilized to approach workforce development in the current and new modern world. The focus of the chapter also provides the readers with a conceptual roadmap on how to develop situated computing solutions for workforce education and learning by using the already existing technologies while pulling in examples from commercial product offerings. Additionally, living and working in an era in which COVID-19 has shifted organizations' operation model to a digital approach has seen the workforce transformed into a digital environment. Similarly, emergency services also have had to adapt, but could also do so systemically by leveraging digital data from mobile and wearable new media technology for long-lasting positive assistance and change for their staff.

Firefighters are required to maintain all aspects of their health and wellness to sustain their fitness for duty. Tracking their metrics, specifically their heart rate variability (HRV) has been used as a reliable tool when assessing stressors placed on firefighters, be it physical, emotional, or psychological. The researchers and authors of this chapter offers a valuable review of new mobile technology that further determined the usefulness of using HRV as a tool to determine the physical, physiological, and psychological health of firefighters at a more regular and frequent scale. HRV can be tracked with versatile technology and can offer a plethora of uses, particularly in monitoring the cardiovascular strain as a result of firefighting and recovery post-fire suppression. The chapter also shows how the use of mobile technology measuring HRV may be used to assess firefighter occupational performance successfully. Lessons from this chapter are transferable to other emergency and civil service occupations across the world ranging from police to emergency first responders, ambulance workers and medical health professionals to name but a few.

The chapter capturing digital narratives of immigrant children in response to a hate crime in the USA, speaks to a series of workshops established to empower, equip, and enhance immigrant youth's means of documenting their lives through digital film making narratives. Conducting the workshops taught the children how to digitally capture incidents during emergencies, as well as post-emergency situations when confronted with hate crime incidents. Either directly or indirectly through family, friends, and community networks the digital film making workshops also hosted benefits for their career and workforce development. Looking at a youth-driven set of summer media workshops that started in 2011, the chapter explores youths' digital narratives and video production and how it can connect youths globally, foster crucial skills, agency, and academic enthusiasm. The chapter discusses how this work has been adapted by formal organizations and included in the curriculum or co-curriculum by educational institutions. The authors' work also presents how mobile learning and telecommunication can be utilized to help recently arrived immigrant students acculturate to a new environment.

The chapter covering the continued use of Personal Response Systems, synthesizes the literature about Personal Response Systems, which are integrated assessment information systems that can support the teaching and learning engagement process. Personal Response Systems is used in many educational institutions to track students' cognitive engagement and learning performance. In the past, personal response systems were separately issued devices but have subsequently been integrated via the use of mobile phones with polling or "clicker-based technology" in the classroom. The authors review various pedagogical applications of Personal Response Systems, and the examination provides the reader a sense of when and how this technology is best suited to benefit learners. The variables that can influence the effectiveness of Personal Response Systems are examined and the authors provide recommendations for maximizing learners' engagement.

The book also has a chapter on creating and maintaining teaching and learning communities within a massively open online course (MOOC) for computer programming reports on methodologies used to cultivate social connectedness for a national based USA learning community participating in a MOOC. Reflecting on a MOOC based workforce training program, this chapter looks at participants of this program who consisted of urban young adults who were provided with the opportunity of participating in a targeted labor market need for computer programming. The trainees had little to no computer programming knowledge or skill. The chapter outlined discussions on current MOOC limitations and challenges, particularly related to computer program learning through MOOC, and how they not only intended to overcome those challenges but did so in a highly successful and award-winning manner. As computer programming was traditionally learned through in-person processes, the authors presented the various challenges and strategies associated with teaching and learning communities remotely and online and how they successfully overcame those challenges. The authors illustrate how the training was operationalized in a way that kept the learning process supportive, dynamic, and engaging for both students and educators involved. This includes a discussion of roles, responsibilities, division of tasks, scheduling systems, clarification of goals, reflections, and continuous evaluation systems put in place as part of the teaching and learning community participation within the MOOC. This chapter inspires the evolution of how to participate successfully in a MOOC either within a community or as an individual, and how online learning needs to continue to shift and respond to different online learning contexts and meet the work skill demands and needs of society. The chapter offers many techniques and examples of how one can overcome many online MOOC challenges to reduce attrition, and work towards completion.

The book also hosts a chapter covering medical science technology that looks at advances in pediatric research using non-invasive technology-showing valuable precursors of higher risks of developing cardiovascular disease later in life. The chapter shows through research that there is an increasing prevalence of cardiovascular risk factors in children, specifically in low socioeconomic regions where children are exposed to several factors as early as the fetal stage, which increases their risk of developing cardiovascular disease (CVD) later in life. However, atherosclerosis develops silently from early childhood, long before the manifestation of cardiovascular risk factors. The chapter provides valuable insights on the advances in technology being used within pediatric research with non-invasive ultrasound technology for the detection of subclinical atherosclerosis in children. The chapter also explores the acceptance, adoption, and distribution of ultrasound technology within this sector for this target audience. The important use of ultrasound technology is increasing in developing countries so much so that many universities are offering technology-focused training courses for health professionals. The chapter also posits that the adoption of low-cost, portable ultrasound machines, as well as training of medical staff, together with teleradiology, could drastically improve health care access to the poor, help with early detection of cardiovascular risk identification in pediatrics and help to develop programs to help prevent the development of CVD in high-risk populations.

Living in a digitally infused and integrated world gives us the opportunities to use online digital data to infer valuable skills that can be used for modern workforce contexts. The chapter on leveraging data from social media networks and forums uncovers the opportunities that online media portals like content sharing and consumption sites or online photography sites have for informal and formal learning. The authors explored online portals and looked at case studies that can provide evidence of evaluating, inferring, measuring skills, and contributing it to the development of competencies and capabilities of the 21st century. The chapter focused on identifying data science topical experts across the Reddit community and another that uses online Flickr data to apply a model that rates aesthetically attractive and technically sound photographs. The authors contend that these models can serve as a base for measuring the photography capabilities of Flickr users and that the presented results can serve as a base to replicate these methodologies to infer other career and work skill competencies and capabilities across online portals and forums. The opportunities abound for schools as this data informed, novel approach can be an effective alternative approach with evaluations put in place to measure key 21st century skills for the modern workforce. Additionally, if incorporated and documented properly through online learning portfolios either in informal or formal co-curricular, and formal curricula contexts, leveraging these tools and data, hosts multiple applications, and widens the narrow scope of lenses through which we often look at, speak of, and write about education and workforce development. Additionally, this data-informed approach using these online portals can also aid our need to look at learners of all ages, more holistically, and not only recognize, but also extract valuable skills and talents for the benefit of the individual, the learning communities as well as support the goals and objectives of learning programs.

A chapter titled The Rise of the Battle for the Planet of the Apps - From L-Class to M-Class talks about how mobile learning has grown in adoption as mobile technology has been evolving. With the advances of mobile technology, mobile learning has seen a natural growth with mobile learning opportunities appearing organically and informally. While mobile phones were more available and accessible in students' hands, even during the time of COVID, many online programs were not adequately informed or prepared to have students conduct or deliver their required schoolwork via their mobile phones The chapter's sub-title of moving from an L-Class to an M-Class uses a Star Trek description of planets and a designation of their habitable state pending certain atmospheric and environmental conditions. The analogy in the title and subtitle suggests that there is still a need to convince many to the idea of leveraging mobile phones and other mobile technology for learning. The chapter hosts how to extract mobile learning opportunities organically and tap into practices of learning on the go. Essentially also showing how to extend learning engagement, as well as hosting the multi-screen lives that learners of all ages have, jumping from one screen to another, depending on where they find themselves during the day and night. This chapter describes the previous successes of a mobile learning graduate class, as well as the characteristics and practical applications of mobile learning theories. Additionally, the author describes the value of mobile first design approaches which can aid instructional designers on how they design with mobile devices at the forefront of their learning design. Lastly, the chapter describes examples of impact and untapped formal learning opportunities that could be derived from mobile learning as indicated in the mobile learning and mobile practice assessment chapter covering learning for project management certifications as well as the teaching and learning communities created and supported remotely through mobile learning in the massively open online course chapter.

The chapter on mobile assessments and applications used for compliance training and to prepare for required or elective professional certificates demonstrates how mobile learning has become integrated into our lives in a seamless manner. Although considered informal learning, many students and working adults use mobile applications (apps) to prepare for various tests such as the GRE, SAT or in the case of working adults, various professional compliance and required or elective certifications for their work. The authors highlight the usefulness of mobile learning (m-learning) and mobile assessment (m-assessment) apps in this regard and the chapter focuses on the m-assessment apps that many use to prepare for project management certifications and examinations. The chapter offers a criteria-based matrix to help either users or m-learning and m-assessment apps based on literature reviews, experiential knowledge, and the practical use of mobile learning theories for m-assessment. The criteria are structured and organized to offer important considerations of features regarding m-apps for professional certification training and do so using three categories: a) general user experience, b) test-taking experience, and c) m-learning experience. The authors also evaluate the features of twenty-four project management training and m-assessment apps found in the two app spaces by applying the categorized and structured criteria. Applying the criteria as evaluative lenses yielded valuable results that helped communicate to users how the examined apps perform against the criteria. A general reader or any person deciding to use an app for SATs, GREs, language learning or professional certifications will be able to use and extract value from the structured criteria matrix to make an informed decision on investing time in an m-learning app, downloading or purchasing the app as it emphasizes numerous ways that the criteria and features can help learners.

The chapter on conceptualizing experiential learning for computer-mediated engagement applies previously presented and tested concepts, theories, as well as principles necessary in a digitally rich world to the telehealth and allied health fields. The chapter aims to equip readers to leverage experiential learning using electronic (e-) and mobile (m-) learning theories in a practical manner with examples from talent development and allied telehealth disciplines. The authors weave learnings from pilot and action research projects, as well as from real-world examples to apply a model of experiential learning for sport science and allied health contexts. The models will help readers critically evaluate learning programs and applications in online or blended environments with knowledge and tools to design their own experiential learning for e-/m-blended, asynchronous, and synchronous learning environments. With the forced switch to online teaching and learning, the authors assert from observations that there is still a dearth with incorporating online, blended, and experiential features in e/m-learning, and more so in workplace contexts. Utilizing learning design cycles, the authors offer cases that offer pragmatic, formal and technical examples. The purpose of the models proposed is to equip readers with the ability to critically evaluate digital learning applications that are either offered as a product or considered for use as part of their own educational, and training programs.

To offer new media, training and skill development for teachers, learners, and the modern workforce, the book and its chapters offer different contexts, tools, and approaches to aid the use of online, blended, and mobile learning interventions. While teaching and learning contexts vary around the world and amongst groups and individuals, the book and its chapters offer a wide variety of applicable examples as well as ideas that can easily be replicated. Adopting the variety of practical uses of theories and approaches is not only possible, but a hybrid approach of using lessons from the different chapters might also be desirable. While the COVID-19 pandemic forced many people to adopt online learning, this book and its chapters will help the reader by offering a plethora of new media technologies with tried and tested ideas for various educational and training programs in various industries, verticals, and sectors.

*Dominic Mentor*
*Teachers, College, Columbia University, USA*

# Acknowledgment

The editor wishes to acknowledge the help of all the people involved in this project. More specifically, to the authors, editorial review board, reviewers that took part in the review process, and libraries that continued to seamlessly operate while many other services stopped operating during pandemic lockdowns. Without their support, this book would not have become a reality.

First, the editor acknowledges the valuable contributions of the editorial review board and reviewers regarding the quality assurance checks, improvement of content alignment, coherence, and content presentation of chapters. Most authors also served as reviewers; we highly appreciate their double task.

Second, the editor would like to thank each of the authors for their contributions. My sincere gratitude goes to the chapters' authors, who contributed their time and expertise to this book.

Finally, the editor wishes to thank librarians and libraries for their tireless and seamless efforts to keep libraries open and accessible during very strict pandemic lockdowns. While for quite a few, digital access to libraries was seamless, there were some cases where in-person and digital access had to be implemented to continue to serve the public. In many university communities, libraries continued to operate seamlessly, and students, researchers, and editors could continue their work without interruption. While librarians fade into the background, this editor wishes to bring their work to the fore, as this book and its chapters from contributing authors could not have been completed.

The editor also wishes to acknowledge librarians and libraries who operate in welcoming and warm ways for being a part of the start of his childhood, teenage and adult intellectual journey. Thanks to those supportive librarians and hospitable libraries, a mother could promote them as active members of a library and inculcate her children to read. While my mother read to us as children, our father donated his purchased books to our local library to expand our reading opportunities. Thanks to my parents and librarians, I picked up that torch of reading with my own children, and planted the same seeds of visiting libraries, reading to my children on subways and busses, and planting the seeds for the love of libraries and reading. Oftentimes also making libraries our places of meet up and center for participating in various library resources driven and community determined activities.

We can all very easily promote libraries and highlight the significant role they play in our lives, in our communities, and the indelible impact they have on societies. Let's thank a librarian and our libraries more often for the amazing work that that they do, and how seamlessly they manage to do it all!

*Dominic Mentor*
*Teachers College, Columbia University, USA*

# Chapter 1
# The Selection of Online Learning Tools for Higher Education:
## Lessons Learned During the COVID-19 Pandemic Applicable to Numerous Learning Contexts

**Paul Evan Acquaro**
https://orcid.org/0000-0003-1473-3267
*FOM Hochschule, Germany*

## ABSTRACT

*Among the many ways the COVID-19 pandemic has been felt worldwide is in the closure of physical spaces, prompting a shift online in many aspects of daily life, including education. Many universities, colleges, and other educational institutions adapted quickly, though often in an ad-hoc manner, to what some researchers have called emergency online learning. Even in pre-pandemic times, selecting and implementing platforms and tools to support online learning effectively in educational contexts was not a clear-cut task. Finding the right balance between pedagogy, training, support, data security, and privacy and ensuring ease of use confounded the efforts to provide an effective online learning environment. This chapter re-examines the results of a study on online learning tool choice conducted pre-pandemic coupled with a review of lessons learned from literature on emergency online learning to better understand how decision makers can best select the tools for their institutions.*

## INTRODUCTION

Prior to the COVID-19 pandemic, which was officially declared by the World Health Organization on March 11, 2020 (WHO, 2020), higher education institutions had already long been developing platforms to support online education. Online learning offerings had been showing continual yearly growth prior

DOI: 10.4018/978-1-6684-3996-8.ch001

to the COVID-19 outbreak. For example, according to a study by Allen, Seaman, Poulin and Straut from 2016, the numbers of students learning online between 2012-2014 had grown 7% and that nearly a quarter of all higher education students had already taken one or more courses online. Di Xu and Ying Xu (2019) underscore the rate at which degree-granting institutions were offering online courses and also noted the yearly increases. They write:

*In 2016–17, approximately 3,500, or 76 percent, of all degree-granting institutions reported offering online courses. This number has increased steadily since 2012, when 70 percent of those institutions reported to offer online courses. (p. 6)*

In fact, prior to the pandemic, EducationData.org reports that "33% of all college students took at least one course online…" (EducationData.org, 2022), a statistic that has surely been rendered obsolete by pandemic induced emergency online learning efforts.

Due to social distancing rules that pushed institutes to make the shift to online from in-person courses, or as researchers Tsang, Chong, Lam and Chu (2021) describe as "emergency COVID-19 online learning" or CoOL (p.1), most higher education students have now experienced an online course. However, the difference is, as Tsang et al. note, that "instructors and students, some of whom may not have had any experience with online teaching or learning and may not have been ready for the move, needed to cope with the changes quickly." (p. 2).

This is an emergency situation was experienced worldwide with varying outcomes (Ebner et al., 2020; Tsang et al., 2021), and there are lessons to be learned, both positive and negative. Goh and Sandars (2020), in reflecting on the impact of the pandemic on medical education, write that the "COVID-19 pandemic has been a major disruptive change to medical education across the world and the use of technology has been rapidly and innovatively used in an attempt to maintain teaching and learning" (p. 16). They also acknowledge that to benefit from this disruption and (sometimes) ad-hoc implementation of technology, the challenges need to be addressed.

Fortunately, there is a rich, recent history of online learning research that can be used to help in this challenge. This chapter evaluates some of the recent literature regarding emergency COVID-19 online learning efforts, and re-examines a study conducted pre-pandemic that sought specifically to understand the factors that influenced decision makers in higher education when selecting the platforms and tools for the online learning environments at their institutions. This new look at the research asks the question what can be learned from the efforts to offer emergency online learning to guide the further development of online learning environments?

## BACKGROUND

An issue to contend with in the switch to online learning, emergency or otherwise, is the process of selecting and implementing the platforms and tools that support online learners in higher education. This is something that to date has not been offered any clear and well-defined approaches. Faced with an expansive selection of tools, competing interests, limited time and budget, stakeholders involved with procurement of education technology must make many important decisions with uncertain outcomes. Fiona Hollands and Maya Escueta described this conundrum perfectly in their 2017 study *EdTech Decision-making in Higher Education:*

> *EdTech decision-makers are in the hot seat, sandwiched between end users who range from intransigent Luddites to technophiles, and vendors who have answers to everything—even when there is no question to start with. EdTech tools and their applications are proliferating in an environment where higher education is viewed as a lucrative market with much work to do to keep up with the 21st century, to provide accountability data to regulators and the public, and to safeguard students' data privacy and other EdTech-related rights. As if these pressures are not enough to deal with, we are now expecting EdTech decision-makers to ensure that their choices lead to better student outcomes—a standard not imposed on many other decisions in higher education. (p. 116)*

Thus, an effort to better understand the opportunities and challenges that decision makers face in their efforts to purchase and implement education technology could be helpful. One such study, seeking clarity in the area of selecting online learning platforms and tools, was conducted by the author of this chapter. The 2017 study probed the influence of the many technical, pedagogical, and experiential factors on the choices that decision makers contend with when evaluating and purchasing learning platforms and tools. In the study, decision-making at higher education institutions were surveyed about their experiences in developing and managing online learning programs with questions that ranged from specific tool types to pedagogical choices. This was followed up by interviews with some of the subjects to provide additional insight and explanation. While their stories were but a very small sample of the many unique and diverse experiences occurring every day, they provided some awareness of both the challenges and successes that institutions have had in their approach to addressing the needs of online learners. The findings provided a snapshot of the considerations that decision makers in the higher education space were making in the years prior to the COVID-19 pandemic, and still provide insight into practices that could be helpful to others in similar position.

Since its onset in early 2020, the COVID-19 pandemic has provided a unique opportunity to observe what happens when a sudden and massive shift towards online learning occurs. In many cases, instructors inexperienced with online learning best practices, institutions possibly without adequate digital infrastructure, were suddenly in charge of transitioning courses online. Suddenly, understanding of the learning tools, security, communication channels, and above all, pedagogy, was in general discussion.

Tsang et al's 2021 study on what they coined CoOL ("emergency COVID-19 online learning") provides a timely look into the impact of the social distancing requirements that resulted in most universities to temporarily halt Face-to-Face (FTF) courses and shift teaching online. Their study focused what was perceived by students to be effective in learning in this time frame. The researchers caution that emergency online learning should be considered differently from the conventional online learning of pre-pandemic times due to the rapid switch and adaptation of curriculum that was not intended to be facilitated on online, often by instructors who had little to no online learning experience. They write: "courses that were originally planned to be delivered FTF were forced online within a very short period of time" (p 2).

However, what they found is that social learning, student to student communication and course design that included clear structuring and group learning activities were, according to students, the most important components in creating an effective online learning environment. Student and instructor interaction was also valued, but in a less direct manner than in the FTF (Face-to-Face) classroom (p. 11).

Shivangi Dhawan (2020), writing about emergency online learning in India, stressed many similar points about the lurch into the online space. He also discussed the need for not just using technology to facilitate online learning, but the correct pedagogy to make it work. "Inadequate compatibility between the design of the technology and component of psychology required by the learning process; and inadequate customization of learning processes can obstruct the teaching process and creates an imbalance" (p 15). He also positively notes:

*This crisis will be a new phase for online learning and will allow people to look at the fruitful side of e-learning technologies. This is the time when there is a lot of scope in bringing out surprising innovations and digital developments (p. 15).*

Some of the tools that are mentioned in his study included Zoom for synchronous web-conferencing and the Google Suite of collaborative technology like Hangouts, Drive, Classroom (Dhawan 2020), all tools that function outside of a specific Learning Management Systems. However, the general Learning Management Systems is considered integral, at least, for the basic administrative functions required to administer online learning (Taylor, Grant, Hamdy, Grant, Marei & Manda, 2020).

An important distinction to make is that these researchers' findings mentioned above have not focused on the actual tools being used, but rather on effective approaches to emergency online learning. The tools are important, as they facilitate what can be done, but as mentioned, it is the ability to facilitate the appropriate learning environment that supersedes the tools themselves, especially when the time frame for implementation is exceedingly tight.

Another aspect to consider in general tool selection are the skills being learned, and in higher education, how these can translate to the skills needed in the 21st century work force (Rios, Ling, Pugh, Becker, & Bacall, 2020). Businesses and governments have experienced the transformative changes made possible by online collaborative tools (O'Reilly, 2005; Tredinnick, 2006) and it stands to reason that if one of the goals of higher education is to help students become competent, collaborative, problem solving employees of tomorrow (Scardamalia, 2002), a logical extension that higher education should be preparing students to be critical producers and consumers of information (Buckingham, 2003; Buraphadeja & Dawson, 2008; Marks, 2009; Mirra, Morrell & Filipiak, 2018). To this end, the development of critical thinking and communication skills is an important component of higher education (Burbach & Matkin, 2004; Tiruneh, De Cock & Elen, 2018), and collaboration with others is a key element to truly support thinking critically (Choy & Cheah, 2009; Shaw, 2021).

In an innovative study, Rios, Ling, Pugh, Becker & Bacall (2020) identified critical 21st century skills desired in the workplace by conducting a content analysis of job advertisements. They write that "to promote workforce preparedness and long-term success of the U.S. economy, it is clear that student development of 21st century skills is greatly needed" (p 3) and their findings, which came through analyzing the content of actual job advertisements, indicated that the most requested skills for the 21st century worker as being oral communication, written communication, collaboration, problem solving, and to some extent social intelligence, and self-directed learning skills.

The results of this study support the findings that many researchers are discovering in the rapid conversion to online courses: namely the need to develop the skills that are steeped in social learning (Harasim, 2017; Lowenthal, 2010) and collaboration (Harasim, 2017; Woo & Reeves, 2019). Essentially, pedagogy that builds upon social learning theories help learners in retaining and applying learned information in other situations. However, researchers and practitioners have also called attention to a gap between the learning approaches considered most effective for learners and the actual instruction found in the online classroom (Meier, 2016) and it is also well established that both the pedagogy used and the tools available for educators still tend to favor more traditional methods (Harasim, 2017; McLoughlin & Lee, 2007).

Before delving into the role of the online tools in closing this gap, it is helpful first to recognize that different philosophies toward learning will suggest different tools, and different tools can be used to reach students in different ways (Harasim, 2017; Kanuka, 2008). Students require a curriculum that teaches them to be active interpreters and competent participants in a "new paradigm emerging from the networked information economy in contrast to the production models of the industrial age" (Bruns, 2009, p. 227), where they are producing knowledge, interacting with each other, and collaborating across distance and time.

Heather Kanuka's chapter in *Theory and Practice of Online Learning* (2008) is helpful in framing this line of thought. It outlines the need for educators to be aware of their own teaching and learning preferences, since they impact the tools selected for teaching. She writes, "the debate over whether or not we need to prepare our learners for a pervasively networked world revolves around what types of persons we expect our education systems to produce" (p. 93).

The assumption is that decision makers in higher education, and specifically for online learning, do want to embrace the actual learning needs dictated by the forces of industry and society. Shifting now to the perspective to the instructional designer whose pedagogical choices are impacted by the tools, the deliberate and thoughtful selection of the platforms and tools again becomes important. The role of tool selection on the interactions within an online learning environment is further underscored by Oubenaissa, Giardina and Bhattacharya (2002) they explained that "with learning spaces becoming more complex and dynamic by the potential of sophisticated and intelligent technologies, these spaces are now defined by their tools, type of activity and interactivity, and work sharing allowed to learners" (p 43). At this point, considering the continued growth in the numbers of students taking online courses, as well as the experience of emergency online learning, the question becomes how can institutions be sure that the tools they are selecting can foster the type of instruction that meets the needs of tomorrow's workforce?

## METHODOLOGY

The data being re-examined in this chapter draws from the study *Investigation of the selection, implementation, and support of online learning tools in higher education* (Acquaro, 2017), which was conducted to develop a broader understanding of the factors that impact decision makers in the selection and implementation of the LMS and other tools. The study used a mixed-methods approach to achieve its goal. An online survey was administered to a group of 30 participants, identified through referrals and social media. After the survey was conducted and evaluated, a series of five interviews with selected participants was conducted to gather more insights into the findings.

A variety of methods were used to identify participants, including attending professional conferences, requesting participants to recommend peers and contacts, and appealing to members of interest groups via the social media tool LinkedIn. The final pool of participants represented undergraduate, graduate, private and public colleges - including two institutions that offered their degrees almost exclusively online. The subjects had professional titles that ranged from Senior Instructional Designer to Provost for Online Learning; however, most important was that all of the respondents had a primary role in making decisions regarding online tool selection.

In the following sections of this chapter, the information, which was gathered prior to the COVID-19 pandemic, is considered against the findings of researchers who have been early to examining the ways in which higher education institutions have adapted to the sudden transition to online learning, or emergency online learning. The results will be discussed against these findings and thoughts on how this may influence the factors of choosing online learning environments will be discussed.

## RESULTS

### The Survey

In the following sections, selected results from the survey are presented, the bolded title indicates the question's focus.

**Ranking the influencing factors:** One aspect of the survey was to determine how online learning tools were chosen, or more precisely, identify which phenomena influence the decision-making process. In the set-up of the study, a list of possible influencing factors was drawn from an extensive literature review (Acquaro, 2017). One of the survey questions asked participants to rank the top three factors out of a list of twenty, which influence their platform and tool choices. Out of the total 30 respondents, *recommendation from faculty* came in at the top spot of 47% (n=14), with 9 participants ranking it in first place and 4 in second. *Research studies* came in second at 40% (n=12), with 8 participants giving it the top choice, and 2 each for second and third place. *Ease of use for faculty* came in third overall (33%, n=10), split evenly between the first and second spots. Figure 1 offers a detailed visualization of this data.

Preferred approaches to teaching and learning: The desired approach to teaching and learning is a possible variable in how tools are chosen for online learning. For example, to support collaborative learning, the tools must support group formation and co-editing activities. To explore the connection between preferred tools and teaching philosophies, participants were asked to rank their preferred learning approaches along a five-point Likert scale with ordinals ranging from very effective to not effective. The list contained several well-known learning approaches, including direct teaching, problem solving and social learning methods. The choices included *case-based*, *client-based, discussion-based, problem-based, project-based, self-paced* and *lecture-based learning*. A choice for *other* was also provided to allow participants to identify options that had not been provided.

On a side note, the term *effective*, as used here, is drawn from the definition proposed by Bradford Bell and Jessica Federman in their 2013 meta-analysis of e-learning in post-secondary education. Bell and Federman wrote that the term is often applied in e-learning studies as comparisons between in-person and online. However, the researchers suggest a more expansive definition of effectiveness and instead take a cue from Richard Clark's (1994) agnostic point of view that technology is a tool to be employed by instructional designers and its pedagogical use is paramount in its proper use. Bell and Federman also cite the work of Steven Ross, Gary Morrison, and Deborah Lowther (2010) in their definition of education technology "as a broad variety of modalities, tools and strategies for learning. Its effectiveness, therefore, depends on how well it helps teachers and students achieve the desired instructional goals" (p. 19). Thus, the term *effectiveness*, in this study, was seen as the degree to which the tool or learning approach in question meets the participant's pedagogical goals.

Among the 30 respondents, it was generally agreed that *lecture-based* learning was the least effective approach to online learning, with all 30 indicating that it was either not effective or only somewhat effective (total: 70%, n=21). All participants indicated that *problem-based (87%, n=26), project-based* (87%, n=26), and *case-based* learning (90%, n=27) were either very effective or moderately effective.

*Discussion-based* learning was considered very effective by 53% (n=16) or moderately effective by 33% (n=10). Figure 2 shows this data as a chart.

**Which types of tools are considered effective?** Because the names and details of tools often change, a question about preferred tool types listed by categories was presented, rather than specific tools. For this question, participants were asked to rank what they believed were the most effective tools in teaching and learning. The tool types were given with a 5-point Likert-scale with following the choices: very effective, moderately effective, somewhat effective, not effective, and unknown.

Across all respondents, the top three tools that were considered to be very effective were *videos* 73% (n=22), *simulations* 72% (n=21) and *discussion boards* 53% (n=16). *Blogs* and *chats* tied for fourth place at 50% (n=15), followed by *social networking* 43% (n=13) and *wikis* 40% (12). At the bottom of the effectiveness ratings were *Podcasting, Drawing, RSS Feeds*, and *Social Bookmarking*, all coming in at 10% (n=3). Figure 3 shows the results of this question.

*Figure 1. Top Factors that impact tool selection as ranked by participants*

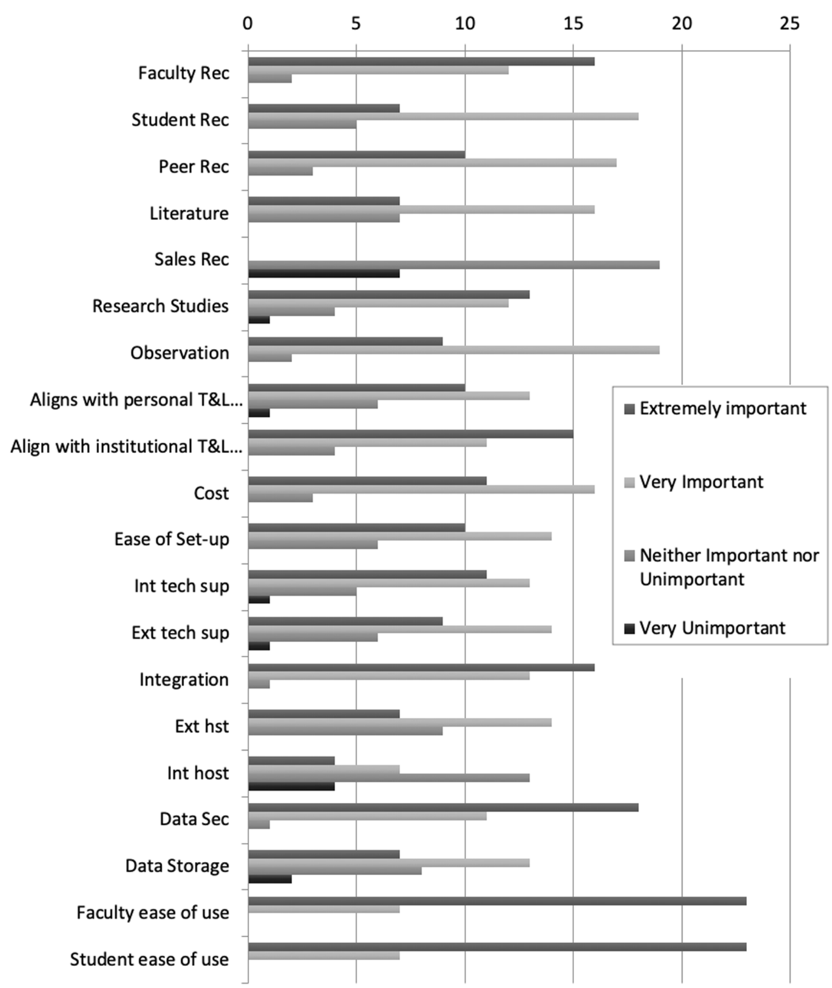


*Figure 2. Preferred approaches to teaching and learning among all participants*

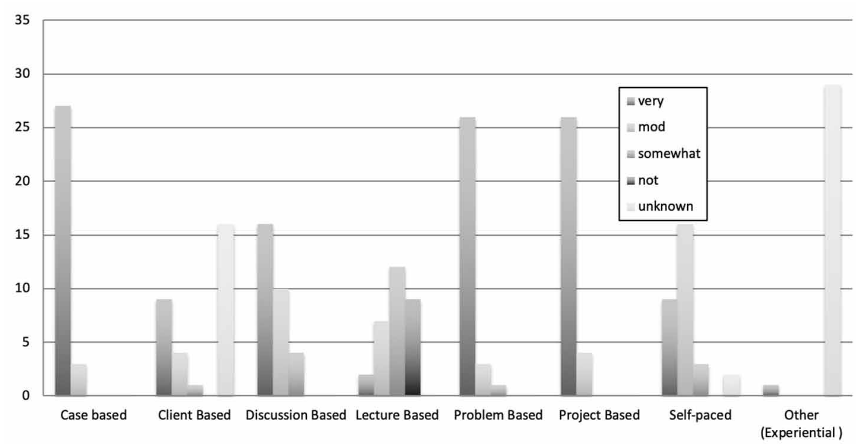
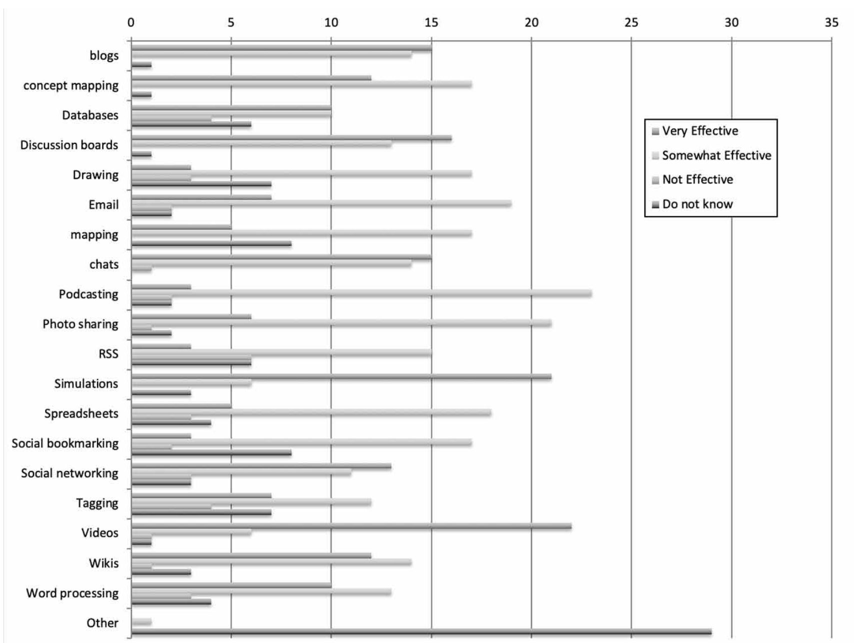



*Figure 3. Effectiveness of online tools by type*




**How does a college respond to support calls and training on new tools, which sometimes they may not even know are in use?** The point of the following question was to see how flexible or structured institutions were in terms of allowing tools use. To explore this question, participants were asked what level of institutional circumscription should exist for faculty tool use. The survey asked:

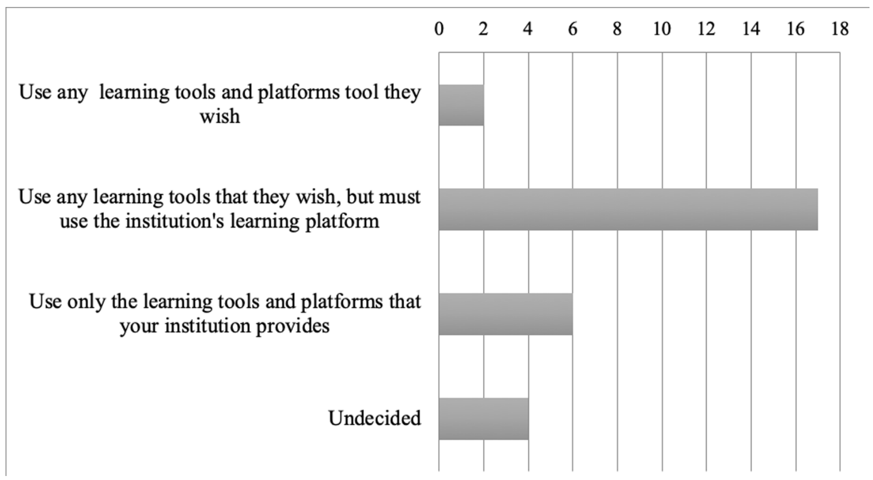
Do you feel that faculty should be able to:

- Use any learning tools and platforms tool they wish
- Use any learning tools that they wish, but must use the institution's learning platform

- Use only the learning tools and platforms that your institution provides
- Undecided

In the results, the majority (56%, n=17) indicated that faculty should be able to *use any tool that they wish, as long as they use the school's LMS as the basis for the course*. Following this, 20% (n=6) took a harder stance, indicating that faculty should only *use school-provided tools*, while 7% (n=2) were open to *any tools*. The remaining 13% (n=4) were *undecided.* Figure 4 displays this information.

*Figure 4. Restrictions on 'outside' tool usage*




While there were many other data points in the survey, these preceding findings offer a small window in what drives tool selection, and which types of learning approaches are valued. These results will be discussed in regards to effective online learning approaches and activities shortly, however, before this select results of the interviews will be presented.

## The Interviews

The following five subjects took part in one-on-one interviews to help give more background to the survey findings. For some context, here are short descriptions (and pseudonyms) of the interviewees:

- **Brad** works at a large, private, multi-campus university with an international reach. His school offers both undergraduate and graduate degrees. He has an extensive background in administration, some background in IT and teaching, and has been working with the administration of online programs for 5 years.
- **Jake** works at a university extension. The university itself is a public, multi-campus institution that offers both undergraduate and graduate degrees. His background is exclusively in IT, with little formal teaching experience, and he has been working with the administration of online programs for 5 years.

- **Kate** works at a large public college that is part of a state education system. Her school offers a great deal of online courses at both the graduate and undergraduate level. She has extensive background in administration, some background in IT and teaching, and has been working in online learning for 14 years.
- **Pat** works at a small private college that offers graduate degrees. Her background is primarily in teaching, and she has little formal background in IT, and has been working with in online learning for 18 years.
- **Scott** works at a medium-size private graduate college. He has an extensive background in both teaching and IT, and has been working with the administration of online programs for 15 years.

The interviews followed a semi-structured protocol with each one taking its own shape as the interviewees expanded upon their answers. First and foremost, the general contention that tools themselves are less important than the learning environment and approach came across in several of the interviews. Another striking idea that came up was the idea that selecting an LMS – hastily – can actual be a 'trap' for a school.

First however, Scott speaks specifically to the point of his efforts to ensure that faculty feel supported and are happy with the tools. In general, he sees tools more as a set of options:

*I think you need to have access to open tools for the faculty where they can go and experiment and not feel like that they have run off the range. That's what I love about Google Apps—it really gives you a way to say—instead when people like I just found this new tool let's buy it—you can say, "Oh, sorry, well you didn't like WebEx, would Google Hangouts help you? Maybe you would just like to try a Skype with this? Maybe that would be all you need.*

Pat's observation about ignoring tool specificity serves well to underscore this point:

*I can't tell you how many times I've hammered a nail into the wall, using a shoe—that's the analogy that I use all the time. I will use any tool if it works. It may not be the tool that was created for that purpose, but I'll use it for something.*

Jake acknowledged that platforms have their limitations and a perfect online environment is probably not a reasonable expectation:

*I actually think that there are some big problems with the LMS and with the way some things are currently handled. So, in that sense I'm a little dissatisfied, but our tools, in comparison to what is available in the world, I'm pretty happy with what we've got.*

However, it was Kate who went further in suggesting that tools, specifically LMS, can even be a "trap" for an institution:

*I think as an institution we fell into the trap that almost every institution falls into when they are going online—and maybe it's not fair to call it a trap but you sort of go "OK, I'm going online, I need an LMS, and there is a thing called a CMS that someone that some said once, I think I must need that too."*

*And you have vendors lining up, saying, "Oh you know Blackboard can do that for you, or whatever ... Canvass ... etc.*

**Other tools.** In the survey results, over half of the survey participants indicated that they felt faculty should use any tool they wish, as long as they utilize the college's LMS. Twenty percent of the participants indicated that faculty must use the tools that are supported and available, and the remaining percentage was comprised of participants either more lenient who thought faculty could use any tool they wish, or they were undecided. It seems that there is a diversion at this point between creating an environment that can be easily supported, data-secured, and quality-controlled versus one that is entirely open for exploration, trial, and error.

On the one hand, Kate's college offers a set curriculum and a suite of officially supported tools that faculty should use. Considering the scale and centralized nature of the institution, it seems like a pragmatic approach. With this scalable, replicable, but restrictive model come options that other schools may not have:

*When you have a traditional university, you have tenured faculty, and each faculty sort of designing their own course. We can't do that. If we did that we'd be teaching statistics 500 different ways, and with 100 different textbooks, so we actually have a standardized curriculum. So, that in turn allows us to make deliberate choices of instructional design at scale and technology at scale.*

It would seem that speaking with Kate, that once the curriculum and teaching approach is established, the challenge moves onto selecting the right technology:

*I think I spend most of my time thinking about the technology and how we can get it to do what we need it to do over anything else. For the curriculum, we have subject matter experts and we know good instructional design and we have the content. It's really the technology that's often the challenge.*

Scott and Pat discussed the importance of having a space to experiment. Pat spoke about a center for technology for faculty to experiment and try out tools and pilot courses using new technologies. Scott spoke about how it is important for faculty to drive the course and choose the tools that work best for them:

*Even if it's not faculty-driven, it should be faculty-guided, there should be somebody there who is engaged with the institution and understands the institutional mission, and not just institutional mission, but departmental and programmatic mission that at the end of the day they are not just cookie cuttering programs out.*

Jake and Brad have separately staked out a middle ground. Brad discussed how his institution established a year-long project during which they canvassed the university and came up with a representative set of tools in use. They then tested and learned them in order to support and integrate them properly into a larger, flexible environment. As Brad explained:

*So, we ran a support pilot for a full year that just kind of said, "Hey, are our school based and central teams able to provide support if faculty are interested in innovating?" Because there was one big dis-*

*cussion around "Well, I don't want to do anything because the university cannot support me so I'm not going to get started and have my dreams dashed, when they can't be achieved.*

Jake discussed the need for the support team to know the tools being used, as they are on the front-line supporting users. He also wants to ensure that software is adhering to best data security and privacy standards, and explained how a systemized vetting helps him:

*Sometimes people have an out of pocket solution that needs to be evaluated in relation to a particular class of software. For example, telecommunications, we already know what we need to know about WebEx and Adobe and Skype, there's the whole lot. We don't have to think too hard about those things, but sometimes unique challenges come forward and we have to spend a little bit more time evaluating those, and depending if it's within our domain, evaluating it in-house here. If it's institutional, then we participate in the committee through the IT department.*

The least structured environment seems to be the one that Scott described. The institution supports multiple LMSs and faculty are encouraged to bring in any tool they wish. The college encourages exploration and discovery on one's own, however the technology may be being implemented less systematically and/or without proper support.

As factors like *security*, *cost*, and *usability* come into play, some sage advice comes from Kate explaining how her college is now rethinking – and reevaluating its LMS strategy from a needs-based perspective:

*We're really starting off with functional requirements. We looked in the past and we said we need an LMS, OK let's go look at LMSs, OK we saw there three, I like that one better, let's go with that. Now what we're trying to do is determine what are they key things that we need to do.*

**Role of pedagogy.** Moving beyond the tools, the role that pedagogy plays in tool selection was also made by several interviewees. For example, Scott discussed his experiences in online education; he explained that students want strong pedagogy, not cumbersome tools:

*My concern isn't the overall online experience in terms of is it the most beautiful, does it have all this branding to it, is it the best experience online. Because at the end of the day what the students want is the experience, and they really want strong transformative pedagogy.*

And also, what faculty should ultimately be concerned with:

*In our meeting yesterday, we started talking about "how do I do this," and the first focus is that they want to talk about the technology but then it starts to have to do more with the pedagogy.*

Pat underscored these statements with a discussion how the tool is a vehicle for getting something done, for driving pedagogy:

*Faculty who come in may need anything … for me technology has always been the tool that we slap on top of what we're trying to get done. So I've set up the environment that I'm working in to be that way.*

**Avoiding the LMS trap and looking ahead.** Scott said he liked his LMS situation because he had several to choose from. His satisfaction seemed to be rooted in the fact that there was a suite of options, and that he also takes an agnostic view of learning tools in general.

*I like my current LMS situation. Which is just that I can just cherry pick from different LMS, that's something I've never had before.*

However, he also tempered this with the following observation about the transient nature of the technology:

*I've never been anywhere that we haven't changed LMS within three years.*

Pat echoed Scott's sentiments:

*The LMS usually is given to you at the institution you are at. I've been through two or three new LMS integrations, but I wasn't a part of the selection committees.*

This question may be best served by Kate's view of the LMS and higher education. As mentioned, her institution has an LMS in place, but there is now a very deliberate process in place to find a replacement that is better suited to the needs:

*What I think has ended up happening in this space is that everyone searches for an off-the-shelf solution and then once they really get into it they find out that it doesn't really work all that well, because it was not ever geared to what their functional requirements were.*

Brad, whose institution has gone through a self-assessment and has settled on a particular LMS, echoed this type of deliberate and thoughtful needs assessment approach:

*We worked this year with Gartner on an external review and also some interests groups both in [city] and [city] to try to understand some of the LMS of note, this year we put together a rubric of evaluation that Gartner helped validate and review and what their results suggest are that there are minimal differences between some of the core LMS administrative systems, the systems that connect to your student system and help you do grade books and rosters and what we call add/drops and stops, those elements that extend to grade books, basic quizzing functionality, lessons, tools.*

The goal for Brad is a solid but flexible architecture:

*That is what we are all looking for—balance in how to sustain a set of services that are flexible from an architectural stand point, secure and reliable from a data standpoint, and still allow for some innovation. For us, it's building that architecture that you can add things in and take things out as they are needed.*

This is a goal shared by all of the interviewees. Everyone is seeking a tool set that is flexible, can be mixed and matched, and supported in an integrated manner. Like, for example, Jake:

*I think that a whole lot of things like LMSs and much of the software is just a front end on a database anyway. So if we can keep the database part but maybe make the interface more in line with synchronous content, while also gaining the advantages of asynchrony and distributed content, I'd be excited for that to happen.*

The dream of the perfect toolset was said well by Scott, who would like to see the tools to be so transparent that students only see the learning:

*My dream environment would be an institution that would be flexible enough to bring in technologies as they become relevant and also focused enough to understand that the online program needs to have a certain experience to it. That experience can be pedagogical, but I think any student coming into it—I want to remove the technology burden on the students so they notice how strong the pedagogy is.*

## DISCUSSION

Linda Harasim, in her 2017 book *Learning Theory and Online Technologies* outlines three general approaches that online learning falls into, each one with its own underlying assumptions; they are: Collaborativism, Online Distance Education, and Online Courseware. These distinctions are important, as Collaborativism is the type of online education where the development of 21st century skills – i.e. collaboration and communication – is at its core. The other two follow more direct instructional approaches.

Turning to the survey, as the results suggest, the participants' main pedagogical choice is to support *project-based*, *problem-based*, and *case-based* approaches. As they are thought to be the most effective ways to teach and learn online, the implied pedagogical approach here is rooted in social learning. It would be reasonable that the selection of the platform and tools that can support these collaborative approaches would be the guiding criteria.

At the LMS level, while each platform has its strengths and weaknesses, the ones that follow a Collaborativism point-of-view, in which it should be a highly adaptable space, is recommended. For example, the LMS should allow the instructor to choose the course structure, mix and match activities as needed, choose whether or not to use scaffolding, and not be beholden to specific patterns or learning models. This may also help institutions avoid the aforementioned 'LMS trap', where the initial impressions of the LMS purchased and rolled out does meet expectations. However, it should also be considered that such an LMS may be more difficult for faculty to simply use than one that offers a pre-built 'plug-and-play' approach.

Thus, the next factor to consider is *ease of use* by faculty and students. This factor is tempered by finding the right balance between *cost*, *security* and *support*. Of course, *faculty recommendations* and *published research* on the tools should help the decision makers with discovering and verifying the quality of the tools, but the *ease of use* should be a very strong consideration in selecting a tool.

In terms of tool selection, the survey findings indicated a possible mismatch between the reported most effective teaching and learning approach vis-à-vis the tool type rankings. What stands out about the results seen in Figure 4 is that when considering how *social teaching and learning approaches* were highly regarded, *video*, which does not typically require much social interaction, is considered a more effective tool than collaborative knowledge building ones like *wikis* or *social bookmarking*. However, this survey did not ask how lessons and activities were constructed and how videos may be utilized within an exercise. Suffice to say, if following the logic that collaboration and communication are key 21st century skills to develop in students, then likely the top ranked tools should be ones that support rich social interaction.

A quick look back at the literature provides a reminder of two important factors may be helpful in thinking about these results: the sudden transition to online learning because of COVID-19 (emergency online learning) and how, even in urgent times, social learning methods should be utilized to offer effective online learning. As mentioned earlier, the pandemic forced extreme temporary changes on higher education and institutions, ready or not, were suddenly supporting online learning environments.

Tsang et al.'s (2021) study on what factors impacted student's perception of emergency online learning revealed that student-student communication and collaboration was the most highly valued aspect of the courses, whereas student-instructor interaction though still significant, was on the whole less valued. They also found that university support did not play a significant role in the perception of learning effectiveness. Boardman, Vargas, Cotler & Burshteyn (2020) in a study of undergraduate student's learning habits after the switch to emergency online learning also note the importance of social connectedness in the classroom, stating "it is important that this feeling of connectedness still exists when classes cannot be held face-to-face" (p. 2). They note that motivation and satisfaction are impacted when students feel disconnected from their courses and that use of web-conferencing (in this case the Zoom platform) and projects that encouraged interaction to help students feel reconnected.

These are but a few examples from studies that have appeared since the need for emergency online learning. The studies all point to the use of collaborative techniques, underscoring much of the research prior to the pandemic, and which is also hinted at in the results of the study discussed in this chapter.

Returning to the concept of Collaborativism, Harasim (2017), frames the biggest problem facing online learning a pedagogical one. She says:

*Despite the growing support for online learning, online education has been poorly defined and theorized, with little explication of which pedagogies, approaches, tools and environments should be used, under which conditions, to achieve the best results. (p. 116)*

At the core of an effective online learning program is what she identifies as "three stages of collaborative discourse from Idea Generating (IG) to Intellectual Convergence (IC)" (p. 122). Idea Organizing (IO) is the middle stage, and together all three encourage a methodical approach to bringing students together an encouraging strong collaboration between them. Within these stages, it is possible to use online tools, such as the online discussion forum, as a central component.

Another online learning framework that has been developed with collaboration at its core, and has already been implemented on multiple LMSs, is from the author of this chapter. It is a "lightweight framework" (Acquaro, 2020) that offers instructors an approach to scaffold, or provide support, to student's in an online learning environment. It encourages developing courses using activities that require collaboration between students and sets up a series of 'mini-deadlines' to help scaffold the students learning. This framework is meant to be easy to use and supportive of both instructors and students new to online learning. While independent of specific online tools, the use of almost any LMS and connection to collaborative tools like a forum, wiki and/or Google Docs for collaborative working, is recommended.

A point suggested in the interviews was that before thinking about the tools themselves, the most important step in selecting and implementing an online learning environment is assessing the type, scale, and program model that makes the most sense for the institute. It became apparent from the interviews, that there exists a contrast between a faculty-driven model and a top-down professional teaching model, with variations in between. Now, complicating matters, is the emergence of COVID-19 emergency online learning. Researchers have already cautioned emergency online learning should not be compared with other more deliberate and planned and approaches:

*What we know from research is that effective online learning results from careful instructional design and planning, using a systematic model for design and development.The design process and the careful consideration of different design decisions have an impact on the quality of the instruction. And it is this careful design process that will be absent in most cases in these emergency shifts. (Hodges, Moore, Lockee, Trust & Bond, 2020, np)*

However, now that most participants in higher education have experienced some sort of online learning, the lessons being learned from the emergency online learning is that collaborative activities, and other related approaches, no matter how they are established, offer a great deal of support the previously established advantages of social learning. Thus, Collaborativism is an important concept in the delivery of effective learning.

Returning to the study one last time, *support* and *training* is also a favored factor; as one interviewee noted, faculty are the last mile in delivering online education, and another interviewee explained how group support of learning technologies is an integral component in creating the overall online learning experience. Questions that emerge are how to best aid faculty and how to open up a process where tools can be selected and vetted so that meet certain support and training criteria. Many institutions already have teaching and learning support units, and in addition from the recent literature, there have also been guidelines created by faculty in the position of having to development content. One such example is from Sandars et al. (2020) who have offered *Twelve tips for rapidly migrating to online learning during the COVID-19 pandemic*. One of the twelve recommendations, incidentally, is utilizing small groups, reflection, and social media. Finally, as one of the interviewees points out, experimenting is important, too. Emergency online learning turned almost everyone into experimenters and the both the good and bad experiences should be examined.

Again, according to the survey, the most influential factor in tool selection is *faculty opinion*, first in terms of ease of use of the tools, but also their overall input and recommendations, thus fostering a process that bridges experimentation and implementation, offers space to explore, proper pedagogical, and technical support all are needed to help bolster developing an effective online learning environment.

## RECOMMENDATIONS FOR FUTURE STUDIES

Since this chapter revisits a study conducted before the COVID-19 pandemic, one recommendation is to re-run the survey itself to see if there are significant changes in how decision makers are currently thinking about tool selection. The impact of the pandemic could perhaps be seen in the types of tools given prominence, or if there is a change in how decision makers are thinking about the narrowness of the tool set offered. After the extensive experimentation in the wake of emergency online learning, it could be that previous concerns about support of tools has changed, or maybe that security concerns have grown.

Regarding conducting the survey and interviews, one obvious suggestion is to expand the number of subjects. This would provide more data for the analysis and likely expand on the findings. Additionally, focus so far has been solely on the administrator, so getting the opinion of faculty and students would add other voices to the mix. This could help place findings into a larger context. Within these three population groups, one would likely find a wealth of information that could help better inform and improve the setup of the teaching and learning environment for online programs.

Finally, it would be of interest to catalog and evaluate the different models of online learning to see if there is a suite of online platforms and tools best suited to a particular approach. While this study has begun exploring these models from an administrative perspective, this is an aspect that emerged during the course of the study.

## CONCLUSION

In looking back at the data gathered pre-pandemic on the opinions of decision makers in the online learning space and aligning the findings of some studies mid-pandemic, it is interesting to see how findings of ad-hoc approaches to emergency online learning efforts, in a sense, support the findings of many years of research on online learning approaches and its effectiveness.

Taking into consideration the warnings that emergency online learning is essentially different from planned, systematized online learning, there are nonetheless lessons to be learned that can be informative to the latter. Within these lessons, perhaps there are best practices to keep and poor ones to be avoided. These practices may be obvious to the seasoned online researcher, administrator, teacher, or student, but to the majority of participants who were pushed by circumstance into a world of online learning that they were underprepared for, these findings can be invaluable.

Additionally, it becomes clearer in retrospect, that the online learning tools themselves must support the pedagogy, and more actionable, well-constructed online learning frameworks are needed. Such frameworks could help guide decision makers in finding simple, effective tools that serve their faculties teaching and learning approaches better, offering a clear approach to selecting the tools and platforms that best support their institution's online learning environment.

## REFERENCES

Acquaro, P. E. (2017). *Investigation of the selection, implementation, and support of online learning tools in higher education* (Unpublished doctoral dissertation). Teachers College, Columbia University, New York, NY. Retrieved January 15, 2022 from: https://www.edtechdecisionmakinginhighered.org/edtech-research-papers

Acquaro, P. E. (2018). Investigation Into the Selection of Online Learning Platforms and Tools in Higher Education. In D. Mentor (Ed.), *Computer-Mediated Learning for Workforce Development* (pp. 150–167). IGI Global. doi:10.4018/978-1-5225-4111-0.ch008

Acquaro, P. E. (2020). Structuring and Scaffolding the Online Course. *International Journal of Online Graduate Education*, *3*(1), 1–16.

Allen, I. E., Seaman, J., Straut, T. T., & Poulin, R. (2016). *Online Report Card: Tracking Online Eucation in the United States*. Retrieved January 15, 2022 from: http://onlinelearningsurvey.com/reports/onlinereportcard.pdf

Bell, B., & Federman, J. (2013). E-learning in postsecondary education. *The Future of Children*, *23*(1), 165–185. doi:10.1353/foc.2013.0007 PMID:25522650

Boardman, K. L., Vargas, S. A., Cotler, J. L., & Burshteyn, D. (2021). Effects of Emergency Online Learning during COVID-19 Pandemic on Student Performance and Connectedness. *Information Systems Education Journal*, *19*(4), 23–36.

Bruns, A. (2009). *Blogs, Wikipedia, second life and beyond: From production to produsage*. Peter Lang.

Buckingham, D. (2003, Fall). Media Education and the End of the Critical Consumer. *Harvard Educational Review*, *73*(3), 309–327. doi:10.17763/haer.73.3.c149w3g81t381p67

Buraphadeja, V., & Dawson, K. (2008, July). Content Analysis in Computer-Mediated Communication: Analyzing Models for Assessing Critical Thinking Through the Lens of Social Constructivism. *American Journal of Distance Education*, *22*(3), 130–145. doi:10.1080/08923640802224568

Burbach, M., Matkin, G., & Fritz, S. (2004). Teaching critical thinking in an introductory leadership course utilizing active learning strategies: A confirmatory study. *College Student Journal*, *38*(3), 482–493.

Choy, S. C., & Cheah, P. K. (2009). Teacher Perceptions of Critical Thinking Among Students and its Influence on Higher Education. *International Journal on Teaching and Learning in Higher Education*, *20*(2), 198–206.

Dhawan, S. (2020). Online Learning: A Panacea in the Time of COVID-19 Crisis. *Journal of Educational Technology Systems*, *49*(1), 5–22. doi:10.1177/0047239520934018

Ebner, M., Schön, S., Braun, C., Ebner, M., Grigoriadis, Y., Haas, M., Leitner, P., & Taraghi, B. (2020). COVID-19 epidemic as E-learning boost? Chronological development and effects at an Austrian university against the background of the concept of "E-learning readiness." *Future Internet*, *12*(6).

Goh, P. S., & Sandars, J. (2020). A vision of the use of technology in medical education after the COVID-19 pandemic. *MedEdPublish*, *49*(9).

Harasim, L. (2017). *Learning theory and online technologies*. Taylor & Francis Group. doi:10.4324/9781315716831

Hodges, C., Moore, S., Lockee, B., Trust, T., & Bond, A. (2020). The difference between emergency remote teaching and online learning. *Educause Review*. Retrieved January 15, 2022 from: https://er.educause.edu/articles/2020/3/the-difference-between-emergency-remote-teaching-and-online-learning

Hollands, F. M., & Escueta, M. (2017). *EdTech decision-making in higher education*. Columbia University, Teachers College, Center for Benefit-Cost Studies of Education.

Kanuka, H. (2008). Understanding e-Learning Technologies-in-Practice through Philosophies-in-Practice. In T. Anderson & F. Elloumni (Eds.), *Theory and Practice of Online Learning*. Athabasca University Press.

Lowenthal, P. R. (2010). Social presence. In S. Dasgupta (Ed.), *Social computing: Concepts, methodologies, tools, and applications* (pp. 129–136). IGI Global. doi:10.4018/978-1-60566-984-7.ch011

McLoughlin, C., & Lee, M. (2007). Social software and participatory learning: Pedagogical choices with technology affordances in the Web 2.0 era. ICT: Providing choices for learners and learning. Proceedings ascilite Singapore 2007.

Meier, E. (2015). Beyond a Digital Status Quo: Re-conceptualizing Online Learning Opportunities. *Occasional Paper Series, 2015*(34).

Mirra, N., Morrell, E., & Filipiak, D. (2018). From Digital Consumption to Digital Invention: Toward a New Critical Theory and Practice of Multiliteracies. *Theory into Practice*, *57*(1), 12–19. doi:10.1080/00405841.2017.1390336

O'Reilly, T. (2005). *What is Web 2.0: Design Patterns and Business Models for the Next Generation of Software.* Retrieved from: http://www.oreillynet.com/lpt/a/6228

Oubenaissa, L., Giardina, M., & Battacharya, M. (2002). Designing a framework for the implementation of situated online, collaborative, problem-based activity: Operating within a local and multi-cultural learning context. *International Journal on E-Learning*, *1*(3), 41–46.

Rios, J. A., Ling, G., Pugh, R., Becker, D. M., & Bacall, A. N. (2020). Identifying critical 21st Century for workplace success: A content analysis of job advertisements. *Educational Researcher*, *49*(2), 80–89. doi:10.3102/0013189X19890600

Sandars, J., Correia, R., Dankbaar, M., de Jong, P., Goh, P., Hege, I., Masters, K., Oh, S., Patel, R., Premkumar, K., Webb, A., & Pusic, M. (2020). Twelve tips for rapidly migrating to online learning during the COVID-19 pandemic. *MedEdPublish*, 9.

Scardamalia, M. (2002). Collective cognitive responsibility for the advancement of knowledge. In B. Smith (Ed.), *Liberal education in a knowledge society* (pp. 67–98). Open Court.

Shaw, A. (2021). Teaching or Cheating? Using Collaboration and Technology to Support Student Learning. *International Journal on E-Learning*, *20*(1), 47–58.

Taylor, D., Grant, J., Hamdy, H., Grant, L., Marei, H., & Manda, V. (2020). Transformation to learning from a distance. *MedEdPublish*, *9*(76).

Tiruneh, D. T., De Cock, M., & Elen, J. (2018). Designing Learning Environments for Critical Thinking: Examining Effective Instructional Approaches. *International Journal of Science and Mathematics Education*, *16*(6), 1065–1089. doi:10.100710763-017-9829-z

Tredinnick, L. (2006). Web 2.0 and Business: A pointer to the intranets of the future? *Business Information Review*, *23*(4), 228–234. doi:10.1177/0266382106072239

Tsang, J., So, M., Chong, A., Lam, B., & Chu, A. (2021). Higher education during the pandemic: The predictive factors of learning effectiveness in covid-19 online learning. *Education Sciences*, *11*(8), 446. doi:10.3390/educsci11080446

WHO. (2020). *WHO Director-General's opening remarks at the media briefing on COVID-19*. Retrieved January 13, 2022 from: https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020

Woo, Y., & Reeves, T. (2019). Interaction in Asynchronous Web-Based Learning Environments: Strategies Supported by Educational Research. *Online Learning, 12*(3-4).

Xu, D., & Xu, Y. (2019). *The promises and limits of online higher education: Understanding how distance education affects access, cost, and quality.* American Enterprise Institute. Retrieved from https://www.aei.org/research-products/report/the-promises-and-limits-of-online-higher-education/

## KEY TERMS AND DEFINITIONS

**Collaborativism:** Is an approach to learning that utilizes social learning techniques, especially utilizing activities that require collaboration and communication between learner.

**Emergency Online Learning:** As a result of social distancing rules adopted in the wake of the COVID-19 pandemic, many educational institutions pivoted to providing courses online. The result was the sudden, ad-hoc nature of the resulting methods used by teachers and institutions to bring courses quickly online.

**Learning Management System:** Software applications for the administration, documentation, tracking, reporting and delivery of educational courses or training programs. LMS facilitate the delivery of instructional material to students, assists in the administration of assignments, quizzes, tests, and other activities, can track student progress, and manage data.

**Online Learning:** Courses offered by institutions that are conducted in a virtual space. Learners can engage with an academic institution in the traditional method of in person classes or through the virtual method computer mediated instruction. A blended-learning approach mixes in-person and online sessions.

**Online Learning Tool:** Software that student can use to work through ideas, concepts, or processes to create, perform, or respond to assignments and problems. LMS will often offer a collection of integrated online learning tools.

**Social Learning Theory:** The theory that people learn by observing others and explains how people learn new behaviors, values, and attitudes. The Internet offers ways to collaborate in learning despite being physically separated.

# Chapter 2
# Managing Work From Home With Young Children:
## A Realistic and Technology-Enhanced Guide

**Jamie L. Krenn**
*Teachers College, Columbia University, USA*

**Monica Miaoxia Chan**
*Teachers College, Columbia University, USA*

**Keying Wang**
*Teachers College, Columbia University, USA*

## ABSTRACT

*Whereas other chapters might provide information on how to work, in this chapter, readers might contemplate the question of what happens when working from home with young children. With the hectic pace of modern life, families unexpectedly or by choice are stressed, balancing parental duties and job tasks while working from home. Negative feelings in a work-from-home environment stem from the stresses of sudden space-sharing to maintain a career and young ones' developmental needs. As a result, young children might feel isolated and have a higher risk for mental health issues, perhaps from the shared space and reduced attentive care. This chapter connects work and daily child-related activities to create a more manageable work-from-home lifestyle. Readers will learn how to utilize cognitive, developmental, educational, and social psychologies and ecological theory in this often-turbulent environment. Any workforce can benefit from implementing these "attitude changing" suggestions into the home to benefit the well-being of working families.*

## INTRODUCTION

This chapter seeks to empower caregivers and parents (in the not-so-easy task) to pursue careers with-

DOI: 10.4018/978-1-6684-3996-8.ch002

out compromising parenthood. What does it mean to work from home in tandem with a child/children aged from birth to middle school? It means taking on the grand task of being a caretaker and educator while maintaining an occupation (and, let's face it, one's sanity). Thinking about this endeavor is an accomplishment. Those in one's life who know you well will either applaud you or think you are crazy. This chapter will empower caregivers and parents to pursue careers without compromising parenthood.

Conference calls and other online communication platforms are a way for many of us to stay connected to colleagues, share information, accomplish tasks, and learn from each other. A digital working environment supports the worker's ability to maintain a contributing force to varying occupations. This ability makes it much easier for families to be where they need to be during the early stages of childhood and when activities/development occur outside the home (i.e., school, playdates, extracurricular activities, etc.). This anytime, anywhere ability provides a workspace beyond the walls of an office (Crosbie & Moore, 2004; Toniolo-Barrios & Pitt, 2021; Narayanan, Menon, Plaisent, & Bernard, 2017).

Considerable research exists that working from home can be trying on both caregivers and families, especially during the pandemic that started in 2019 (Dunatchik et al., 2020; Martucci, 2021). Various sources support that while parents work from home, social and environmental effects are present (Viola & Nunes, 2021) that affect overall well-being (physical and mental health) (Campbell & Gavett, 2021) creates technological challenges (such as connectivity and shared device issues) (Walker, 2021) and, of course, affects sleep deprivation for all involved (Liu et al., 2021). In addition, there is evidence to suggest some effects on mothering and telecommuting (Peng & Wong, 2013) work-life balance (Hilbrecht et al., 2008) and screen time balance (Gold, 2014) were all difficult for those working at home prior to the challenges of the most recent pandemic. Traditionally, decades ago, mothers stayed at home and reared their children. While economic needs have shifted, so has the work culture. A redesign of sorts is happening in the home workspace that considers daily family needs more concretely during the day than ever before (Kane et al., 2021; Adisa et al., 2021). For example: Have a last-minute meeting? Parenting responsibilities now differ. Working from home with kids may mean having no sitter on hand, a partner busy with other work obligations, kids are off from school with nothing to occupy their time. What is a caregiver to do?

By reading this chapter, caregivers and parents can affirm a commitment to their children by making connections to their work and daily child-related activities, which at best can be a good future plan. They will also have information that will help create a quality work-from-home lifestyle that suits one's needs while building a support system for overall well-being.

This piece will also inform the reader about applying psychological theory to practical situations. Even if you don't have children, recommendations are present for self-care and time management that may benefit any worker.

To assist a modern workforce, recommendations on integrating work and childcare may boost caregiver confidence in working and parenting activities. This chapter seeks to:

- Show how to collaborate with other parents/coworkers to reinforce work-life-integration culture
- Build productivity into the work-from-home environment
- Train the brain to switch between the tasks of childcare and work
- Show the developmental benefits of working from home for children
- Provide short enrichment activities caregivers can do with their child to increase productivity

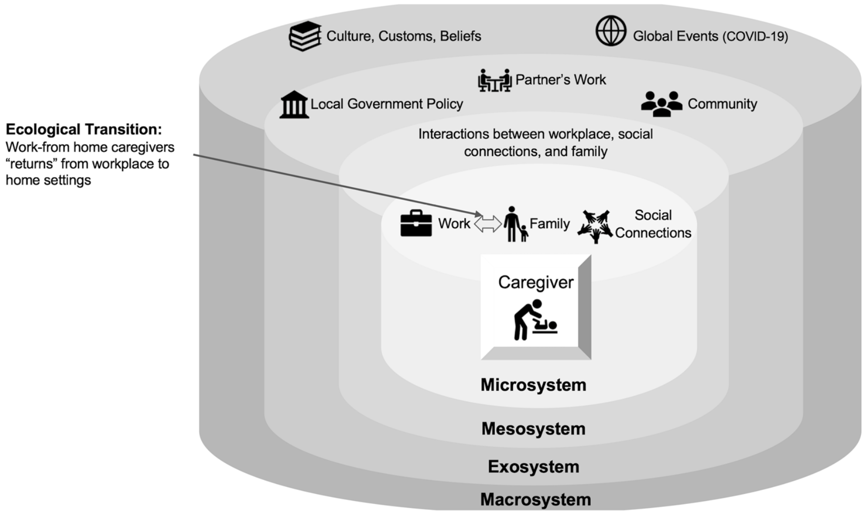
- Show you how to be more present and focused on each task
- Show how, when necessary, to make screen time a learning experience for your little ones; Interpretations of the American Academy of Pediatrics (AAP) screen-time recommendations during times of crisis; Use of quality media as a support system
- Provide recommendations for building a schedule that works
- Explain when one should ask for help as a work-from-home parent

The proposed recommendations are based on theories from Behaviorism, Constructionism, social connectedness (to children, work, and professional self and parent self), and cognitive development (for both caregivers & children). Additional information to be provided that can assist with parenting with young children during mandated stay-at-home times is the use of quality media as a support system and some useful everyday information based on the interpretations of the American Academy of Pediatrics (AAP) on the use of screen time during times of crisis. Finally, the use of Bronfenbrenner's ecological systems theory (1979) will make the case that the home is in and of itself an ecosystem with its internal exchanging members (families) and the environment surrounding them (digitally and in-person). Specifically, the theory will help explain the impact of merging working environments with family settings on both caregivers and children.

Bronfenbrenner's ecological systems theory (1979) suggests that an individual's development is influenced by multiple settings of the surrounding environment as well as the interrelationships among those settings (Bronfenbrenner, 1979). In this chapter, we view the microsystem as the parent's work, social connections as well as their activities, roles, and relationships within family settings; mesosystem as the interactions between work, social life, and child care; exosystem as the community, local government policy, and partner's work; and macrosystem as the culture of the country and international events such as the pandemic. As you can see in Figure 1, working from home may induce a merge between the work and the family setting because the parent's workplace is now located in the family environment. The fact that a parent "returns home" from the workplace could also be viewed as an ecological transition, which refers to a time when a person changes their role, setting, or both in the ecological environment. Although the transition is more of a physical change in terms of the location of the workplace, it results in a series of changes in the interactions between the parent's work, social connections, and child care (Fong & Iarocci, 2020; Uzun et al., 2021; Vaterlaus et al., 2021).

It is thus important for caregivers and parents to be aware of the changes in the interactions between their work, social life, and child care and then try to adapt to the changes (Donker & Branje, 2021; Schieman, Badawy, Milkie & Bierman, 2021). The current chapter provides hands-on recommendations for work-from-home parents to adapt to the changes to pursue their career goals while taking good care of their children. Throughout this chapter, there will be opportunities for the reader to reflect on their definition of working from home while raising a child or children. Using the writing prompts can give the reader a more realistic picture of what they want out of the experience while also organizing their thoughts on how to approach this endeavor. Finally, the benefits of journaling have often been shown to positively affect self-awareness and self-care (Coaston, 2017; Rudrum et al., 2022).

*Figure 1. Bronfenbrenner's ecological systems theory and the developing individual such as a caregiver during the pandemic*




## JOURNAL PROMPT

Journal prompts will be provided throughout the chapter. They are a means to have the reader think deeply about their own experiences working from home and what they hope to accomplish in the future as they make the ecological transition to home from work settings. By taking part in the exercises and returning to them from time to time, readers can keep their perspective on the challenges they face working from home with young children.

### Work-Life Balance and Integration

Having a positive attitude toward work-life situations is essential for maximizing productivity. Even during times of extreme pressure and anxiety, remember the answer to this question: "What about working from home do I *love* the most?" Often, we are overwhelmed by the many tasks thrown at us, that we fail to see the benefit of our situation. Reflection time will only improve the big picture when tasks are too many and time is too little.

It may be helpful to keep a journal or folder of the questions handy in the workspace. Even if you take a couple of minutes to reflect, it can set you up to have a better mindset than if you sit down harried from just getting everyone set up for their day before you think of your own (Marin & Rotondo, 2017; Inbar-Furst, Douglas, & Meadan, 2020). Start by focusing on the following questions:

#### What Does Work-Life Balance/Integration Mean to You?

Write a few lines, keep it handy, even display it on a post-it near one's workspace.

## Is One's Past Training Currently Beneficial in the Work-From-Home Environment?

You may have administrative experience that can help with organizing life. Being a parent means you have a certain amount of problem-solving skills and perhaps juggle many things at once. Use this thinking skill with adding work activities to the day.

## Imagine an Ideal Work-Life Scenario. Write it Down in A Few Sentences.

Quiet? Uninterrupted? Is that possible? Whatever you wish for, write down what you ideally want. Try to make it possible in small ways (i.e., quiet space = noise cancellation headphones or a sign on the door "Papa is planning" or "Momma is in a meeting!" or "Jane is juggling calls!" or "Uncle Lou is unavailable for 35 minutes!"

## Work From Home Self-Assessment (i.e., The Survey of Worries) View Appendix 1

Taking the self-assessment at the end of the chapter prior to reading the rest of the provided material will allow reflection on one's current work from home situation. This assessment is not meant to be done once, but rather something to re-take from time to time, but focus on what is important to you and the family.

For work-from-home parents, it is essential that they be aware of and reflect on their habits to be role models for their little ones. If you act flustered when you are interrupted during a project, they are going to emulate the same behaviors when they are also interrupted. Thinking about one's behavior will be helpful when working from home (Sadka et al., 2018; Buheji & Ahmed, 2020; Resttubog et al., 2020; Preuss et al., 2020). The survey found at the end of this chapter is not a psychological assessment but a method to record how one feels and bring one back to what is most important in one's work from home. It is for one to keep with throughout work-from-home sessions. Use it as often as you like, but it is recommended perhaps once-per week as you become adjusted.

## Thinking About One's Time

Finding time to focus on occupational duties while parenting is challenging for the mind and the body. There is no getting around a child's needs. It is important for a working parent to reflect on the type of task and the required thinking/awareness needed to complete it while balancing parenting and/or partner's schedule (Craig & Churchill, 2021). Below is a list of items that may challenge one's focused dedication to work time:

- Children's Schedules
- Children's School
- Meetings
- Independent Work
- Spouse's Work
- Living situation
- Designated Work Areas
- Internet Connectivity
- Rest/Break Areas

- Errands/House Management/Chores during the day/work time?
- Outdoor noise (from traffic, construction, etc.)
- Health conditions of the parent/partner/children

There are many aspects to manage as noted above while trying to work whether it is a large or small task. So it is important to keep in mind that you should not expect to finish massive projects in a single sitting. Many of these guidelines follow a "learning by doing" format—where you dive in without a script (*What is experiential learning?* Institute for Experiential Learning, 2021). Often, when you make a plan to work, it is a great starting point but will require edits more often than not. Thus, the first few times, keep expectations low. You might simply catch up on emails while children are milling about, have a few casual conversations with coworkers rather than focused attention on a presentation or giving a presentation, or even check off a few clients' phone calls. Larger projects, such as interviews, demonstrations, or training workshops, should be done or conducted at home during naps or in the early morning or evening hours if need be. They can also be done if you have a part-time caregiver available or a partner at home that has less on their plate on that given day. It isn't the schedule forever trying to fit in work that needs focused attention because as a work-from-home parent, there is a precedent established that juggling is the nature of one's time (Bezovski et al., 2021; Lopez-Leon et al., 2020; Lades, Kaffan, et al., 2020). Here are more helpful recommendations to follow when thinking about one's time:

### *Set Expectations Accordingly (With the Self and Others)*

Do some *micro project management*. Do NOT commit to 5 days' worth of work when you only have 5 hours a week. Be honest about how much you can accomplish in an hour. Perhaps do some trial tests to assess how much you can get done (e.g., I need 1 hour per day to respond to emails properly, 5 hours over the course of one week to create a 10-page report, etc.). Calculate how many hours you get in each work time period, then how many hours per week you get if you stick to that schedule. Do a little bit of project planning to see how much work you need to get done and compare it with how many hours you have in a morning, afternoon, day or working work or weekend. Start small and, if possible and one's economic circumstances allow for it, pay for additional hours of *babysitting* to add to those hours, as work needs become more demanding (this can be done after careful thought/comfort of the situation, of course). When sitters are not free, try having a video chat session with a loved one - for example, a Storytime with grandma for 60 minutes each day can be fun for kids.

### *Start Small*

Start by carving out at least 20 minutes per day (over one week) to focus on work. This number sounds small, but I find that low expectations get surpassed because when in the zone and making real progress, one always hits deadlines early, which boosts self-worth. Starting small and saying, "let's see what I can get done in 20 minutes!" by setting a time on a phone may provide surprise and relief that at least got started while accomplishing even a portion of a larger task.

### *Think About Rising Early*

Getting up early before kids may be difficult but starting a project or answering emails is a great way to spend the morning with a hot beverage of choice. Plus, you get clarity in thoughts from the silence. At the beginning of the day, extra time can be used to plan or mental checklists of tasks. This can be done either regularly or on an as-needed basis.

### *Work During nap Time/evenings*

Nap times are great for getting work done. Try to schedule a call at least 30 minutes after a child sleeps if they have trouble getting to sleep. Save the project and deadlines for focused attention here but know you can pick work again if needed later in the evening after bedtime. Try at best to save some “me time” at the end or the beginning of the day because this may be one’s only chance in the day for some self-care. And if doing dishes while listening to music makes “me time” better, go for it - if checking tasks off a list is preferable. Late evenings can be a time to work if you have a spouse/partner who can help put children to bed to provide you with more work time or some peace while they slumber. Single parents can also benefit from this peace by checking a few tasks off their list upon bedtime.

## JOURNAL PROMPT

## What Does it Mean to Have a Complete Play/Learning Area while at Work?

Thinking about what you have at home: think about what it means to have a place for children to play while attending to business. Something to keep in mind is creating a microsystem of the workplace and childcare at the same time. Things to consider are having the space open filled with activities that can captivate a child for several minutes between tasks. Using what you have at home is best and preparing this space for children’s enjoyment. You can use anything from toys to screens, crafting items, sensory tables, to name a few. The section following this journal activity will provide you with some things to keep in mind when selecting choice activities, as well as a few examples.

## What Are Three Ways to Create a Positive Learning and Work Environment?

Examples include but are not limited to specific activities with manipulatives, toys, digital applications, and particular activities that spark the imagination. Some ideas include: changing the furniture around to function for better flow in the workspace and living space, changing lighting with brighter/softer lights, or even having a tech-free zone/box to take a break from connectivity.

## In the Home—Building an Environment for Productivity

In this section, readers can learn more about how to make their surroundings at home more manageable for the chaos that is the workspace.

### *Think of the Home as a Learning/working Environment*

As a caregiver, one is an activity tool and a resource to children for the time being. It is important to set up a road for success, even if it isn’t perfect - that can be anything from an entire home office (with a door - WOW! Privacy!) to park under a kitchen table with pillows (it has been known to happen). If you have a dedicated workspace, you can go into it with the “I will get something done!” attitude and leave with "I accomplished that task!" joy. By having a place known for producing thought of work, you can train the mind to be productive in an ample, adequate, or less than stellar space. The good thing about working from home is that you can work anywhere. The bad thing about working from home is that you can work anywhere. "Was that a typo?" you ask. Well, in some ways, it is excellent to do so, due to the positives of more family time and reduced commuting, yet negative in that you may share space with other people and that space might have a multitude of purposes (Toniolo-Barrios & Pitt, 2021; Das et al., 2021). The following suggestions below will help you give rise to a more probable conducive working environment when you have young children:

1. Preparing before a Workday

Before the workday the following evening, prepare independent play and ill-structured project-based learning activities for the next day. These could be things like having videos (TV or mobile device) that are either static (simple streaming programs) or active (an online kid's yoga session directed to the audience). It might be helpful to make lunches and snacks as if you were dropping the kids off at an outside care facility. Why? When lunchtime hits, you are ready to feed the masses without staring at the fridge wondering what you make in under 15 minutes. By having a basket of activities, a few screen time possibilities, and food ready to go, you have fewer stressors and more time to get through the day with an adequate amount of time to focus on work tasks that require low to medium levels of attention (Restubog et al., 2020; Bezovski et al., 2021; Lopez-Leon et al., 2020).

2. Bring Out a Small Blanket or Mat with Arranged Toys, Coloring Books, and the Like near Where You Work or in an Office

Creating a small play area on the floor will let a child feel welcomed and part of the environment and provide them with their own space. Stock a reading book with books about healthy habits, play, science, mathematics, and literacy. Crafts, simply painting, drawing, sensory tables can work as well, or a few toys that promote pretend and building skills. Research also shows that having fewer toys rather than more available to children leads to more fruitful, more extended independent play (Dauch et al., 2018; Lottero-Perdue, 2019).

3. Have A Proper, Uncluttered Workstation Even if it's the Kitchen Table or Underneath it

Uncluttered in that you make sure you have folders dedicated to "currently working projects," either tangible or digital. It may help you feel more in control of the working space should you have a pencil cup with writing implements, sticky notes, a stand-up file organizer. These small steps can give you the feel of the office during work times. It also prevents you from messing up things and losing your place in essential projects. At the beginning of the workday, pull out "workstation" items and tuck them away at the end of the day. With a start and stop, you create physical boundaries through objects and movement, and these limitations are more likely to lead to balance (Phillps, 2020). This helps the mind from becoming blurred, which can frequently happen with other family activities and obligations. You may even want to consider having better lighting (purchase a brighter lamp to promote focus; a 30-minute hourglass to devote a visual image/progress timer).

4. Supervision of the Kids

By oneself and/or with a spouse/partner, one must decide how the care for children will work and manage the day accordingly. If you are lucky enough to hire a sitter in the home, find a quiet and productive space to do work. If kids are occupied with another human, one can get more accomplished. If you have a partner or spouse working from home, make sure that you set clear rules for the following type of instances:

- **Regular Day Items***:* Checking email, lunch breaks, dedicated work time that is not a formal meeting with colleagues.
- **Planned/Scheduled Items***:* Meetings with Colleagues, Training sessions, tests/exams/ presentations.
- **Last-Minute Items**: (Emergencies, last-minute scheduling, once-in-a-lifetime opportunity (you never know when you will get a call/email/text/carrier pigeon about a dream job!).

Each of you ought to start with a clear rule book of how this works, as there are meetings that require concentration and focus giving a presentation, for example) and those one can ping-pong one's attention to (checking/returning emails, for instance). Always check with one's partner in caregiving (if applicable) daily, weekly - hourly if necessary regarding who will provide more focus to meet child needs and who will only come to aid in an absolute emergency. An example of having more focus would be making lunch or helping with homework versus the emergency of a tree falling on the house during a windstorm.

If alone during the day, it may help to have this space very close to the child, either in a nearby room or somewhere visually accessible while sitting. Partners can work together and moderate needs in tandem while accomplishing things. If you are within an earshot of children, you will feel better about leaving them to play independently for a bit. More tips for the type of work to accomplish when you are alone during the day and behavior recommendations for kids to make the day a bit smoother for the both of you to come later in this chapter.

5. Remove Digital Devices and Hide Social Media Apps Deep in Folders on the Phone (s)

If necessary, in the workspace (but not on the work computer if you need them for digital networking), remove social media applications during working hours. Any checking, scrolling, or liking within the more popular sites will only steal valuable work time that can feel very limiting when trying to maintain a career and care for children. If you can, set aside dedicated time for these sites and only have a limited number of browser windows open at a time solely focused on work activities or work communications. The mind and work quality will benefit from this avoidance primarily as excessive use has been known to affect productivity and mental health (Priyadarshini et al., 2020; Orhan et al., 2021; Mark et al., 2017). Studies have shown that social media addiction negatively affects job performance through work-family balance, and self-regulation reduces the negative effect of social media addiction on mental health and work performance (Yu et al., 2018; Zivnuska et al., 2019; Khan et al., 2021). Instead, replace social media apps with productivity apps and tools, such as reminders, calendars, notes, and other office communication apps one's co-workers are using to communicate. It will help you stay connected and focused, even as you constantly multitask during the day.

## Becoming Mentally Disciplined

As with any other type of discipline, there are no shortcuts. The ability to focus on the chaos of home life is challenging as long as you forgive yourself and understand how these organizational and mental recommendations can benefit you and those around you. Here are some key skills that may help you work from home productively:

### *Train one's Brain to Switch Between Tasks and Capitalize on "Divided Attention Work"*

Divided Attention Work is referred to as "Ping-Pong Focus"—tasks you can quickly pick up and begin again (Rubinstein, Meyer & Evans, 2001). Client calls or quality work/reports may need early or late-hour work time. However, when you have children nearby, you can complete some of this work as it can be quickly put down and picked up again. The possibility of multitasking doesn't exist, but we can feel like we have a hold on having multiple projects in front of us and still feel we can accomplish smaller parts when time is provided (Xu, Kee & Mao, 2021).

### *Plan with a Categorized to-do List*

Do this by preparing the night before or early morning, depending on when focus level is best, so you are familiar with the day's flow and order of events. It is perfectly fine to have a list of to-dos near you during the day. By creating separate lists for work and home tasks, you can organize responsibilities into clear areas. It's hard to quantify the importance of a weekly conference call compared to joining one's child in an art activity. Creating separate lists will prioritize the categories, not rank those you care about the most (perhaps emotionally). By having lists in general, you can reward yourself mentally by seeing accomplishments and reduce the likelihood of forgetting items (Masicampo & Baumeister, 2011).

### *Capitalize on Small Increments of Time*

Any working person with lots to do can take advantage of 5 minutes. When spare moments materialize, use the time to accomplish a task. When you have "only got five minutes," sometimes you can surprise yourself with how much you can get done. On the flip side, when you are time-limited, say, "I will work on this task for just five minutes." Mentally, you will feel better carving out a few moments to focus. Sometimes, you also get "in the zone" and feel the need to keep working on that task at hand. By having a small achievable goal in the forefront of the mind, you are better able to provide positivity in smaller goals that are more likely to be accomplished (Gaskin & Skousen, 2016). If it helps, keep a notebook, or use a to-do list or notes function in a smart device to remember where you left off between each increment of time. This will allow you to get back "in the zone" more quickly and effectively.

### *Be Utterly Absorbed in the Current Task*

Try your best to forget about "parental guilt" at bay while working, and do not let upcoming deadlines bother you while you're engaged with child(ren). While easier said than done, simply keep in mind one cannot work on any task when you are away from "the workspace" you might as well focus on the loved ones! Practice compartmentalizing and putting the guilt out of your mind. By creating boundaries, blurred lines will be reduced as well as stressful thinking (Mark, Iqbal & Czerwinski, 2017).

Be more present and focused on each task by having some focus (as much as you can) on the body, mood, and self-awareness

The following recommendations will help you to concentrate on this area. As most of us know, if we do not take care of ourselves, those around us may feel the ill effects.

1. **Exercise:** Working out saved my sanity and self-esteem. It can only elevate mood and make home a happier place for all. No matter how athletic you are, find something to move the body, and get the blood flow l. Get the stroller out, go for a walk, help one's spouse/partner, or play with the kids for 20 minutes. Anything that can help move will lead to a higher likelihood of positive mental well-being and functioning in a better place (Lippi, Mattiuzzi & Sanchis-Gomar, 2020; Tomporowski & Pesce, 2019; Strasser & Fuchs, 2015; Limbers, McCollum, & Greenwood, 2020).
2. **Socialize:** Having meetings/playdates with friends that have children (or don't have children) is a helpful way to care for kids and talk to pals. A change of environment is always beneficial for the mood. Have a digital storytime if travel time is limited. It is also important for parents to socialize and build a support network to minimize caregiver burnout (Mikolajczak & Roskam, 2020).
3. **Sleep**: A person needs an optimal amount of sleep with a significant amount of wind-down time before going to bed (Paller, Creery & Schechtman, 2021). Going right to bed with a laptop is a recipe for problems and tasks that have not been worked out in the head, eventually invading dreams and reducing the possibility of quality rest. Make that a goal most nights – at times, you will be guilty of working late. There are days when this does not happen. Follow an 80/20 rule of devoting time to sleep vs. late nights, and one should have happier days. It means the majority of time is spent on goal/mission, while the minority percentage of time is where you forgive yourself or unexpected things occur (Vaccaro, 2000; Neill & Bowen, 2021; Fernandes, 2021).
4. **Limit distractions.** Social media, returning emails, watching television, etc., while seeking to accomplish other tasks, like paying attention to the kids or a colleague on a call, only limits attention to the task at hand. You aren't doing yourself any favors by doing two things simultaneously, because as research notes, this process is impossible (Rubinstien, Meye & Evans, 2001).
5. **Clean up.** Reduce the clutter in the brain by reducing the chaos around you. Cleaning a workspace gives you a clean slate each morning to start the day so you can focus on one task at a time. Single-minded focus will make you a more efficient worker and a more attentive parent. A study done by Saxbe and Repetti (2010) showed that women with stressful home environments showed increased depressive mood and cortisol levels while women with restful home environments showed decreased depressive mood and cortisol level over three workdays.
6. **Thinking about thinking**. This concept is called "metacognition," meaning awareness of one's thought processes which includes relationships with others (Aldahadha, 2021). The influence of the home environment can weigh on mental health (Peltz, Daks & Rogge, 2020), it is important to determine where one's stressors are of the highest potency. Having an idea of what needs to be adjusted to maximize one's needs as a worker and caregiver will positively affect energy and sleep quality. Start by making a list of what you must accomplish in a general way each day and then pair that with a reflection on one's energy, mood, and anxiety levels. You may find readjusting a day to mirror a positive mood/higher energy level will suit you and a family's well-being in the long run (Russell et al., 2021). One help thinking is to engage in mindfulness activities - no matter how brief.

## Mindfulness Activity: Engaging Physical Senses [2-5 Minutes]

Free yourself from distraction for a short time as you read this chapter. It only takes a few minutes to complete. Keep in mind that this type of pause in the day will be helpful when you have a sense of being overwhelmed, and the five minutes away from work will provide more benefit than if you continue to stress about the day (Cheng, Croarkin & Lee, 2019; Coastworth et al., 2014).

- ***Inhale*** deeply, filling the lungs with air. Bring the air into the abdomen, not just the chest. Count slowly to five as you inhale.
- ***Exhale*** deeply, emptying the lungs. Again, count slowly to five as you exhale. As you exhale, release tension from the muscles.
- ***Continue*** to inhale and exhale deeply five more times, counting slowly to five each time. Concentrate on breathing and counting. Let the mind take a break from distractions. If necessary, remove yourself from the room while children are in a safe environment to give the brain a bit of peace for a brief moment. This small relaxation technique allows our brains to come back to the present rather than lost in thought. Doing this each day will provide you with a moment of peace.

## JOURNAL PROMPT_

### How do Your Kids React when You're Sitting Down to Work? [Takes About 5 Minutes]

What are your children's reactions when on a phone or other electronic device? Reflect on their children's behavior when you have to answer an email or talk on the phone.

## How Can You Help Your Kid(s) Help you?

Teaching children how to work with one's work schedule is key to successful work-life integration (Chung, Chan, Lanier & Wong, 2020). After all, they are the most substantial stakeholders in this massive feat after you. Here are some tips:

### *Use and Encourage Proactive Verbalizing*

Tell them what to expect. Sometimes, we forget to do the seemingly most straightforward things. Transitioning attention away from them for a while is contrary to the present and focused parent you wish to be. As much as you can, reframe a situation during working hours as kids vs. coworkers, clients, students, etc. Help the child to learn effective ways of getting attention. Encourage an "excuse me" or a non-verbal gesture. That way, they know you heard/saw them in need and will get to them as soon as you can. A practical non-verbal example is highlighted below:

*Hand on Top of Hand:* If a child needs attention, teach them to put their hand on top of yours and wait. You then place your hand on top of theirs for a few beats. This signals you are aware they need help. It also says you will be there as soon as you can. Then, they can go back to what they were doing until you are free to devote attention.

### *Start with Small-Time Increments of 1 to 2 Minutes, then Gradually Increase*

As with anything else, change for children can be difficult. When you start working on small projects and directing attention to a child repeatedly, back and forth, they eventually realize that you are busy and are likely to return attention to them when you are finished/free.

### *Provide Non-Food Prizes and Privileges Such as Kind Behaviors*

For example, offer coupons, listen to music, read a favorite story during free play time, a chance to be daddy's or grandma's work helper, or even offer extra pencils, stickers, art supplies, or small toys (Halbeisen & Walther, 2021; Bartan, 2020).

### *Hide the Phone*

If nothing is urgent, stick phones under a mattress when playing with kids. Turn up the ringers for those emergency phone calls. You can even have a different ringtone for your spouse, your boss, and other emergency numbers and set a phone silent for a while when you are off the clock to focus on your kids.

### *Give Your Kids Open-Ended, Ill-Structured Projects*

Project-based learning is a great way to engage kids in interdisciplinary topics and explore self-directed learning. Project-based learning could include a blend of digital and physical technologies, crafts, and design. Still, typically kids are guided with an overall scope or theme or problem that they are trying to solve. Stemming from the learning theories Constructivism (Piaget, 1970) and Constructionism (Papert, 1980), maker/STEAM education emphasizes making personally relevant projects – an aspect crucial to supporting interests for kids and youth of diverse backgrounds (Blikstein, 2013b).

### *Give Your Kids the Agency*

Have your kids direct how they want to approach the project or solve the problem and schedule a time to brainstorm independently or with their siblings (if their ages are close) before they ask you for ideas or directions. This gives you time to leave them to "work" while you work at home—Foster independent play. Help your kids help you. Help them develop an interest in playing by themselves, as this helps while you answer emails or begin a report draft. Novice makers may need scaffolded support to realize products with different materials and electronic tools, an educational process, which, for the most part, has taken place face-to-face in physical makerspaces located in libraries, schools, or community centers. At home, you could assign a sibling to be the facilitator for support, to help them learn to support one another so that resorting to you as the adult becomes a last resort.

### *Involve Your Child in an Activity They Enjoy*

Once the child is fully engaged, slowly move a few feet away or pick up a magazine. When they give you the toy, simply give it back with cheerful banter and a smile, and continue reading/working. Surrounding them with their favorite toys will merely overwhelm the child. Instead, structure their activities by presenting them one at a time in a sequence. Keep most playthings in another room and bring some out for short sessions. When they lose interest in an activity/toy, reengage them with questions. If they are playing with a car, for example, engage in talking while continuing an activity, but don't get directly involved. You might say, "Wow! You lined up four cars. Can you take one away?" Usually, this type of support is all the help children need from a safe distance. Never say no to a request for help, but ask lots of questions and assist as minimally as possible. For example:

*Child: "I want to build."*

*Parent: "What would you like to build?"*

*Child: "I want to make a house."*

*Parent: "You have the orange and green blocks. What block will you use next?"*

*Child: "This one!"*

*Parent: "Okay, let's see how you'll place that orange one on top of the green."*

### *Cycle Through Play Choices*

Initial attempts may yield only a few minutes before a child needs something. Don't respond instantly. Give them a chance to work things out by themselves for a brief period. Engage with them actively with activities and be fully present during allotted times to provide kids with feedback and guidance on their projects. Having a balance is also about choosing activities with the right amount of play, physical movement (when necessary), and fun. Older children can talk to you about what they like and don't like. You can use contact comfort, gestures, or positive emotional expressions for younger children to learn what they want and don't. For pre-language youngsters, it is excellent to smile, talk, sing, and laugh with them as much as possible.

### *For Maker Projects, Celebrate Errors, Failures, and Iterations*

Something not working right is part and parcel of the process of making (Bevan, 2017; Maltese, Simpson & Anderson, 2018). Although children may feel frustrated or demotivated, these are important moments of reflection when prompting children with questions such as "what didn't go as expected?" and "what would you change if we were to build this again?" will trigger them to be persistent, rethink specific steps and methodologies and be creative for their next attempt (Ryoo & Kekelis, 2018). Below are some examples of other activities that can help you at home organized by specific topics.

### *Example Activities and Maker Projects for Home Use*

- *Arts*: Set out an ice cube tray with watered-down paint. Have children finger-paint on paper plates, swirls, and rainbow colors. Many groups exist on social media that provide helpful at-home activities. Knowing a child's interest and taking stock of what can be found at home is a good idea week to week when planning for a few activities to keep them busy at a moment's notice. Some ideas include creating sensory tables, clay stations, block building challenges, or a "bored basket" filled with simple items you can pick up craft or discount stores (only bring out the "bored basket" during times when you are out of ideas. It keeps its contents novel and exciting).
- *Food relationships*: Have a child help make a salad for dinner by tearing, chopping (with child-safe knives if age appropriate), or shaking ingredients in small bottles for dressing. Create shop-

ping lists with new food vocabulary learned; read poetry about food, eating, and cooking; have children write "all about me" sentences about making healthy food choices and physical activities. For example, "My favorite fruit is a banana. Mom's favorite vegetable is kale. I like to run."

- *Social life skills (interactions & emotions)*: Role-play situations where you meet a new person, go to the post office or shop for groceries. Pretending to play with caregivers is positively related to children's emotional regulation (Galyer & Evans, 2001). Talk to kids as they are watching their favorite show to help them understand different emotions and interactions they may have outside the home with others. Listen to different kid songs and act out the lyrics to help them understand new vocabulary while relating them to facial and body gestures.
- *Free play/exploration:* Put out toys with various textures, shapes, and sizes. See what you can build or hide some toys around the room and have your kids go on a "hunt;" use blocks or other manipulatives to count, sort, or build. By touching objects and counting, children can understand concepts based on seeing and feeling; ask children about the healthy food they like and graph the results (Fromberg & Bergen, 2015). They can draw and color in the graph after counting how many people like pears or peaches or play "hide & find" games using colored shapes on cards. Have children be on the lookout for the "purple circle."
- *Science [elementary to middle school]:* Make a 3D COVID-19 model out of recycled materials to learn its parts and educate others about how the COVID-19 virus spreads. What kinds of scientific phenomena take place?
- *Math (middle school):* At the start of the pandemic, the number of COVID-19 cases in a city doubled every day. What data is there on the number of COVID-19 instances over the past few months? How could you construct a mathematical model using this data? What does this mathematical model tell you about the spread and latency of COVID-19?
- *Science, Technology, Engineering, Arts, and Mathematics (STEAM):* There are a variety of STEAM kits in the market, such as Kiwi Crate, MEL Science, Ozobot, LittleBits, LightUp AR, and more. As a parent, you could consider investing in one or more of these kits for your children. These STEAM kits promote creative experiential learning and some come with guides that children can use when making with tools provided in the kits. For supervised play, provide your child with agency on structures or games they want to build, and discuss with them science, math or art concepts that may emerge.

## When Necessary, Use Screen Time as A Learning Experience (18 mo.+)

The American Academy of Child and Adolescent Psychiatry (AACAP) suggests no screen time for infants under 18 months except for video chatting with an adult such as grandma who lives out of town (AACAP, 2020). They also suggest minimal and high-quality screen time (e.g., watching educational programs) with a caregiver for 18- and 24-months, about 1 hour of non-educational screen time per weekday and 3 hours on the weekend days for children aged between 2 to 5, and no specific time limits on screen time for children ages six and older. However, since the COVID-19 significantly impacts families and keeps children at home, the American Academy of Pediatrics (AAP) points out that while limits on screen time are still necessary, it is unavoidable that children's screen time will increase during the unprecedented period of staying home as their caregivers are struggling with balancing their work and childcare responsibilities (AAP, 2020). The situation closely relates to the microsystem model due to work and childcare present in the same setting - an instance where screen time can overlap. A potential reason for the increasing screen time is that children are more likely to rely on online social networking to connect with family members and their friends during the pandemic (Singh & Balhara, 2021). Moreover, the remote learning situation also increases the amount of time children spend on looking at a screen. Therefore, there is a need to differentiate the purposes of different kinds of screen time. The specific amount of screen time other than learning and social networking you use is a family decision; however, when it's necessary, instead of feeling guilty, try to make screen time a learning experience rather than using it as a cheap "babysitter." The following section summarizes both recommendations and caveats about screen time usage.

### Select Appropriate Content and Discuss it With Children

Content should be chosen based on a child's current stage of development. The appropriateness of language, dramatic themes, and humor are things to consider. Furthermore, content within a television program is an opportunity to talk about various exciting aspects of our enormous world. Asking questions is always helpful during television viewing. Avoid "static viewing" by responding to questions if characters address the audience. Parents as co-viewers can explain what is happening on the screen by pointing to exciting objects or asking the child if they like what they see on screen.

### What if Co-Viewing is Unavailable?

When coviewing is hard to achieve, it is still a good idea to select programs where the TV characters look at the audience, ask direct questions, and invite the audience to play games. Such features can motivate children to pay more attention to the on-screen material and promote learning (Troseth et al., 2016; Crawley et al., 1999; Krcmar & Cingel, 2017; Piotrowki et al., 2014). Some examples include *Dora the Explorer, Blue's Clues and You!, Super Why!, Daniel Tiger's Neighborhood, Little Einsteins*. In addition, it is natural that kids are attracted to fantastical content on-screen, such as a talking sun and someone walking in the sky. Children can still benefit from watching fantastical television programs as long as the impossible events are combined with realistic educational messages such as using a tape to fix a hole on a canvas on a boat - at least the function of the tape is real! (Richert & Schlesinger, 2016; Bonus, 2019). However, it is worth noticing that a child's ability to distinguish fantasy from the realistic educational content on-screen is important to their learning and transfer (Mares & Sivakumar, 2014; Bonus & Mares, 2019). It is possible that children have to be familiar with the subject area in reality (such as the basic rules of Physics) to critically assess the impossible events (such as walking on the wall) (Hopkins & Lillard, 2021).

### Be Humorous While Watching Children's TV or Any Other Technology

When grown-ups giggle, it is due to something being funny. Surprisingly, preschoolers mimic the laughter of adults. Two- and three-year-olds are prone to copycat laughter, which is a typical display of modeling as learning from adults in their environment. Things that preschoolers find funny are often impossible or inappropriate. Anything that goes against what children consider routine and predictable can trigger their sense of humor (Krenn, 2015; Simons, 2013). A wrong word or funny sound in responding to a character's onscreen question might get a little snicker, which then opens to a smile, which leads to a reciprocal bond. Yes! Give an incorrect answer! Bonding while playing has been shown to promote strong relationships and encourage healthy development (Krenn, 2015; Milteer et al., 2012).

### *Involvement is a Key Factor Determining What a Child Understands After Viewing Children's TV or Any Other Technology*

Children sometimes see things outside the home. Parents can only control factors to a certain degree, especially today, and peers are evermore a factor in media consumption. Parents and children ought to view media as an enriching experience with proper guidelines and information. If your child has questions about something they have seen outside the home, always discuss their uneasiness or confusion.

### *Try Your Best to Limit Screen Access to About Two Hours Per Day, According to Guidelines Recommended by the American Academy of Pediatrics*

Most young viewers will want to watch for hours on end. The pandemic also fostered problematic media use as parents became less restrictive and less able to monitor their kids' screen media use during the chaotic time (Eales et al., 2021). Remember that television viewing is a privilege and not an all-day activity or replacement for reading or other supplementary educational activities (Krenn, 2016; Managing Media: We Need a Plan, 2013). Screen time is an opportunity for you to get some much-needed tasks checked off a list, and it is okay to do so if you stay within the screen time limits and monitor the selection of applications, or it will facilitate and maintain the child's problematic media use (Domoff et al., 2020).

### *Television is Not a Full-Time Caregiver*

The challenge for parents is not to use TV as a substitute babysitter. Since children become enthralled with a show, it's understandable why parents would want to opportunistically use viewing time to give themselves a short break or focus on work. It is important to be aware of the benefits and limitations of television viewing on children's learning. It is worth noting that educational messages embedded in television programs facilitate neural activities in children's brain regions that play a role in processing the information. Cantlon and Li did a study (2013) that suggested that the brain region (intraparietal sulcus) associated with basic numerical cognition showed a significantly greater response when children watched numerical portions of a video from *Sesame Street* than when they were watching other parts of the video. However, neurobiological evidence suggests that animation may induce a bias toward visual perception and thus may not provide effective scaffolding to support children's learning from the on-screen material (Hutton et al., 2020).

### *Selecting Beneficial (and fun!) Media*

The biggest challenge most educational technology developers face is not to cognitively overload users with an array of information (Huber et al., 2018). When selecting apps, video games, or programs, look for video tutorials and parent reviews. One highly recommended reviewer of quality artifacts is Common Sense Media: https://www.commonsensemedia.org. All caregivers want to provide a learning experience that ensures as much retention as possible while kids look for the most fun and excitement. It can be challenging to find a balance between the two. This can now be accomplished in several ways and applied to any technology (Dias & Brito, 2021; Lee, 2015b) - by being cognizant of pace and the information provided so that children are not overwhelmed by their digital experiences. Below are helpful recommendations:

- Allow children to explore and play a tutorial level at their own pace and on their computer, tablet, or smartphone device with supervision in the first few levels, minutes, etc.
- Look for embedded in-game textual information about how to play (e.g., controls, direction, etc.). Even if you don't understand the rules, at least help a child find them, read them together and figure it out.
- If possible, provide physical printouts of controls. If you have something nearby or even write something on scrap paper to remember at first, it would be easier than moving back and forth between screens.
- Listening for verbal cues, attention checks, pausing for progress enhances learning. If they can talk through the game's mechanics, they can understand the processes.
- Provide feedback on student progress (e.g., constructing, placement of actual and virtual manipulatives, etc.).
- Be mindful of age-appropriate content before downloading/purchasing. Most companies will provide recommendations for age-appropriate use before buying. It is also an excellent idea to co-view/play with a child, so they can ask you questions regarding any content that is confusing or beyond their maturity level.

## When to Ask for Help?

We try to be self-aware, but we all need a reminder sometimes. In times of crisis, it is always optimal to take care of yourself as best as possible so that you can take care of others (Fiebig et al., 2020). Here are some signs you may need some help listed below. This list is not exhaustive, but it highlights those specific to the working from home situation.

When you feel overwhelmed, the difference between a healthy and unhealthy level of being overwhelmed can be subjective.

- When you are unable to make deadlines regularly.
- When you are happy/relieved, your kids get sick, so you can focus on work as they just lie in bed recovering with little to ask of you.
- When you use your kids as excuses for not meeting goals when you are just too tired to do little else.
- When you are spending many nights working late in a row with little energy left for the daytime.
- You are forgoing/postponing personal care tasks. You are not feeling "yourself" because you haven't had the chance to wash your hair or exercise for over a week or perform whatever habits matter to you personally for the betterment of mental health.

## JOURNAL PROMPT

### Write Down at least Five Tangible Things You Can do Differently to be Effective Work-from-Home Caregivers

Collaborate with other parents and colleagues to create a checklist of things you can do together or collect the ideas and share with other work-from-home parents. There's no harm in networking with other parents! Creating a supportive and healthy learning environment can be healthy and positive for home workers.

## CONCLUSION

It must be difficult for parents/caregivers to adapt to the series of changes due to the "ecological transition" from workplace to the home setting and the subsequently merged work and family environments. Take a little time per day to reflect on what you have accomplished - it could be work, childcare, and self-care. Give yourself a big hand, and think about what you plan to do tomorrow. To make limited work time more efficient at home, prepare a workstation to focus on the business while preparing a play area for children to explore freely. It is challenging to work at home, even with a clear-cut workspace. Thus it is important to "discipline" the mind and focus on one task at a time. In addition, you can help yourself by helping kids learn to work with your schedule. There is also an option to use screen time as a learning experience for your kids and a working time for yourself to keep track of the time limits and supervision of the content on-screen. With the recommendations presented, anyone can feel more secure in finding a good balance of fun and learning with media. Finally, it is always a good idea to ask someone for help. Talk with other work-from-home caregivers. It doesn't have to be strictly about kids. It can be about work! Build a community to know each other more deeply.

Working from home with children creates an ever-growing buzz among employers and caregivers; all will need the information to understand this new (sometimes chaotic) environment. It is hoped that employees will then ask their supervisors for support or guidance and find an organization day-to-day that will benefit all. Additionally, it is hoped that these recommendations will break new ground in work-from-home culture. It is anticipated that this chapter may be the first step in contributing to family work-life balance education through cognitive and developmental psychology lenses.

The following questions can help administrators guide workroom home caregivers:

- Are supervisors supported with non-typical 9-5 working hours?
- Do caregivers have sufficient support?
- Are supervisors aware of how employees balance their days? And, if so, how can they support employees so that self-care and productivity can be balanced?
- If using a combination of working from home can make life more pleasant and less stressful, is it not crucial for supervisors to incorporate working from home education/training into office culture?

## ACKNOWLEDGMENT

Dr. Jamie Krenn would like to acknowledge Monica Miaoxia Chan and Keying Wang for their help in writing, thinking, and support. Dr. Krenn, who works from home with a kid, found it challenging to balance caregiving and occupational responsibilities. Thus, she reached out to two competent, hard-working, talented, and thoughtful graduate students who attend Teachers College, Columbia University to assist and rightly earned authorship on this piece. They both immensely helped make sense of what it means to work from home as a parent in today's changing times. Finally, to Emma Krenn (9-years-old) who helped with her good humor and smiles in the chaos of working from home while parenting.

## REFERENCES

Adisa, T. A., Aiyenitaju, O., & Adekoya, O. D. (2021). The work–family balance of British working women during the COVID-19 pandemic. *Journal of Work-Applied Management*, *13*(2), 241–260. doi:10.1108/JWAM-07-2020-0036

Aldahadha, B. (2021). Metacognition, mindfulness attention awareness, and their relationships with depression and anxiety. *Journal of Rational-Emotive & Cognitive-Behavior Therapy*, *39*(2), 183–200. doi:10.100710942-020-00367-y

American Academy of Child and Adolescent Psychiatry. (2020, February). *Screen time and children*. https://www.aacap.org/AACAP/Families_and_Youth/Facts_for_Families/FFF-Guide/Children-And-Watching-TV-054.aspx

American Academy of Pediatrics. (2020, March 17). *AAP: Finding ways to keep children occupied and during these challenging times*. https://www.aap.org/en/news-room/news-releases/aap/2020/aap-finding-ways-to-keep-children-occupied-during-these-challenging-times/

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Prentice Hall.

Bartan, M. (2020). Preschool Teachers' Informal Learning Behaviors. *Journal of Education and Future*, (18), 17–27.

Bevan, B. (2017). The promise and the promises of making in science education. *Studies in Science Education*, *53*(1), 75–103. doi:10.1080/03057267.2016.1275380

Bezovski, Z., Temjanovski, R., & Sofijanova, E. (2021). Telecommuting best practices prior and during the COVID-19 pandemic. *Journal of Economics*, *6*, 85–100. doi:10.46763/JOE2160085b

Buheji, M., & Ahmed, D. (2020). Optimising Empathy in Dealing with Complex Problems during Challenging Times-The Case of Mariam & Empathetic Parenting. *International Journal of Management*, *11*(11).

Cheng, K. S., Croarkin, P. E., & Lee, P. F. (2019). Heart rate variability of various video-aided mindful deep breathing durations and its impact on depression, anxiety, and stress symptom severity. *Mindfulness*, *10*(10), 2082–2094. doi:10.100712671-019-01178-8

Chung, G., Chan, X., Lanier, P., & Ju, P. W. Y. (2020, June 25). Associations between work-family balance, parenting stress, and marital conflicts during COVID-19 pandemic in singapore. doi:10.31219/osf.io/nz9s8osf.io/nz9s8

Coaston, S. C. (2017). Self-Care through Self-Compassion: A Balm for Burnout. *The Professional Counselor*, *7*(3), 285–297. doi:10.15241cc.7.3.285

Coatsworth, J. D., Duncan, L. G., Berrena, E., Bamberger, K. T., Loeschinger, D., Greenberg, M. T., & Nix, R. L. (2014). The Mindfulness-enhanced Strengthening Families Program: Integrating brief mindfulness activities and parent training within an evidence-based prevention program. *New Directions for Youth Development*, *2014*(142), 45–58. doi:10.1002/yd.20096 PMID:25100494

Craig, L., & Churchill, B. (2021). Dual-earner parent couples' work and care during COVID-19. *Gender, Work and Organization*, *28*(S1), 66–79. doi:10.1111/gwao.12497 PMID:32837023

Crosbie, T., & Moore, J. (2004). Work–life balance and working from home. *Social Policy and Society*, *3*(3), 223–233. doi:10.1017/S1474746404001733

Das, M., Tang, J., Ringland, K. E., & Piper, A. M. (2021). Towards Accessible Remote Work: Understanding Work-from-Home Practices of Neurodivergent Professionals. *Proceedings of the ACM on Human-Computer Interaction, 5*(CSCW1), 1-30. 10.1145/3449282

Dauch, C., Imwalle, M., Ocasio, B., & Metz, A. E. (2018). The influence of the number of toys in the environment on toddlers' play. *Infant Behavior and Development*, *50*, 78–87. doi:10.1016/j.infbeh.2017.11.005 PMID:29190457

Dias, P., & Brito, R. (2021). Criteria for selecting apps: Debating the perceptions of young children, parents and industry stakeholders. *Computers & Education*, *165*, 104134. doi:10.1016/j.compedu.2021.104134

Domoff, S. E., Borgen, A. L., & Radesky, J. S. (2020). Interactional theory of childhood problematic media use. *Human Behavior and Emerging Technologies*, *2*(4), 343–353. doi:10.1002/hbe2.217

Donker, M. H., Mastrotheodoros, S., & Branje, S. (2021). Development of parent-adolescent relationships during the COVID-19 pandemic: The role of stress and coping. *Developmental Psychology*, *57*(10), 1611–1622. doi:10.1037/dev0001212 PMID:34807684

Fernandes, T. (2021, February 24). *How you can apply the 80/20 rule in your life and work*. Medium. Retrieved January 10, 2022, from https://medium.com/pm101/how-you-can-apply-the-80-20-rule-in-your-life-and-work-7d094a78e136

Fiebig, J. H., Gould, E. R., Ming, S., & Watson, R. A. (2020). An Invitation to Act on the Value of Self-Care: Being a whole person in all that you do. *Behavior Analysis in Practice*, *13*(3), 1–9. doi:10.100740617-020-00442-x PMID:32837703

Fromberg, D. P., & Bergen, D. (2006). *Play from birth to twelve: Contexts, perspectives, and meanings*. Routledge.

Galyer, K. T., & Evans, I. M. (2001). Pretend play and the development of emotion regulation in preschool children. *Early Child Development and Care*, *166*(1), 93–108. doi:10.1080/0300443011660108

Gaskin, J. E., & Skousen, T. (2016). Time-chunking and hyper-refocusing in a digitally-enabled workplace: Six forms of knowledge workers. *Frontiers in Psychology*, *7*, 1627. doi:10.3389/fpsyg.2016.01627 PMID:27822193

Halbeisen, G., & Walther, E. (2021). How to promote healthy eating in preschool children: Evidence from an associative conditioning procedure with non-food stimuli. *Appetite*, *166*, 105472. doi:10.1016/j.appet.2021.105472 PMID:34153424

Huber, B., Yeates, M., Meyer, D., Fleckhammer, L., & Kaufman, J. (2018). The effects of screen media content on young children's executive functioning. *Journal of Experimental Child Psychology*, *170*, 72–85. doi:10.1016/j.jecp.2018.01.006 PMID:29448235

Inbar-Furst, H., Douglas, S. N., & Meadan, H. (2020). Promoting caregiver coaching practices within early intervention: Reflection and feedback. *Early Childhood Education Journal*, *48*(1), 21–27. doi:10.100710643-019-00980-2

Kane, G. C., Nanda, R., Phillips, A., & Copulsky, J. (2021). Redesigning the Post-Pandemic Workplace. *MIT Sloan Management Review*, *62*(3), 12–14.

Krenn, J. (2015, June 10). *Appisode Applications: Tips & Developmental Recommendations for Disney, Jr.'s Interactive Entertainment* [Web log post]. Retrieved from https://www.psychologytoday.com/blog/screen-time/201506/appisode-applications

Krenn, J. (2015, August 18). *Humor, Screens & Children: Understanding a child's humor as stages applies to their programming* [Web log post]. Retrieved from https://www.psychologytoday.com/blog/screen-time/201508/humor-screens-children

Krenn, J. (2015, October 2). *New Screen Suggestions by The American Academy of Pediatrics. Insights as a media professor and parent* [Web log post]. Retrieved from https://www.psychologytoday.com/blog/screen-time/201510/new-screen-suggestions-the-american-academy-pediatrics

Lades, L. K., Laffan, K., Daly, M., & Delaney, L. (2020). Daily emotional well-being during the COVID-19 pandemic. *British Journal of Health Psychology*, *25*(4), 902–911. doi:10.1111/bjhp.12450 PMID:32573074

Lee, L. (2015b). Technology play and learning. In D. P. Fromberg & D. Bergen (Eds.), *Play from birth to twelve: Contexts, perspectives, and meanings* (pp. 217–224). Routledge.

Limbers, C. A., McCollum, C., & Greenwood, E. (2020). Physical activity moderates the association between parenting stress and quality of life in working mothers during the COVID-19 pandemic. *Mental Health and Physical Activity*, *19*, 100358. doi:10.1016/j.mhpa.2020.100358 PMID:33072187

Lippi, G., Mattiuzzi, C., & Sanchis-Gomar, F. (2020). Updated overview on interplay between physical exercise, neurotrophins, and cognitive function in humans. *Journal of Sport and Health Science*, *9*(1), 74–81. doi:10.1016/j.jshs.2019.07.012 PMID:31921482

Lopez-Leon, S., Forero, D. A., & Ruiz-Díaz, P. (2020). Recommendations for working from home during the COVID-19 pandemic (and beyond). *Work (Reading, Mass.)*, *66*(2), 371–375. doi:10.3233/WOR-203187 PMID:32568161

Lottero-Perdue, P. S. (2019). Engaging young children in engineering design: Encouraging them to think, create, try and try again. In *STEM in Early Childhood Education* (pp. 99–117). Routledge. doi:10.4324/9780429453755-6

Maltese, A. V., Simpson, A., & Anderson, A. (2018). Failing to learn: The impact of failures during making activities. *Thinking Skills and Creativity*, *30*, 116–124. doi:10.1016/j.tsc.2018.01.003

Marin, K. A., & Rotondo, E. K. (2017). Rumination and self-reflection in stress narratives and relations to psychological functioning. *Memory (Hove, England)*, *25*(1), 44–56. doi:10.1080/09658211.2015.1124122 PMID:27905255

Mark, G., Iqbal, S., & Czerwinski, M. (2017, September). How blocking distractions affects workplace focus and productivity. In *Proceedings of the 2017 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2017 ACM International Symposium on Wearable Computers* (pp. 928-934). 10.1145/3123024.3124558

Masicampo, E. J., & Baumeister, R. F. (2011). Consider it done! Plan making can eliminate the cognitive effects of unfulfilled goals. *Journal of Personality and Social Psychology*, *101*(4), 667–683. doi:10.1037/a0024192 PMID:21688924

Media, M. (2013). *We Need a Plan*. Retrieved June 9, 2015, from https://www.aap.org/en-us/about-the-aap/aap-press-room/pages/managing-media-we-need-a-plan.aspx

Mentor, D. (2016). Learning cultivating connected communities: Sustainable workforce talent development. In *Handbook of Research on Mobile Learning in Contemporary Classrooms* (pp. 240–259). IGI Global. doi:10.4018/978-1-5225-0251-7.ch012

Mentor, D. (2018). Micro to macro social connectedness through mobile phone engagement. In *Encyclopedia of Information Science and Technology* (4th ed., pp. 6184–6194). IGI Global.

Mikolajczak, M., & Roskam, I. (2020). Parental burnout: Moving the focus from children to parents. *New Directions for Child and Adolescent Development*, (174), 7–13.

Milteer, R. M., Ginsburg, K. R., Mulligan, D. A., Ameenuddin, N., Brown, A., Christakis, D. A., Narayanan, L., Menon, S., Plaisent, M., & Bernard, P. (2017). Telecommuting: The work anywhere, anyplace, anytime organization in the 21st century. *Journal of Marketing Management*, *8*(2), 47–54.

Neill, M. S., & Bowen, S. A. (2021). Ethical listening to employees during a pandemic: New approaches, barriers and lessons. *Journal of Communication Management (London)*, *25*(3), 276–297. doi:10.1108/JCOM-09-2020-0103

Orhan, M. A., Castellano, S., Khelladi, I., Marinelli, L., & Monge, F. (2021). Technology distraction at work. Impacts on self-regulation and work engagement. *Journal of Business Research*, *126*, 341–349. doi:10.1016/j.jbusres.2020.12.048

Paller, K. A., Creery, J. D., & Schechtman, E. (2021). Memory and sleep: How sleep cognition can change the waking mind for the better. *Annual Review of Psychology*, *72*(1), 123–150. doi:10.1146/annurev-psych-010419-050815 PMID:32946325

Peltz, J. S., Daks, J. S., & Rogge, R. D. (2020). Mediators of the association between COVID-19-related stressors and parents' psychological flexibility and inflexibility: The roles of perceived sleep quality and energy. *Journal of Contextual Behavioral Science*, *17*, 168–176. doi:10.1016/j.jcbs.2020.07.001 PMID:32834971

Phillips, S. (2020). Working through the pandemic: Accelerating the transition to remote working. *Business Information Review*, *37*(3), 129–134. doi:10.1177/0266382120953087

Preuss, H., Capito, K., van Eickels, R. L., Zemp, M., & Kolar, D. R. (2021). Cognitive reappraisal and self-compassion as emotion regulation strategies for parents during COVID-19: An online randomized controlled trial. *Internet Interventions: the Application of Information Technology in Mental and Behavioural Health*, *24*, 100388. doi:10.1016/j.invent.2021.100388 PMID:33912402

Priyadarshini, C., Dubey, R. K., Kumar, Y. L. N., & Jha, R. R. (2020). Impact of a Social Media Addiction on Employees' Wellbeing and Work Productivity. *Qualitative Report*, *25*(1), 181–196. doi:10.46743/2160-3715/2020.4099

Restubog, S. L. D., Ocampo, A. C. G., & Wang, L. (2020). Taking control amidst the chaos: Emotion regulation during the COVID-19 pandemic. *Journal of Vocational Behavior*, *119*, 103440. doi:10.1016/j.jvb.2020.103440 PMID:32390659

Rubinstein, J. S., Meyer, D. E., & Evans, J. E. (2001). Executive control of cognitive processes in task switching. *Journal of Experimental Psychology. Human Perception and Performance*, *27*(4), 763–797. doi:10.1037/0096-1523.27.4.763 PMID:11518143

Rudrum, S., Rondinelli, E., Carlson, J., Frank, L., Brickner, R. K., & Casey, R. (2022). When work came home: Formation of feeling rules in the context of a pandemic. *Emotion, Space and Society*, *42*, 100861. doi:10.1016/j.emospa.2021.100861

Russell, B. S., Tomkunas, A. J., Hutchison, M., Tambling, R. R., & Horton, A. L. (2021). The protective role of parent resilience on mental health and the parent–child relationship during COVID-19. *Child Psychiatry and Human Development*, 1–14. PMID:34533667

Ryoo, J. J., & Kekelis, L. (2018). Reframing "failure" in making: The value of play, social relationships, and ownership. *Journal of Youth Development*, *13*(4), 49–67. doi:10.5195/JYD.2018.624

Sadka, O., Erel, H., Grishko, A., & Zuckerman, O. (2018, June). Tangible interaction in parent-child collaboration: Encouraging awareness and reflection. In *Proceedings of the 17th ACM Conference on Interaction Design and Children* (pp. 157-169). 10.1145/3202185.3202746

Schieman, S., Badawy, P. J. A., Milkie, M., & Bierman, A. (2021). Work-life conflict during the COVID-19 pandemic. *Socius: Sociological Research for a Dynamic World*, *7*, 2378023120982856. doi:10.1177/2378023120982856

Shuler, C. (2009). *Pockets of potential: Using mobile technologies to promote children's learning*. The Joan Ganz Cooney Center at Sesame Workshop.

Simons, C. (2013). Perspectives on the Development of Humor during Infancy, Childhood, and Adolescence. *Humor and Aging, 53*.

Singh, S., & Balhara, Y. P. S. (2021). "Screen-time" for children and adolescents in COVID-19 times: Need to have the contextually informed perspective. *Indian Journal of Psychiatry*, *63*(2), 192. doi:10.4103/indianjpsychiatry.indianjpsychiatry_886_21 PMID:34194066

Strasser, B., & Fuchs, D. (2015). Role of physical activity and diet on mood, behavior, and cognition. *Neurology, Psychiatry & Brain Research*, *21*(3), 118–126. doi:10.1016/j.npbr.2015.07.002

Swanson, W. S. (2012). The importance of play in promoting healthy child development and maintaining strong parent-child bond: Focus on children in poverty. *Pediatrics*, *129*(1), e204–e213. doi:10.1542/peds.2011-2953 PMID:22201149

Tomporowski, P. D., & Pesce, C. (2019). Exercise, sports, and performance arts benefit cognition via a common process. *Psychological Bulletin*, *145*(9), 929–951. doi:10.1037/bul0000200 PMID:31192623

Toniolo-Barrios, M., & Pitt, L. (2021). Mindfulness and the challenges of working from home in times of crisis. *Business Horizons*, *64*(2), 189–197. doi:10.1016/j.bushor.2020.09.004 PMID:33041346

What is experiential learning? Institute for Experiential Learning. (2021, October 22). Retrieved January 10, 2022, from https://experientiallearninginstitute.org/resources/what-is-experiential-learning/

Xu, S., Kee, K., & Mao, C. (2021). Multitasking and Work-Life Balance: Explicating Multitasking When Working from Home. *Journal of Broadcasting & Electronic Media*, *65*(3), 1–29. doi:10.1080/08838151.2021.1976779

## KEY TERMS AND DEFINITIONS:

**Artifacts:** Any media application that includes screen-time attention. Such examples include apps, video games, television programs, streaming programs, technology platforms and the like.

**Bronfenbrenner's Ecological Systems Theory:** An individual's development is influenced by multiple settings of the surrounding environment as well as the interrelationships among those settings. The theory includes four systems: the immediate environments such as family and work (microsystem), the interrelationships among multiple settings such as the relations among home, work, and neighborhood (mesosystem), settings that influence the developing individual indirectly such as partner's workplace (exosystem), and a broader setting such as cultural values and global events (macrosystem).

**Co-Viewing:** Parents/caregivers watch television with their children at the same time in the hopes novel information will be explained while increasing the likelihood of bonding opportunities.

**Cognitive Psychology:** Relating to, being, or involving conscious intellectual activity (such as thinking, reasoning, or remembering). Branch of psychology that explores the operation of mental processes related to perceiving, attending, thinking, language.

**Developmental Psychology:** A scientific approach which aims to explain growth, change, and consistency throughout the lifespan.

**Maker Education:** Problem-based, project-based activities, typically STEAM-related (Science, Technology, Engineering, Art & Mathematics)

**Ping-Pong Attention:** Tasks you can quickly pick up and begin again (Rubinstein, Meyer & Evans, 2001). Work that can be completed quickly but also put down and picked up again.

## APPENDIX 1

### Work from Home Self-Assessment (i.e., The Survey of Worries)

Use this self-assessment to help you identify goals. Begin by asking yourself: What does working from home and taking care of children in tandem mean to me? Complete BEFORE and AFTER reading this document.

## QUESTIONS:

1. What are you currently doing to help the children learn and be physically active?
2. What personal occupational goals do you have?
3. What educational and physical goals can you accomplish during the rest of the year with your children?
4. What is your biggest challenge working from home?
5. Describe in three words your experience working from home.
   a. Work From Home Word 1: ______________________
   b. Work From Home Word 2: ______________________
   c. Work From Home Word 3: ______________________
6. How happy are you working from home? (Circle One.)
   1 2 3 4 5
   (1 being not at all happy, 5 being very happy)
7. How productive do you feel working from home? (Circle One.)
   1 2 3 4 5
   (1 being not at all productive, 5 being very productive)

# Chapter 3
# Optimization of Job Boards and the Graduate Recruitment Process:
## Advancing HRM Strategies for the Acquisition of Early Career Talent

**William E. Donald**
https://orcid.org/0000-0002-3670-5374
*University of Southampton, UK & Ronin Institute, USA*

**Peter Pychtin**
*GradSift, Australia*

## ABSTRACT

*This chapter aims to enable organizations to optimize their use of job boards and the graduate recruitment process based on feedback from university students and recent graduates of their lived experiences. A theoretical framework of signaling theory is applied. A sample of 321 university students and recent graduates in Australia completed an online survey incorporating quantitative and qualitative elements during the COVID-19 pandemic. Opportunities for job board optimization include increasing the relevance of search results, providing metrics about the company, and increasing integration between applicants and organizations to facilitate communication. Opportunities for optimization of the recruitment process include the removal of unnecessary stages to reduce time investment of applicants, increasing clarity of requirements and providing timely and constructive feedback. Implications come from informing the human resource strategy for early careers talent acquisition. Optimization of the process can offer competitive advantage, cost savings, and organizational sustainability.*

DOI: 10.4018/978-1-6684-3996-8.ch003

## INTRODUCTION

A job search is defined as a motivational and self-directed process driven by the goal of sourcing relevant employment opportunities (Van Hooft, Kammeyer-Mueller, Wanberg, Kanfer, and Basbug, 2021). Job boards are a key source of information that can be self-accessed by jobseekers (Bonet, Capelli, and Hamori, 2013; Parry and Wilson, 2009). This can help to overcome information asymmetry that is common between jobseekers and employers (Larsen and Vesan, 2012). However, whilst jobseekers are attracted to job boards with a higher number of opportunities, they still only review a limited number of job postings (Brenčič, 2014). Furthermore, the capability for job boards to help overcome information asymmetry relies on both parties having the ability to use the platform effectively and beneficially (Kuhn and Skuterud, 2004).

The COVID-19 pandemic as a global level chance event with over 257 million cases and 5 million deaths since December 2019 has impacted our day-to-day lives in ways that previously seemed unimaginable (Coronavirus Resource Center, 2021). One group of society that has been significantly affected by the pandemic is university students and recent graduates. These individuals have experienced a combination of virtual lectures, mobility restrictions due to border closures, limited social contact, and increased competition for graduate jobs (Brammer and Clark, 2020), which have negatively impacted their mental health (Savage et al., 2020).

The social distancing guidelines, local or national level lockdowns, and the speed with which the pandemic evolved has also proved particularly challenging for organizations seeking to recruit early careers talent (Jena, 2020). The assessment center and final interview stages of the graduate recruitment process which were traditionally run in-person had to rapidly shift to a virtual format (Laker, Godley, Patel, and Kudret, 2021). This accelerated the trend of using technology in the graduate recruitment process to enhance productivity via automation and data analytics that had begun to emerge in the years preceding the COVID-19 pandemic.

Furthermore, individuals across the lifespan experienced information overload during the COVID-19 pandemic that negatively impacted their wellbeing (Fan and Smith, 2021). In the context of graduate recruitment, information overload makes it harder for organizations to differentiate themselves from the competition and reach prospective applicants during their university studies. Traditionally, organizations have tended to use job boards as a static means to communicate information about employment opportunities to jobseekers. However, the increased use of technology and emphasis on virtual engagement indicates that organizations will need to use job boards more dynamically and interactively in the future to foster the dyadic relationship between jobseekers and employers.

Donald, Ashleigh, and Baruch (2021) have explored the views of university careers advisors and graduate recruiters concerning the impacts of the COVID-19 pandemic on the recruitment of early careers talent. However, the student and recent graduate views of how organizations use job boards and carry out the graduate recruitment process since the COVID-19 pandemic began are lacking representation in the Human Resource Management (HRM) literature. These views are important because they can facilitate feedback-seeking behavior to inform the HRM policy of organizations leading to process optimization (Donald, 2021). Therefore, this chapter aims to enable organizations to optimize their use of job boards and the graduate recruitment process based on feedback from university students and recent graduates in Australia of their lived experiences.

Implications come from identifying opportunities for organizations to optimize their use of job boards and the graduate recruitment process, which can help to inform the HRM strategy for early careers talent acquisition. Optimization of the process can lead to competitive advantage, cost savings, and organizational sustainability. Future students and graduates benefit through clearer communication and a streamlined recruitment process. The theoretical implications come from the application and advancement of signaling theory as a theoretical framework, which is now discussed.

## THEORETICAL FRAMEWORK

Spence (1973) introduced signaling theory to the field of economics in the context of contract theory whereby information asymmetry is overcome by an agent (the signaler) conveying information about themselves (the signal) to the principle (the receiver). The concept of signaling theory was subsequently applied to the field of Vocational Behavior and continues to be used today with a focus on strategies for applicants to signal their employability and enhance their employment outcomes (Bridgstock and Jackson, 2019). The signaling of information by the applicant enables the hiring organization to make an informed decision regarding the suitability of offering an employment contract. Signaling theory has also been applied in parallel in the HRM literature. For example, the decoding of signals from applicants enables organizations to identify appropriate talent (Anderson and Tomlinson, 2021).

In the context of this chapter, the focus is on extending the work of HRM scholars with an interest in brand marketing to enhance talent management strategies (Ahamad, 2019; Vinayak, Khan, and Jain, 2017) as an antecedent to firm performance (Bandyopadhyay and Srivastava, 2021). Organizations can embrace feedback-seeking behavior to advance HRM strategies for the acquisition of early careers talent, offering opportunities for competitive advantage, diversity of talent, and organizational sustainability.

Innovative approaches to signaling and securing early careers talent also take on increased importance in the context of the COVID-19 pandemic as a global chance event (Akkermans, Richardson, and Kraimer, 2020) and as the future of work continues to evolve (Tomlinson and Anderson, 2020). Technology can address key areas of automation and data analytics within the recruitment process, particularly given the benefits that technology has been shown to have on streamlining operational activities and increasing productivity (Tarofder, Azam, and Jalal, 2017). These areas take on increased importance as organizations seek to manage an increased volume of applications and identify talented applicants as competition for graduate jobs increases due to the COVID-19 pandemic (Donald et al., 2021). Technology can also help to reduce the carbon footprint of the hiring process (e.g., via reduced travel for candidates and assessors, reduced printing of assessment materials, etc.) and signal the organization's commitment to a green agenda as an additional diversification strategy for the acquisition of early careers talent. This also reflects concerns of the threats of global warming as a future global level event, which places additional emphasis on the environmental strategies of organizations given the links to sustainability and financial performance (Clemens and Bakstran, 2010).

## DEVELOPMENT OF RESEARCH QUESTIONS

### Job Boards

The initial phase of graduate recruitment involves the attraction of talent via employer branding strategies (Shenoy and Aithal, 2018). This stage is critical since the provision of realistic job-related information is positively related to job pursuit intention and behavior (Jaidi, Van Hooft, and Arends, 2011). The COVID-19 pandemic has accelerated the adoption of technology within the graduate recruitment process and organizations that make use of multiple e-channels to address information asymmetry will benefit the most (Alsaghir, Abdallah, and Bazan, 2020). Job boards are one such HRM strategy to attract talent to the organization (Shenoy and Aithal, 2018). Yet, despite job boards offering a simple way to search a pool of talent for suitable candidates, this approach remains underutilized by organizations – perhaps due to a lack of focus and innovation in this area over the last few decades (Peltokorpi, 2021).

Additionally, job boards can help organizations to access diverse candidates who lack social capital, which is a determinant of perceived employability in undergraduates (Donald, Baruch, and Ashleigh, 2019). However, the strategies for attracting and hiring individuals from disadvantaged groups tend to focus on social policy rather than on the role of HRM during the recruitment process (Ingold and Valizade, 2017). To address this issue, organizations need to craft job postings in a way that does deter diverse jobseekers from applying and entering the selection process (Laker et al., 2021). This is of particular significance since the return on investment from participation in higher education is higher for men than for women despite more women undertaking degree studies (Workplace Gender Equality Agency, 2021). Additionally, diverse workforces have been shown to increase creativity, problem-solving, and innovation in the workplace (Patky, 2020), which are indicators of organizational sustainability (Brandi and Thomassen, 2021).

Feedback-seeking behavior by organizations from students and recent graduates can lead to benefits for both parties (Donald, 2021). The optimization of job boards facilitates organizations to amend their HRM attraction strategies to signal to jobseekers the opportunities available in a more meaningful and engaging way (Alsaghir et al., 2020). Prospective applicants as the receivers of the signals benefit from access to clearer information empowering them to make informed decisions regarding the fit of the role to their preferences and intrinsic values (Van Hooft et al., 2021). The increased relevance of information on job boards will also attract a higher number of jobseekers which increases the pool of talent available for organizations to search (Peltokorpi, 2021). Thus, this chapter seeks to address the following research question:

**Research Question One:** How do university students and recent graduates feel that job boards can be optimized?

## Graduate Recruitment Process

Once organizations have received applications from jobseekers, the focus shifts from talent attraction to selection. This process usually entails initial screening of applications, psychometric testing, assessment centers, interviews, and a final decision (McCracken, Currie, and Harrison, 2016). Organizations had begun integrating technology into the screening and psychometric testing phases of the selection process before the COVID-19 pandemic. However, reliance on technology for these phases will continue to increase due to a high volume of applications per role driven by fierce competition for jobs and a 3.5 percent reduction in full-time graduate employment rates to 68.7 percent (Quality Indicators for Learning and Teaching, 2020). The COVID-19 pandemic also forced organizations to pivot from in-person to virtual assessment centers and interview stages due to social distancing regulations (Laker et al., 2021).

Yet, the adoption of technology has not been without its limitations. Tomlinson and Anderson (2020) highlight the mediating roles of signals in the selection of graduate talent. Bias in the algorithms used to screen applicants can negatively impact social mobility (Trendence, 2020). Additionally, Bradley et al.

(2021) found that 50 percent of university students failed the verbal and numerical reasoning tests that many employers use during the psychometric testing stage. The same study also reported that the sole factor linked to increasing the chance of passing the tests was practising them.

Moreover, access to technology can prove difficult for candidates from lower socio-economic backgrounds who are subsequently disadvantaged during the assessment process (Trendence, 2020). These applicants often have to access content on a phone screen with a limited speed internet connection and no private space (Bright Network, 2020). These barriers are in addition to the pre-existing challenges to social mobility from the amount of time required for jobseekers to navigate multiple recruitment processes with different organizations (Bright Network, 2020). Employers will need to monitor the diversity of the candidates who make it to the later stages of the selection process and look for proactive ways to promote equality of opportunities. Organizations that achieve this will benefit from a diverse workforce and enhanced firm performance (Bandyopadhyay and Srivastava, 2021; Cooke, Dickmann, and Parry, 2021).

The final stage of the selection process involves informing the candidate of the outcome. Organizations that address information asymmetry by providing feedback to their candidates regardless of the outcome are likely to benefit from positive brand awareness as candidates share their experiences with other jobseekers (Ahamad, 2019; Vinayak et al., 2017). The dissemination of information via feedback can also help to empower future applicants to make informed decisions about their careers (Van Hooft et al., 2021). In contrast, failure to provide feedback can result in negative publicity resulting in future jobseekers applying to competitor organizations instead (Jaidi et al., 2011).

Innovative use of technology to condense the graduate recruitment process combined with cyclical reviews to identify areas for improvement can offer strategic competitive advantage via the acquisition of early careers talent (Subat, Rahman, and Rahman, 2020). Feedback from students and recent graduates can provide additional insights to inform these strategic HRM decisions (Donald, 2021). Thus, this chapter seeks to address a second research question:

**Research Question Two:** How do university students and recent graduates feel that the graduate recruitment process can be optimized?

## METHOD

### Participants and Procedure

The participants for this study were 321 university students and recent graduates based in Australia. Table 1 provides the participant information. The 55.45 percent of females in the survey participants is representative of the 59.00 percent of females in higher education in Australia (Department of Education, Skills and Employment, 2020).

The data were collected between 13th December 2020 and 18th December 2020 via an online survey to ensure the safety of all parties during the COVID-19 pandemic. Ethical approval was obtained, and informed consent was sought from each of the study participants before the completion of the survey. The link to the survey was sent once to university students and recent graduates on the mailing list of a company in Australia that focuses on using technology to streamline the process of selecting internship, graduate, and entry-level talent. Recipients were asked to complete the survey and pass the link on to other university students and recent graduates in their personal and professional networks. The sharing of the link helped to ensure the inclusion of responses by students and recent graduates beyond solely those who had interacted with the specific company. No incentive was provided for participation in the survey to minimize bias. The survey responses were collated in a password-protected Microsoft Excel spreadsheet and the data were shared within the organization and with the research team only. Once the data had been collated and aggregated, the raw data were deleted. The data presented in this chapter are the aggregated data in its entirety.

*Table 1. Participant information*

| Category | n | % |
|---|---|---|
| Gender | 321 | 100.00 |
| *Female* | *178* | *55.45* |
| *Male* | *143* | *44.55* |
| Resident Status | 321 | 100.00 |
| *Resident* | *316* | *98.44* |
| *Non-Resident* | *5* | *1.56* |
| Life Status | 321 | 100.00 |
| *Recent Graduate* | *238* | *74.14* |
| *University Student* | *83* | *25.86* |
| Job Board User | 321 | 100.00 |
| *Yes* | *273* | *85.05* |
| *No* | *48* | *14.95* |
| Job Board Registered | 321 | 100.00 |
| *Yes* | *237* | *73.83* |
| *No* | *84* | *26.17* |

## Survey Instrument

The survey instrument mixed quantitative (closed-ended) and qualitative (open-ended) questions. Both forms of data were subsequently integrated and analyzed. The choice of survey questions was driven by the two research questions in combination with the desires of the company in Australia to understand the level of student satisfaction with the current recruitment process and the reliance on job boards. The survey consisted of four sections. The first section captured participant information. The second section focused on the experience of using job boards. An example closed-ended question was: "*How satisfied were you with your experience of using job boards?*". The third section addressed job board optimization. A sample closed-ended question was: "*You register a profile and use technology to rate your employability. You benchmark your profile against a database of other students and graduates to see how you rate, your strengths, and your areas for improvement. How valuable would this feature be to you?*". A sample open-ended question was: "*What additional features would be useful to you on a job board?*". The final section captured information on the graduate recruitment process. A sample closed-ended question was: "*To what extent do you agree with the following statement? Overall, I found the recruitment pro-*

*cess to be efficient.*" A sample open-ended question was: "*What, if anything, would make a significant improvement to the effectiveness of the graduate recruitment process?"*. All close-ended questions for sections two, three, and four used a 5-point Likert scale, and all open-ended questions used a free text response where participants were asked to write in full sentences and to provide as much information as possible. Appendix 1 provides the survey in full for reference and to facilitate replication of the study.

### Strategy of Analysis

All responses were collated in a Microsoft Excel Document. The quantitative data were aggregated as percentages for each item using the 5-point Likert scale. The descriptive results provided an initial understanding of the participant views, which were then developed further via the qualitative data. Thematic analysis was applied to the qualitative data because it responds to calls by Corley (2015, p.2) to "*engage with those living the phenomenon and attempt to understand it from their perspective."* The six stages of thematic analysis were employed consisting of "*familiarizing yourself with your data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report*" (Braun and Clarke, 2006, p.35). The six phases were applied iteratively because this approach enhances the depth of findings (Clarke and Braun, 2013). Two researchers independently conducted the thematic analysis, and the outputs were then compared. This helped to ensure the validity of the findings and reduce researcher bias (Saldaña, 2015). Both researchers independently agreed that saturation had been reached at the category level as the responses from additional participants failed to generate additional themes (Corbin and Strauss, 2015). This is crucial since saturation is considered the primary means of verification for thematic analysis (Suddaby, 2006). The responses from n=105 participants to the qualitative parts of the survey also exceeded typical thresholds for saturation of n=20-30 (Morse, 1994) and n=32.5 (Saunders and Townsend, 2016).

## RESULTS AND ANALYSIS

### Job Board Optimization

Research Question One asked, "How do university students and recent graduates feel that job boards can be optimized?". The quantitative descriptive results for job board optimization are evidenced in Table 2.

The results indicate that students and recent graduates feel that there is significant scope for optimization of job boards. For example, just 5.31 percent of participants were extremely satisfied with their experience of using job boards, and 72.37 percent felt the notifications they received for job opportunities were either not relevant or only moderately relevant. Additionally, 64.80 percent of participants rated the value of information from employers on job boards as neutral or of little or no value, and 56.94 percent gave the same rating for the relevance of the employment opportunities they received based on their interests.

The quantitative results also indicated some additional features that participants rated as useful or extremely useful. These included contact by employers based on profile fit (83.64 percent), the opportunity to be fast-tracked to the later stages of the selection process (86.32 percent), and the opportunity for ad-hoc paid insights (57.21 percent). Additionally, the ability to use technology to compare a jobseeker's fit with an employer (74.29 percent), to benchmark their own employability against other jobseekers

(68.54 percent), and for this benchmark to update based on changes to their profile (71.83 percent). Finally, automated feedback to help improve their employability (71.37 percent).

The thematic report for job board optimization based on the qualitative data is evidenced in Table 3. The thematic analysis results show that students and recent graduates believe there are three core areas for job board optimization. Firstly, increasing the relevance of search results along with job specifications and salary expectations. Secondly, providing metrics about organizations based on student ratings and employment statistics. Thirdly, looking at ways to increase integration by enhancing communication between jobseekers and employers, enabling employers to shortlist talent for assessment, and combining job postings from multiple job boards.

### Graduate Recruitment Process Optimization

Research Question Two asked, "How do university students and recent graduates feel that the graduate recruitment process can be optimized?". The quantitative descriptive results for graduate recruitment process optimization are evidenced in Table 4. The results indicate that students and recent graduates feel that there are significant opportunities for employers to enhance the graduate recruitment process. For example, for all five statements, the percentage of participants who strongly agreed (score of 5 in Table 4) was outweighed by the number of participants who strongly disagreed (score of 1 in Table 4). Furthermore, for all five statements, the number of participants who agreed or strongly agreed was outweighed by the number of participants who strongly disagreed, disagreed, or were neutral. The two statements with the largest discrepancies were the time spent on applications being reasonable and the recruitment process being efficient. Just 3.13 percent and 4.69 percent of respondents strongly agreed with the two statements respectively. Furthermore, 68.44 percent and 71.56 percent of respondents strongly disagreed, disagreed, or were neutral to the two statements respectively.

The thematic report for graduate recruitment process optimization based on the qualitative data is evidenced in Table 5. The thematic analysis results show that students and recent graduates believe there are three core areas for graduate recruitment process optimization. Firstly, by focusing on improving efficiency via a standard application portal for all employers, avoiding the duplication of data between the CV and online application form, and by streamlining the recruitment process to make it simpler and shorter. Secondly, by being more open regarding the requirements for the role including desired characteristics, flexibility on previous experience, and clearly stating the salary being offered. Thirdly, providing feedback in a timely and constructive manner thus enabling candidates to identify areas for self-improvement if they are unsuccessful.

## THEORETICAL AND PRACTICAL IMPLICATIONS

The aim of this chapter was to investigate the views of students and recent graduates in Australia concerning the optimization of job boards and the graduate recruitment process during the university-to-work transition. The findings highlighted a plethora of opportunities for organizations to optimize their use of job boards and the graduate recruitment process in the context of early careers talent. Clear of opportunities, requirements, and the recruitment process to jobseekers combined with relevant signaling and timely feedback to candidates can enhance the brand marketing of an organization. Moreover, organizations that can streamline their early careers recruitment process can differentiate themselves from the competition. These strategies can increase competitive advantage, diversity of talent, and firm performance as a means for organizational sustainability (Ahamad, 2019; Bandyopadhyay and Srivastava, 2021; Vinayak et al., 2017).

*Table 2. Job board descriptive statistics*

| Item | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| a. Relevance of notifications for job opportunities | 4.39 | 22.37 | 45.61 | 18.42 | 9.21 |
| b. Relevance of employer opportunities to interests | 15.20 | 15.20 | 34.40 | 21.60 | 13.60 |
| c. Satisfaction with experience of using job boards | 4.90 | 13.06 | 37.14 | 39.59 | 5.31 |
| d. Value of job boards for information about employers | 9.12 | 13.50 | 34.32 | 31.02 | 12.04 |
| e. Contact by employer via profile fit to apply | 2.34 | 1.87 | 12.15 | 38.32 | 45.32 |
| f. Contact by employer via profile fit for fast track | 2.83 | 0.94 | 9.91 | 32.08 | 54.24 |
| g. Technology to compare own fit with employer | 2.34 | 3.74 | 19.63 | 35.97 | 38.32 |
| h. Ability to benchmark own employability | 3.76 | 3.29 | 24.41 | 35.68 | 32.86 |
| i. Profile updates to change employability benchmark | 5.16 | 2.82 | 20.19 | 37.09 | 34.74 |
| j. Automated feedback to improve employability | 5.63 | 3.29 | 19.72 | 31.46 | 39.91 |
| k. Contact by employer for career related roles | 1.49 | 1.49 | 15.42 | 39.80 | 41.79 |
| l. Contact by employer for non-career related roles | 6.47 | 15.92 | 32.33 | 22.89 | 22.39 |
| m. Contact by employer to provide ad-hoc paid insights | 5.47 | 12.94 | 24.38 | 32.33 | 24.88 |

**Key** n=321
Items a-b: 1=None, 2 = A Little, 3 = A Moderate Amount, 4= A Lot, 5= A Great Deal
Item c: 1=Not at all Satisfied, 2 = Not Satisfied, 3 = Neutral, 4= Satisfied, 5= Extremely Satisfied
Items d-m: 1=Not at all Valuable, 2 = Not Valuable, 3 = Neutral, 4= Valuable, 5= Extremely Valuable

*Table 3. Job board optimization thematic report*

| Aggregate Dimension | Theme | Example Excerpt(s) |
|---|---|---|
| Relevance | Search Results | Specific search engine options where posts can be filtered to jobs that match the jobseeker's degree and tertiary qualifications. Current matching based on keywords often produces results that are not relevant. |
| | Job Specifications | Consistent labelling of student and entry-level roles to make it easier to filter for them, More concise job ads with a precise and meaningful description of the role and requirements. Accurate closing dates and remove soon as closing date passes. |
| | Salary Expectations | More clarity on salary expectations instead of the generic "competitive market rate". How are we supposed to know the market rate if all the employers are just saying "competitive market rate? Transparency, transparency, transparency. |
| Metrics | Student Ratings | Student ratings of the organization for comparison. Knowing about them and where to find them/which ones are reputable. |
| | Employment Statistics | Better tracking of employers that previously have hired through boards. Previous employment statistics i.e., of X000 applications, 4 were hired etc. |
| | Relationship Dynamic | The job board needs to be listings of applicants, not employers. Employers can then make their own "short-list" without the roller coaster ride of hope and rejection. |
| Integration | Two-Way Communication | More methods to facilitate communication between candidates and employers. If rejected, personalized suggestions can be made to improve the profile or have a specialized person to have a 5 min chat on how to proceed. |
| | Other Job Boards | Have one website to access job boards clearly. Links to search results from other job boards if there were new listings that didn't register in the current job board. |

*Table 4. Graduate recruitment process descriptive statistics*

| Item | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| n. Easy to learn about job opportunities | 8.07 | 23.60 | 18.63 | 42.56 | 7.14 |
| o. Online application process simple and efficient | 8.70 | 27.02 | 17.70 | 40.99 | 5.59 |
| p. Number of recruitment stages seemed appropriate | 9.63 | 23.91 | 23.60 | 36.03 | 6.83 |
| q. Time spent on applications was reasonable | 16.88 | 33.43 | 18.13 | 28.43 | 3.13 |
| r. Overall, the recruitment process was efficient | 18.44 | 29.68 | 23.44 | 23.75 | 4.69 |

**Key** n=321
Items n-r: 1=Strongly Disagree, 2 = Disagree, 3 = Neutral, 4= Agree, 5= Strongly Agree

*Table 5. Graduate recruitment process optimization thematic report*

| Aggregate Dimension | Theme | Example Excerpt(s) |
|---|---|---|
| Efficiency | Standard Application Portal | Having to submit the same information into each platform is an extremely tedious and time-consuming process. A single portal for multiple applications similar to the university application approach would be helpful. This could include live application tracking so that you're not ghosted by recruiters. |
| | Avoid Data Duplication | There is significant duplication between information provided in a resume which we spend hours crafting and the information we also have to manually input during the application process in a very inefficient way. Either one or the other. |
| | Streamline Recruitment Process | Make the process simpler, rather than having all these unnecessary stages – many do not seem relevant. Fewer steps. It's an exhausting process when the odds of success are so low. Waiting over 6 months for an offer is excruciating. |
| Clarity of Requirements | Transparency of Desired Characteristics | It would be great if employers could specify the exact skills/ knowledge background they are looking for. More information would help people to know what to work on. |
| | Flexibility on Experience | Be more flexible to accept graduates who have little to no experience |
| Feedback | Timely Feedback | Businesses actually replying to applications, the amount of companies that never get back to you or just don't let you know what's happened is ridiculous. I think if you have interviewed they should have the decency to let you know you didn't get the job. If replies do come back they take a long time. Faster reply would be appreciated. |
| | Constructive Feedback | Constructive feedback, why you specifically weren't chosen over another candidate or pool of candidates. It's difficult for people to learn from the process when there is no clear reason or understanding as to why your application wasn't successful. |

Yet, the views of students and recent graduates are underrepresented in HRM literature and instead tend to cluster within Vocational Behavior literature with a focus on career agency and sustainable careers (e.g., Donald, Baruch, and Ashleigh, 2020; Nimmi, Kuriakose, Donald, and Nowfal, 2021; Van der Heijden et al., 2020). Giving a voice to students and recent graduates within the HRM literature can facilitate researchers and practitioners to gain a holistic view of the early careers landscape. This chapter addresses the research gap and responds to a recent call in the HRM literature for organizations to facilitate feedback-seeking behavior to optimize the recruitment process for early careers talent (Donald, 2021). Representing the views of students and recent graduates in the HRM literature is also timely given the impact of the COVID-19 pandemic as a global chance event (Akkermans et al., 2020) and the evolving future of work (Tomlinson and Anderson, 2020).

The COVID-19 pandemic has helped to overcome pre-existing barriers to change (e.g., cost, employee resistance, lack of organizational buy-in, etc.), by making HRM and talent management teams more receptive to innovative approaches due to necessity. The significant investment in technology during the pandemic presents opportunities and risks for organizations. When used correctly, investment in technology has been shown to streamline operational activities and increase productivity in organizations (Tarofder et al., 2017). However, technology can also increase the risk of inherent bias and act as an additional barrier to jobseekers with limited access to broadband, devices, or a quiet space to participate in the selection process (Bright Network, 2020; Trendence, 2020). Therefore, feedback from as many channels as possible can help organizations to identify issues and make informed decisions to address them. This approach can help to enhance firm performance through the diversification of the workforce (Bandyopadhyay and Srivastava, 2021; Cooke et al., 2021).

Organizations can also benefit from using job boards in innovative ways. This study highlights that in their current form job boards are often viewed by jobseekers as ineffective in addressing information asymmetry and attracting talent. Concurrently, organizations are seeking new ways to differentiate themselves and gain access to jobseekers who are often experiencing information overload. Clear signaling of opportunities and requirements coupled with two-way communication between organizations and jobseekers can overcome such challenges. Organizations that make use of multiple e-channels to address information asymmetry will benefit the most (Alsaghir et al., 2020). Additionally, providing transparency of job requirements and pay scales can help jobseekers to make more informed decisions about whether to apply for the role. This self-selection by jobseekers can benefit the organization by creating a high quality and diverse pool of applicants rather than focusing purely on the volume of applicants. Open communication also enables jobseekers to track their progress through the selection process and receive feedback alongside an outcome. Our findings suggest this will increase satisfaction levels in jobseekers. Increased levels of satisfaction have previously been linked with positive impacts on brand marketing for organizations (Shenoy and Aithal, 2018). This can lead to sustainable competitive advantage by attracting future early careers talent.

Whilst the focus of this chapter is predominantly from an HRM perspective, the practical implications extend to jobseekers and career counselors. Jobseekers gain from being able to make informed decisions whether to apply for specific roles and through participation in a streamlined selection process. Where candidates are unsuccessful, informed feedback can help them to identify areas for self-improvement to increase their employability and the likelihood of a successful employment outcome in the future. Unsuccessful students and recent graduates are likely to share their experiences with their peers and with career counselors. Therefore, career counsellors can modify their advice and prepare future students more effectively. This can also help to support students with low levels of social capital to navigate the application and selection process. Subsequently, organizations gain additional benefits as the quality and diversity of their pipeline of early careers talent improves with each recruitment cycle. Universities also gain as employment outcomes are linked to league table rankings and the attraction on future students and revenue streams.

## LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

One potential limitation of the study was the recruitment of the participants. The survey link was initially sent to university students and recent graduates on the mailing list of a company in Australia that focuses on using technology to streamline the process of selecting internship, graduate, and entry-level talent. Individuals on this mailing list may be more proactive in managing their careers when compared to their peers. Participants contacted via the mailing list were asked to pass the survey link on to additional students and recent graduates in Australia to reduce the risk of sample bias.

The study's other limitation was related to the potential risk of common method bias since the survey instrument served as a single source of data collection. However, the combination of quantitative and qualitative aspects within the survey helped reduce this risk by capturing the views of students and recent graduates in Australia through the use of descriptive statistics and thematic analysis. This approach was suitable because it helped to build an initial understanding of the views of students and recent graduates.

Future work can test hypotheses based on our initial findings via a quantitative approach and use inferential statistics. Alternatively, interviews or focus groups can be carried by identifying questions from our initial findings to expand the application of thematic analysis. The views of other actors could also be explored to build a richer picture of the research area and to identify any barriers that may prevent the findings from this study from being implemented pragmatically. The views from other countries may also be of interest to enable comparisons and to share knowledge and best practices.

## CONCLUSION

This chapter investigated the views of students and recent graduates in Australia concerning the optimization of job boards and the graduate recruitment process during the university-to-work transition. Our chapter is one of the first to capture feedback from these actors on their lived experience of using job boards and undertaking the graduate recruitment process during the COVID-19 pandemic. Optimization of early careers talent management strategies can lead to competitive advantage, cost savings, and organizational sustainability. Students and graduates can also benefit via clearer communication, timely feedback, and a streamlined recruitment process.

## ACKNOWLEDGMENT

The research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors. The research was supported by GradSift, Australia.

## REFERENCES

Ahamad, F. (2019). Impact of word-of-mouth, job attributes and relationship strength on employer attractiveness. *Management Research Review*, *42*(6), 721–739. doi:10.1108/MRR-11-2017-0382

Akkermans, J., Richardson, J., & Kraimer, M. (2020). The Covid-19 crisis as a career shock: Implications for careers and vocational behavior. *Journal of Vocational Behavior, 119*(1) 103434. doi: https://doi.org/10.1016/j.jvb.2020.103434

Alsaghir, L., Abdallah, N., & Bazan, S. B. (2020). Optimizing Recruitment Online: The Critical Importance of Using the Right Channels. *International Journal of E-Business Research*, *16*(4), 18–33. doi:10.4018/IJEBR.2020100102

Anderson, V., & Tomlinson, M. (2021). Signaling standout graduate employability: The employer perspective. *Human Resource Management Journal*, *31*(3), 675–693. doi:10.1111/1748-8583.12334

Bandyopadhyay, C., & Srivastava, K. B. L. (2021). HR signals in the context of HRM-firm performance relationship: Development of a conceptual framework. *International Journal of Productivity and Performance Management*, *70*(2), 376–390. doi:10.1108/IJPPM-03-2019-0141

Bonet, R., Capelli, P., & Hamori, M. (2013). Labour market intermediaries and the new paradigm for human resources. *The Academy of Management Annals*, *7*(1), 341–392. doi:10.5465/19416520.2013.774213

Bradley, A., Beevers-Cowling, F., Norton, C., Hill, C., Pelopida, B., & Quigley, M. (2021). Falling at the first hurdle: Undergraduate students' readiness to navigate the graduate recruitment process. *Studies in Higher Education*, *46*(9), 1827–1838. doi:10.1080/03075079.2019.1709164

Brammer, S., & Clark, T. (2020). COVID-19 and Management Education: Reflections on Challenges, Opportunities, and Potential Futures. *British Journal of Management*, *31*(3), 453–456. doi:10.1111/1467-8551.12425

Brandi, U., & Thomassen, M. L. (2021). Sustainable organizational learning and corporate entrepreneurship: A conceptual model of sustainability practices in organizations. *Journal of Workplace Learning*, *33*(3), 212–228. doi:10.1108/JWL-05-2020-0084

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. doi:10.1191/1478088706qp063oa

Brenčič, V. (2014). Search online: Evidence from acquisition of information on online job boards and resume banks. *Journal of Economic Psychology*, *42*(1), 112–125. doi:10.1016/j.joep.2014.02.003

Bridgstock, R., & Jackson, D. (2019). Strategic institutional approaches to graduate employability: Navigating meanings, measurements and what really matters. *Journal of Higher Education Policy and Management*, *41*(2), 1–17. doi:10.1080/1360080X.2019.1646378

Bright Network. (2020). *What do graduates want? 2020/21. Data Insights from the future workforce*. https://www.brightnetwork.co.uk/employers/bright-network-research-report

Clarke, V., & Braun, V. (2013). Teaching thematic analysis: Overcoming challenges and developing strategies for effective learning. *The Psychologist*, *26*(2), 120–123.

Clemens, B., & Bakstran, L. (2010). A framework of theoretical lenses and strategic purposes to describe relationships among firm environmental strategy, firm performance, and environmental performance. *Management Research Review*, *33*(4), 393–405. doi:10.1108/01409171011030480

Cooke, F. J., Dickmann, M., & Parry, E. (2021). IJHRM after 30 years: Taking stock in times of COVID-19 and looking towards the future of HR research. *International Journal of Human Resource Management*, *32*(1), 1–23. doi:10.1080/09585192.2020.1833070

Corbin, J., & Strauss, A. (2015). Basics of Qualitative Research. *Sage (Atlanta, Ga.)*.

Corley, K. G. (2015). A commentary on 'what grounded theory is…' engaging a phenomenon from the perspective of those living it. *Organizational Research Methods*, *18*(4), 600–605. doi:10.1177/1094428115574747

Coronavirus Resource Center. (2021). *COVID-19 Data in Motion*. https://coronavirus.jhu.edu/

Department of Education, Skills and Employment. (2020). *Higher Education Statistics Data Cube*. http://highereducationstatistics.education.gov.au/

Donald, W. E. (2021). *Conceptualisation of a new 'Early Careers Talent Pipeline' Framework: Enhancing Organizational Sustainability via Feedback-Seeking Behaviour*. Graduate Recruitment Bureau.

Donald, W. E., Ashleigh, M. J., & Baruch, Y. (2021, September 03). (in press). The university-to-work transition: Responses of universities and organizations to the COVID-19 pandemic. *Personnel Review*. Advance online publication. doi:10.1108/PR-03-2021-0170

Donald, W. E., Baruch, Y., & Ashleigh, M. J. (2019). The undergraduate self-perception of employability: Human capital, careers advice, and career ownership. *Studies in Higher Education*, *44*(4), 599–614. doi:10.1080/03075079.2017.1387107

Donald, W. E., Baruch, Y., & Ashleigh, M. J. (2020). Striving for sustainable graduate careers: Conceptualization via career ecosystems and the new psychological contract. *Career Development International*, *25*(2), 90–110. doi:10.1108/CDI-03-2019-0079

Fan, J., & Smith, A. P. (2021). Information Overload, Wellbeing and COVID-19: A Survey in China. *Behavioral Sciences (Basel, Switzerland)*, *11*(5), 62. doi:10.3390/bs11050062 PMID:33925611

Ingold, J., & Valizade, D. (2017). Employers' recruitment of disadvantaged groups: Exploring the effective labour market programme agencies as labour market intermediaries. *Human Resource Management Journal*, *27*(4), 530–547. doi:10.1111/1748-8583.12154

Jaidi, Y., Van Hooft, E. A. J., & Arends, L. R. (2011). Recruiting Highly Educated Graduates: A Study on the Relationship Between Recruitment Information Sources, the Theory of Planned Behavior, and Actual Job Pursuit. *Human Performance*, *24*(2), 135–157. doi:10.1080/08959285.2011.554468

Jena, P. K. (2020). Impact of COVID-19 on higher education in India. *International Journal of Advanced Education and Research*, *5*(3), 77–81.

Kuhn, P., & Skuterud, M. (2004). Internet job search and unemployment durations. *The American Economic Review*, *94*(1), 218–232. doi:10.1257/000282804322970779

Laker, B., Godley, W., Patel, C., & Kudret, S. (2021). Four Steps to Successful Virtual Hiring. *Sloan Management Review*.

Larsen, C. A., & Vesan, P. (2012). Why public employment services always fail: Double-sided asymmetric information and placement of low-skill work in six European countries. *Public Administration*, *90*(2), 466–479. doi:10.1111/j.1467-9299.2011.02000.x

McCracken, M., Currie, D., & Harrison, J. (2016). Understanding graduate recruitment, development and retention for the enhancement of talent management: Sharpening 'the edge' of graduate talent. *International Journal of Human Resource Management*, *27*(22), 2727–2752. doi:10.1080/09585192.2015.1102159

Morse, J. M. (1994). *Critical issues in qualitative research methods*. Sage Publications.

Nimmi, P. M., Kuriakose, V., Donald, W. E., & Nowfal, M. (2021). HERO Elements of Psychological Capital: Fostering Career Sustainability via Resource Caravans. *Australian Journal of Career Development*, *30*(3), 199–210. doi:10.1177/10384162211066378

Parry, E., & Wilson, H. (2009). Factors influencing the adoption of online recruitment. *Personnel Review*, *38*(6), 655–673. doi:10.1108/00483480910992265

Patky, J. (2020). The influence of organizational learning on performance and innovation: A literature review. *Journal of Workplace Learning*, *32*(3), 229–242. doi:10.1108/JWL-04-2019-0054

Peltokorpi, V. (2021). In search of 'low-hanging fruits' or 'ideal' candidates? Understanding headhunters' candidate search activities. *Human Resource Management Journal*, *31*(3), 639–657. doi:10.1111/1748-8583.12325

Quality Indicators for Learning and Teaching. (2020). *2020 Graduate Outcomes Survey*. https://qilt.edu.au/surveys/graduate-outcomes-survey-(gos)

Saldaña, J. (2015). *The Coding Manual for Qualitative Researchers*. Sage Publications.

Saunders, M., & Townsend, K. (2016). Reporting and justifying the number of interview participants in organization and workplace research. *British Journal of Management*, *27*(4), 836–852. doi:10.1111/1467-8551.12182

Savage, M. J., James, R., Mahistro, D., Donaldson, J., Healy, L. C., Nevill, M., & Hennis P. J. (2020). Mental health and movement behaviour during the COVID-19 pandemic in UK university students: Prospective cohort study. *Mental Health and Physical Activity, 19*.

Shenoy, V., & Aithal, P. S. (2018). Literature Review of Primary Organizational Recruitment Sources. *International Journal of Management, Technology, and Social Sciences*, *3*(1), 37–58. doi:10.47992/IJMTS.2581.6012.0035

Spence, M. (1973). Job Market Signaling. *The Quarterly Journal of Economics*, *87*(3), 355–374. doi:10.2307/1882010

Subat, A., Rahman, M. M., & Rahman, M. R. (2020). Employees Perception on Recruitment and Selection Process in Banking Sector in Bangladesh. *The Journal of Management Theory and Practice*, *1*(3), 21–27. doi:10.37231/jmtp.2020.1.3.41

Suddaby, R. (2006). From the Editors: What Grounded Theory is Not. Academy of Management Journal, 49(4), 633-642.

Tarofder, A. K., Azam, S. M. F., & Jalal, A. N. (2017). Operational or strategic benefits: Empirical investigation of internet adoption in supply chain management. *Management Research Review*, *40*(1), 28–52. doi:10.1108/MRR-10-2015-0225

Tomlinson, M., & Anderson, V. (2020). Employers and graduates: The mediating role of signals and capitals. *Journal of Higher Education Policy and Management*, *43*(4), 384–399. doi:10.1080/1360080X.2020.1833126

Trendence. (2020). *Black Lives Matter Infographic: Racial justice in the workplace.* https://trendence.co.uk/thought-leadership/reports

Van der Heijden, B. I. J. M. (2020). Sustainable careers across the lifespan: Moving the field forward. *Journal of Vocational Behavior, 117*.

Van Hooft, E. A. J., Kammeyer-Mueller, J. D., Wanberg, C. R., Kanfer, R., & Basbug, G. (2021). Job search and employment success: A quantitative review and future research agenda. *The Journal of Applied Psychology*, *106*(5), 674–713. doi:10.1037/apl0000675 PMID:32658493

Vinayak, P. C., Khan, B. M., & Jain, M. C. (2017). Role of signaling theory in potential applicant attraction: An employer branding perspective. *International Journal of Emerging Research in Management & Technology*, *6*(4), 2278–9359. doi:10.23956/ijermt/V7I3/0188

Workplace Gender Equality Agency. (2021). *Higher education enrolments and graduate labour market statistics*. https://www.wgea.gov.au/resources/publications/higher-education-enrolments-and-graduate-labour-market-statistics

## ADDITIONAL READING

Baruch, Y., Bhaskar, A. U., & Mishra, B. (2019). Career dynamics in India: A two-wave study of career orientations and employability of graduates. *Personnel Review*, *49*(3), 825–845. doi:10.1108/PR-10-2018-0429

Bright, J. E. H., Pryor, R. G. L., & Harpham, L. (2005). The role of chance events in career decision making. *Journal of Vocational Behavior*, *66*(3), 561–576. doi:10.1016/j.jvb.2004.05.001

Chiesa, R., Fazi, L., Guglielmi, D., & Mariani, M. G. (2018). Enhancing sustainability: Psychological capital, perceived employability, and job insecurity in different work contract conditions. *Sustainability*, *10*(7), 2475. doi:10.3390u10072475

D'Armagnac, S., Al Ariss, A., & N'Cho, J. (2021, March 15). Talent management in turbulent times: Selection, negotiation, and exploration of strategies for talent management in aeronautics and space industries. *International Journal of Human Resource Management*, 1–29. doi:10.1080/09585192.2021.1879205

De Vos, A., & Van der Heijden, B. I. J. M. (2017). Current thinking on contemporary careers: The key roles of sustainable HRM and sustainability of careers. *Current Opinion in Environmental Sustainability*, *28*(1), 41–50. doi:10.1016/j.cosust.2017.07.003

Donald, W. E., Ashleigh, M. J., & Baruch, Y. (2018). Students' perceptions of education and employability: Facilitating career transition from higher education into the labor market. *Career Development International*, *23*(5), 513–540. doi:10.1108/CDI-09-2017-0171

Nimmi, P. M., Joseph, G., & Donald, W. E. (2022). Is it all about perception? A sustainability viewpoint of psychological capital and life well-being of management graduates. Higher Education. *Skills and Work-Based Learning.*, *12*(2), 384–398. doi:10.1108/HESWBL-01-2021-0004

Tomlinson, M. (2021). Employers and Universities: Conceptual Dimensions, Research Evidence and Implications. *Higher Education Policy*, *34*(1), 132–154. doi:10.105741307-018-0121-9

Veld, M., Semeijn, J., & van Vuuren, T. (2015). Enhancing perceived employability: An interactionist perspective of responsibilities of organizations and employees. *Personnel Review*, *44*(6), 866–882. doi:10.1108/PR-05-2014-0100

## KEY TERMS AND DEFINITIONS

**Chance Event:** The occurrence of a circumstance that had not previously been foreseen.

**Early Career Talent:** An individual about to graduate from university or in the initial stages of their employment (usually with less than three years of work experience).

**Graduate Recruiter:** An individual who works for (or on behalf of) an organization with the remit of recruiting graduates to meet the headcount demand of the business.

**Graduate Recruitment:** The process of attracting, selecting, and hiring individuals who are undertaking the university-to-work transition upon completion of their degree studies.

**Job Board:** An online space where jobseekers can share their availability for work and organizations can share employment opportunities.

**Talent Management:** The process of attracting, hiring, and retaining employees across an organization.

**University Careers Advisor:** An individual who works for (or on behalf of) a university to provide careers support to current students and recent graduates.

## APPENDIX 1: SURVEY

### Introduction

We are researching how job boards and the graduate recruitment process can be optimized. You have been invited to participate because you are based in Australia and are either a university student or have graduated within the last twelve months.

### Section One: Participant Information

**Question 1.** What is your gender? *Female/Male/Other (Please Specify)/ Prefer not to Say*
**Question 2.** What is your resident status? *Resident/Non-Resident*
**Question 3.** What is your life status? *University Student/Recent Graduate*
**Question 4.** Are you a job board user? *Yes/No*
**Question 5.** Are you registered with a job board? *Yes/No*

### Section Two: Job Board Experience

The next section focuses on your experience of using job boards.
If you have not used a job board then please skip to Section Three.

**Question 6.** How relevant were the notifications for job opportunities from job boards?
None, A Little, A Moderate Amount, A Lot, A Great Deal
**Question 7.** How relevant were employer job opportunities from job boards to your interests?
None, A Little, A Moderate Amount, A Lot, A Great Deal
**Question 8.** How satisfied were you with your experience of using job boards?
Not at all Satisfied/Not Satisfied/Neutral/Satisfied/Extremely Satisfied
**Question 9.** How valuable were job boards as a primary source of information about an employer?
*Not at all Valuable/Not Valuable/Neutral/Valuable/Extremely Valuable*

### Section Three: Job Board Optimization

The next section focuses on job boards and how they could be optimized. For the purpose of this questionnaire the term "strong fit" refers to a situation where an applicant would be expected to reach at least the final stages of the recruitment process.

**Question 10.** You register a profile and opt-in to be contacted by employers. An employer reaches out to you to attend an event or to apply for a role/programme. You can accept or decline the offer. How valuable would this feature be to you?
*Not at all Valuable/Not Valuable/Neutral/Valuable/Extremely Valuable*

**Question 11.** You register a profile and opt-in to be contacted by employers. An employer considers you to be a strong fit and invites you to an advanced assessment stage via a fast-track route. You

can then accept or decline. How valuable would this feature be to you?
Not at all Valuable/Not Valuable/Neutral/Valuable/Extremely Valuable

**Question 12.** You register a profile and use technology to find employers who would consider you a strong fit based on your profile and the employer's hiring profile. If you are interested, you can apply to that organization knowing you are already a strong fit. How valuable would this feature be to you? *Not at all Valuable/Not Valuable/Neutral/Valuable/Extremely Valuable*

**Question 13.** You register a profile and use technology to rate your employability. You benchmark your profile against a database of other students and graduates to see how you rate, your strengths, and your areas for improvement. How valuable would this feature be to you?
Not at all Valuable/Not Valuable/Neutral/Valuable/Extremely Valuable

**Question 14.** You register a profile and use technology to rate your employability. You update your profile and the changes made are reflected in your employability ranking and benchmark against a database of other students and graduates. How valuable would this feature be to you?
Not at all Valuable/Not Valuable/Neutral/Valuable/Extremely Valuable

**Question 15.** You register a profile and use technology to rate your employability. You have the option to receive automated feedback on ways to improve your employability. How valuable would this feature be to you?
Not at all Valuable/Not Valuable/Neutral/Valuable/Extremely Valuable

**Question 16.** You register a profile and opt-in to be contacted by employers for paid work related to your career preferences. How valuable would this feature be to you?
Not at all Valuable/Not Valuable/Neutral/Valuable/Extremely Valuable

**Question 17.** You register a profile and opt-in to be contacted by employers for paid work that is not related to your career preferences. How valuable would this feature be to you?
Not at all Valuable/Not Valuable/Neutral/Valuable/Extremely Valuable

**Question 18.** You register a profile and opt-in to be contacted by employers for ad-hoc paid insights. For example, market surveys, research projects, brand/product insights. How valuable would this feature be to you?
Not at all Valuable/Not Valuable/Neutral/Valuable/Extremely Valuable

**Question 19.** What, if anything, would make a significant improvement to the effectiveness of job boards for students and graduates? Please write in full sentences and provide as much information as possible. *Free Text Response*

**Question 20.** What additional features would be useful to you on a job board? Please write in full sentences and provide as much information as possible. *Free Text Response*

## Section Four: Graduate Recruitment Process

The next section focuses on the graduate recruitment process and how it could be optimized. To what extent do you agree with the following statements:

**Question 21.** I found it relatively straightforward to learn about internship or graduate job opportunities.
*Strongly Disagree/Disagree/Neutral/Agree/Strongly Agree*

**Question 22.** I generally found completing online applications to be a simple and efficient process.
*Strongly Disagree/Disagree/Neutral/Agree/Strongly Agree*

**Question 23.** From my experience, the number of recruitment stages (e.g., application, testing, video interview, assessment center, interview etc.) seemed appropriate.
Strongly Disagree/Disagree/Neutral/Agree/Strongly Agree

**Question 24.** When I look back at all the employers that I applied to, the amount of time spent going through the recruitment process was reasonable.
Strongly Disagree/Disagree/Neutral/Agree/Strongly Agree

**Question 25.** Overall, I found the recruitment process to be efficient.
Strongly Disagree/Disagree/Neutral/Agree/Strongly Agree

**Question 26.** What, if anything, would make a significant improvement to the effectiveness of the graduate recruitment process? Please write in full sentences and provide as much information as possible. *Free Text Response*

## Close

You have completed the survey. Thank you very much indeed for your time.

# Chapter 4
# A Primer for Developing Computer-Mediated Solutions for the Modern Workforce:
## Using Artificial Intelligence for Situationally Aware Human-Computer Interaction

**Edward Bednar**
*Columbia University, USA*

## ABSTRACT

*With perceptual capabilities, computers can intelligently function as a part of our everyday lives, helping us make sense of what is happening as we experience and navigate through many different types of situations. In this way, computing systems can be situated when they combine machine perception with an individual's background knowledge to observe, explore, and interpret human and environmental activity in a way that supports decision-making. Many of the current, prominent situated computing solutions are consumer-focused in nature. But these systems will, in time, change the way we work as well as how we learn. Many disciplines are adapting and changing in the process, and many opportunities remain, including the use of situated computing systems for workforce education. This chapter offers many opportunities on how to innovate and improve workforce education by leveraging the power and affordances of personal mobile devices and intelligent personal assistant technologies to turn everyday situations into everyday learning opportunities.*

DOI: 10.4018/978-1-6684-3996-8.ch004

## INTRODUCTION

### Rapid Shift to Digital Workforces

In early 2020, SARS-CoV-2, the coronavirus that causes the disease COVID-19 (Centers for Disease Control and Prevention [CDC], 2021), ensnared the world. As the virus quickly spread, all organizations—companies, governments, schools, nonprofits—had to shift their operations to digital models and approaches, almost overnight.

At this point—good or bad—every organization knows where it stands in terms of its ability to function as a digital entity, especially in terms of functioning with a digital workforce. And as the global workforce shifted to remote work, intelligent personal assistants became another nearby device, always accompanying workers as they do their jobs.

This unprecedented transformation to a digital workforce has challenged and changed the workforce in many ways, perhaps permanently. According to Arenas and Silver-Malyska (2021), citing a 2020 study, more than half of all employers in the United States anticipate that remote work (i.e., working from home or somewhere other than a traditional office) will likely remain after the coronavirus pandemic is over (pp. 50-51). It is, thus, a good time for employers to consider the needs and possibilities of advanced technological approaches to training and skill development for the modern workforce.

In 2018, when the initial chapter, "A Roadmap for Developing Computer-Mediated Solutions for Workforce Learning," was written for this book's first edition, it was noted that Google, Facebook, and many other companies were developing innovative situational and contextually aware solutions for personal mobile devices. At the time of this writing, looking back over just a few short years, this point was certainly an understatement—far exceeded by many innovations in this space since that time.

According to Lee (2017), digital technology has reached the point where its possibilities are limited more by human imagination than any physical constraints. What can be accomplished by software, which has become a digital medium for creativity, far exceeds what can already be accomplished today, even without further technological improvements (p. 92). This headroom for what we can accomplish with digital technology is a good thing, especially now that technology plays an outsized role as we individually and collectively reorient our lives in response to a global pandemic—as we reorient to a new normal.

This chapter looks at contemporary computer-mediation approaches—how the current use of artificial intelligence and machine learning can inspire the creation of situationally aware human-computer interactions—to identify ways of approaching training and skills development in the modern workforce. It begins with a review of situated learning and informal learning theories to develop an educational context for situated computing. It then covers contemporary technologies for developing situated computing systems. Then, the chapter aims to provide a conceptual roadmap for developing situated computing solutions for workforce education using existing technologies, referencing examples from commercial product offerings.

### Personal Mobile Devices

In the mid-1990s, a group of researchers at MIT used computers and peripheral equipment available at that time to experiment with the idea of wearable technology. This assembly of researchers, eventually named the MIT Media Lab Wearable Computing Group, carried computers and radio transmitters around in backpacks, stored keyboards in their pockets, and wore eyeglasses with digital displays integrated into the frames (Turkle, 2006, p. 220). By lugging around what was still at that time big computing equipment, these innovative researchers were exploring the future of personal mobile device technology—"wireless devices with multimedia user interfaces such as cell phones, tablet computers, and so on" (Hennessy & Patterson, 2019, p. 7). That is, technology that is wearable, mobile, and convenient for modern use.

Many years later, in 2007, Apple fundamentally changed the personal mobile device landscape—accessibility, connectivity, the potential for creative use—by putting extraordinary computational power and the Internet literally in our hands to use anywhere we might be, even, and perhaps especially, while on the go. There are, of course, many personal mobile devices that pre-date the iPhone. Some, most notably the BlackBerry, designed and marketed by Research in Motion Limited [now BlackBerry Limited], profoundly impacted workforce productivity, especially for remote communication with email. But in 2007, when Apple released the iPhone, it was a seminal moment in what is still our brief history of computing. Someday we may stop pointing back to this moment as being so pivotal, but not today.

For the first time, the physical capabilities of a personal mobile device were integrated and improved with affordances like a multi-touch interface. The iPhone, importantly, also became a must-have consumer technology. But more importantly, this mobile-computing system was significantly enhanced when Apple introduced the App Store, a software development and distribution platform. This platform fueled the proliferation of applications, and thus the many uses for these devices. Similarly, Google, together with several hardware vendors, created a competing commercial mobile-computing system based on the Android operating system.

Although they are not exactly wearable, the collective proliferation of iPhone and Android devices has resulted in a new norm where computing devices are now rarely very far removed from our attention. Now, in workforce settings, nearly every employee has a smartphone. This situation contrasts with just a subset of employees previously having specialized mobile devices like the Blackberry.

We are now at a point where being able to communicate instantly with anyone around the world has become a background fact, an ambient part of the technological basis through which we understand and manage our daily lives (Lee, 2017, p. 30), both individually and collectively. This improvement in network access and speed has opened up many possibilities for developing mobile computing systems backed by cloud computing infrastructure and, especially, very powerful data analysis technologies based on artificial intelligence and machine learning.

## Intelligent Personal Assistants

In addition to personal mobile devices, intelligent personal assistants such as Google Home and Amazon Alexa devices have become available, even ubiquitous. These devices are always on, always listening—to foreground and ambient sounds—and ready to provide information or to complete digital tasks. In many ways, "these machines observe, learn, and reflect human thought, and then synthesize structures of knowledge" (Lee, 2020, p. 55).

## CONTEXTUAL AND SITUATED COMPUTER-MEDIATED SYSTEMS

### Situated Learning

#### Pedagogy

Learning theories—such as the prominent pedagogical theories of behaviorism, constructivism, and connectivism—provide instructional strategies and techniques for facilitating learning and serve as a foundation for making strategic decisions in that regard (Ertmer & Newby, 1993, p. 50). They provide methods for considering how learning will occur, the factors that influence learning, the role of memory in learning, and how transfer occurs. Additionally, they present a mechanism for evaluating different types of learning (Ertmer & Newby, 1993, p. 53). With any process of knowledge construction in a learning strategy, the instruction should be designed to create the conditions for meaningful learning (Wilson, 2017, p. 61). Put into practice, an important way in which learners interact with their environments is through situations that allow them to bump up against the world in order to test their thinking (Bransford & Schwartz, 1999, pp. 82-83).

However, with a digital workforce, opportunities for in-person instruction may be limited, or nearly impossible as has been the case during the coronavirus pandemic. Formal instruction must, therefore, be accomplished through digital instruction channels, in either static or situated settings. But, with little or no face-to-face contact between students and instructors during online computer-based (i.e., digital) instruction, there are also fewer opportunities for instructors to get feedback from students than in a traditional classroom setting (Ortigosa, Martin, & Carro, p. 1). According to el Kaliouby (2017), given this limitation, there are fewer touchpoints to tell if a student is struggling with a lesson or assignment. But if intelligence is built into a learning system such that it can personalize the learning experience, it could, for example, offer additional explanations of a concept, slow down the lesson in times of confusion, or tell a joke for a fun pause (p. 9).

For example, as reported by Ortigosa et al. (2013), hypermedia has been used in e-learning environments to support personalized learning by recommending the most suitable tasks to be accomplished by each student according to personal features, preferences, previous actions, context, etc. Different workspaces are then generated to support each activity in a personalized manner with the most suitable content and tools for the individual learner/student (p. 3). The input for this type of personalization can be obtained and can be used to adapt the learning system—enhance its native affordances—based on the student's learning state (Ortigosa et al., 2013, p. 1).

#### Situated Learning Theory

As a theory, situated learning—or situated cognition—presumes that knowledge accrues in meaningful actions that have relative meaning to each other within some cultural system (Driscoll, 2017, p. 55). More specifically, situated cognition theory suggests that learning is tied to the activity, context, and culture within which knowledge is developed and used—through which, an authentic setting for learning can be created (Turkay, Hoffman, Kinzer, Chantes, & Vicari, 2014, p. 5).

Generally, human cognition is all the ways in which people draw information from the world, combine that information with the knowledge that they already possess, and subsequently, interpret and make decisions about the information (Baber, 2003, p. 11). Situated cognition is largely based on embodied cognitive science, which is a theoretical framework for understanding cognition in terms of the whole body and its interaction with the world (Dawson, 2013, p. 11). In embodied cognition theory, the mind uses the external world as scaffolding to enhance the cognitive function that occurs between sensory inputs and behavioral outputs (i.e., sensing and responding to what is happening) (Dawson, 2013, p. 11-12).

When, for instance, we use a map—in digital or analog form—while we are attempting to navigate in real-time, we are learning where to go relative to where we are. We are constructing an understanding of our situation and applying that understanding to our goal of getting to where we want to be. This experience is different, from a learning standpoint, from just perusing a map at home; it is situational regarding our environment and our actions rather than just informational. Since it is situated, it involves thinking that relates to and expands on the information that has been presented, meaning that the thinking is a form of elaboration (Anderson, 2015, p. 141).

Because of the effect elaboration has on memory, information that is presented in the context of solving problems is more likely to be subsequently remembered and used than information presented in the form of simple facts (Bransford & Schwartz, 1999, p. 64). Looking at a map before driving somewhere is different cognitively from simply driving somewhere or just thinking about where you would like to go. The former is a rote activity whereas the latter draws on elaborative processing of the situation.

## Cognition in Everyday Situations

Situated learning theory is principally focused on how everyday cognition occurs, specifically that the nature of human knowledge is to dynamically construct meaning in real-time as we navigate situations (Clancey, 1995, p. 2) and as we experience whatever the world has to offer at any given moment. From a neuroscience standpoint, it is likely that human information processing is hierarchically organized by the brain. However, we don't yet know how, in a way where some information is processed in detail, with great effort, while other information is processed quickly, with less, or, perhaps very little, effort (Baber, 2003, p. 11).

According to embodied cognition theory, the latter, shallower type of cognitive function reduces the information that is physically manipulated and stored by framing it within the situation—in a way, out in the world rather than internally—rather than attempting to mentally store and manipulate everything relevant to that given situation (Robbins & Aydede, 2009, p. 7). This cognitive efficiency is a form of mental offloading that significantly reduces the load on working memory (Robbins & Aydede, 2009, p. 6) and is an important method of carrying the cognition of everyday things, including workplace activities.

## Anchored Instruction

Much of the historical influence of situated learning theory has been in designs for anchored instruction, which is a means of providing a simulated-situational context for problem-solving (Driscoll, 2017, p. 56). For example, for many years, very sophisticated simulators have been developed for anchored instruction purposes, putting situated learning theory into practice for the training of pilots. But these are big, expensive, highly specialized, and stationary systems. Now, with the proliferation of consumer, personal mobile-device and intelligent personal assistant technologies, the intersection between human interaction and technology can be mediated in real-time. Rather than for simulation, this mediation can be for the purpose of immediate, informal, active learning within a situational context—technology meeting us in everyday occurrences like GPS-based navigation systems to support, influence, and, hopefully, improve our lives.

Thus, anchored learning from a situated perspective occurs through the learner's active participation in real or simulated events and activities (Driscoll, 2017, p. 55)—real-world situations harnessed into learning opportunities. The computer science part of anchored instruction is about using the mechanics of machines to process user interactions within that anchored context. For example, evaluative language can be analyzed during computer-based interactions to identify emotionally based phenomena like anger or boredom. Additionally, information such as the structure of social networks and user profiles and preferences can be utilized to enhance the accuracy (Banamara, Toboada, & Mathieu, 2016, p. 203) of that computer mediation. Collectively, once these phenomena are understood algorithmically, they can be mediated programmatically in ways that improve the quality of these anchored-instruction interactions.

## Informal Learning and Experiential Computing

### Informal Learning

According to Carliner (2017), citing a 2005 article, informal learning is a process in which learners set their own learning objectives, which contrasts with formal learning where those objectives are set by an instructor or instructional designer. Oftentimes, though, informal learning activities include some elements of formal learning characteristics (p. 142). In this way, formal learning can be linked to informal learning.

Much of the success with informal learning is based on motivation and accessibility. Suppose we want to learn something and have an opportunity to do so through accessible content, via a mediated solution, or both. In that case, we are likely well-positioned to succeed in that effort—even if doing so is unintentional. MasterCard, for example, developed a learning platform called Degreed, which enables individuals and subject matter specialists to curate learning "playlists" mixing internal and external learning content—articles, videos, podcasts, to name a few—into a personalized learning experience ("Global Human Capital Trends," 2016, p. 62).

Informal learning is manifested through specific learning processes, including: (1) Non-Formal Learning – instruction that occurs outside schools, workplaces, etc.; (2) Incidental Learning – knowledge unexpectedly gained through interactions; and (3) Self-Directed Learning – formal educational activities undertaken by the learner in a self-directed manner (Carliner, 2017, p. 143).

The second informal learning process—Incidental Learning—offers a significant opportunity for situated learning solutions, including in workforce settings. This opportunity as a facilitated learning process is interesting because it can be triggered—activated situationally—and subsequently mediated for the purpose of targeted, directed learning activities. If done cleverly, learners may not even realize that they learned something until long after the situation or experience occurred (Carliner, 2017, p. 143) even, again, if unintentional.

### Experiential Computing

Computing as part of experiential interactions is a form of digital mediation for everyday activities through embedded computing capabilities (Yoo, 2010, p. 213), meaning, somewhat, that experiential computing is the mediation of human experiences through digital technology (Yoo, 2010, p. 215). Much of the literature about experiential computing focuses on the ability to mediate experiences because of the intersection with computer-enabled devices that takes place during those experiences.

The Internet of Things is a more recent descriptor for this type of computing, where everyday items like thermostats are Internet-enabled. Computing takes place in an everyday artifact, so the interactions are more of a peripheral activity than a dedicated one (Yoo, 2010, p. 217). An intelligent thermostat can, for example, recognize weather patterns, the user's preferences, and continually intervene. This type of interaction can be completely peripheral (i.e., automatic).

One of the most compelling applications of experiential computing solutions is to assist people in the completion of activities—to augment human tasks with assistive technology. These activities may be actions the computer completes or task assistance that the computer provides (Carliner, 2017, p. 143), like reminders.

We are in an age where the systems that are coming online offer unprecedented capabilities which can be harnessed into situationally relevant and personally oriented solutions. But relevance is key and humans are often anything but predictable, including, especially, in their use of personal mobile devices and intelligent personal assistant technologies.

For instance, according to Akbiyik (2010), learning is associated with our cognitive abilities but also our emotions, expectations, prejudices, self-efficacy, and social needs. Accordingly, emotions initiate, terminate, and disrupt information processing and can result in selective information processing as well as how recall is organized cognitively. In this way, according to a 1988 study, emotions have an effect on learning and achievement, mediated by attention, self-regulation, and motivation, and they direct the learner toward or away from learning matters in educational situations (p. 5).

Most of the existing solutions for situated computing are commercially driven products from companies like Google, Apple, and others—not products and services specifically designed for situated workforce learning. So we have to draw on these solutions as examples and use them to consider the possibilities for computer-mediated solutions for the modern workforce. We can use them to dream about possibilities, for chances are good that there are immediate options for creating these types of situated computing solutions for the modern workforce.

## Perceptual Computing

Similar in the ways that the personal computer made computing "personal," the affordances that personal mobile devices and intelligent personal assistants have achieved has unleashed the ability to make computing perceptual. "Perceptuality" is an aspect of human-centric computing systems—systems that sense, measure, and monitor data about what a particular individual in a specific context is doing, and then those still external systems react to that person's physical, cyber, and social realms to, in many cases, intimately support decisions and actions (Sheth, Avantharam, & Henson, 2016, p. 64).

With perceptual capabilities, computers can intelligently function as a part of our everyday lives—part of our everyday experiences—helping us to make sense of what is happening and joining in with us as we experience and navigate through many different types of situations.

### Sensory Capabilities

In 2007, the first iPhone, for example, had three sensors that provided perceptual input and actuation to its primary user. The proximity sensor enabled the device to detect when objects were nearby. This feature was mainly employed to disable the touch screen and turn off the display while the device was being used as how a conventional phone would be used, held close to the ear. The ambient light sensor measured the light intensity of the physical environment. By calibrating the brightness of the display, based on the conditions where the device was being used, this sensor enhanced the visual experience, reduced eye strain, and helped preserve the battery. The accelerometer detected movement of the device. It was initially just used to change the display orientation between portrait and landscape modes.

These three sensors were designed, built, and integrated into the iPhone to make it more accommodating to the user—to make the device human-centric—affording simple, immediate benefits. While other devices like the Blackberry and Palm Pilots had touch screens and usability features, they did not have sensory capabilities through which the device and user interactions could be situated based on environmental conditions, including ambient (i.e., background) conditions.

Along with advances in software, innovative people and organizations will continue to develop and further advance personal mobile-device and intelligent personal assistant hardware and software. As the technology continues to advance, additional perceptual capabilities will emerge, which will allow developers to create additional human-centric features and situational interventions that leverage those capabilities. Many personal mobile devices now have, for example, gyroscopes, fingerprint detectors, barometers, compasses, magnetometers, and photodetectors, to name a few other commonly found sensors that can be leveraged for situational data capture.

Additionally, wireless connectivity technologies built on standards for data exchange like Bluetooth® enable the integration of personal mobile devices with external devices. This integration creates a seemingly endless array of possibilities for expanding the sensory data that perceptual computing systems can leverage, including physiologically-based sensing capabilities. As examples, external, specialized devices with sensors can capture and relay data like blood pressure and blood sugar levels, making a personal mobile device much more than just an accessory for a person living with heart disease or diabetes, respectively.

## Output and Auxiliary Capabilities

The typical output and auxiliary capabilities of personal mobile devices—speakers, cameras, microphones—may no longer seem unique or impressive. Still, their use as a channel for interactivity will continue to develop and will play an important role in perceptual computing over time. For instance, Pokémon Go, released by Niantic in July 2016, bridged a virtual world with the real world by taking advantage of commonly available personal mobile-device capabilities—GPS sensor, Internet connectivity, the touch screen display, and the camera—to create a cartoon monster scavenger-hunt game, which was the first widespread, massive implementation of augmented reality (McDermott, 2016, p. 27).

As an additional example, Snapchat allows users to augment pictures with the artificial addition of bunny ears and mustaches, allowing for creativity and self-expression within a social media environment. Pokémon Go and Snapchat are using personal mobile devices to provide augmented reality solutions even though the devices these applications run on were not explicitly designed to provide that type of capability. These companies—and many others—are simply reimagining and repurposing the input and output capabilities of today's personal mobile devices to build innovative products. This cycle of innovation in the personal mobile-device and intelligent personal assistant space is just beginning, but the rate of adoption of their technology affordances and the speed at which solutions are arriving is accelerating to the point where yesterday's ideas are quickly becoming today's must-have applications.

### Internet Connectivity and Cloud Computing

While modern personal mobile devices and intelligent personal assistants are powerful and their sensors can effectively collect data, they are still resource-constrained from the standpoint of computational capacities. Using a classical view of balancing computational resources, for example, a personal mobile device's wireless radio can interact with cellular towers to collect data while the CPUs [central processing units] process instructions that implement positioning algorithms, all in a performant manner, but these computational resources can burn through the device's battery capacity very quickly if the load is not properly balanced.

This type of computational processing—massive amounts of data about individual interactions—must also leverage institutional information for enriching that data (e.g., entity masters, lexicons, geolocation anchors). This enrichment requires substantially more powerful computational resources than a personal mobile device or intelligent personal assistant can handle on its own.

At the time of this writing, cloud computing services have become mainstream, offered as for-rent hosted solutions, and when paired up with resource-constrained personal mobile devices, can provide a seemingly endless supply of data storage, computation, and energy (Vinh, Bouzefrane, Farinone, Attar, & Kennedy, 2015, p. 235). The primary public cloud providers—Amazon AWS [Amazon Web Services], Microsoft Azure, and Google GCP [Google Cloud Platform] have also released higher-order services that abstract complex technologies like artificial intelligence and machine learning to make them accessible for applications such as image processing and speech recognition. These sophisticated capabilities are solid and the pace of innovation by these companies will continue to advance.

### Summary

Collectively, these technology affordances, amplified by the pervasiveness of personal mobile-device and intelligent personal assistant technology, present an immediate and accessible opportunity to leverage perceptual computing methods and systems to create computer-mediated solutions that facilitate and/or support many everyday interactions—everyday situations that we commonly find ourselves in, like needing a reservation at a restaurant or finding an alternate route home because of traffic situations. If we draw on ideas from the learning sciences and computer science, there is a rich collection of theoretical frameworks and practical work to provide a solid basis for developing these computing solutions—these situated computing solutions—including modern workforce solutions for situated learning.

## Situated Computing

Computing systems are situated when they combine machine perception with background knowledge to observe, explore, and interpret human and environmental activity in a way that supports decision-making (Sheth et al., 2016, pp. 64-68). These systems incorporate appropriation by users within the context of their immediate situation (Beaudouin-Lafon & Mackay, 2000, p. 369). In this way, human interaction with the computer can be an integrated experience from the standpoint of environmental factors like time and location, but also of more personalized factors like preferences and activity patterns that apply within that situational context. As situated computing systems perceive and leverage our physical environment to know who we are, where we are, what we are doing, and what we want, they can be used to bridge the gap between our intentions and the actions we can take to achieve them (Gershman, McCarthy, & Fano, 1999, p. 1). They can, in many ways, intelligently intervene.

## Computer Mediation

The opportunity to provide relevant and timely situated information is a result of the affordances of modern computer mediation—using, for instance, the perceptual capabilities of personal mobile and intelligent personal assistant devices and the pattern identification capabilities of artificial intelligence and machine learning to develop probabilistic models of what someone is doing or about to do. While sensory capabilities serve as the primary entry point of situated computing solutions, the data generated by the sensors must be processed to the extent that meaning is derived from those values.

This processing must occur immediately for responsiveness purposes, and, additionally, over time, for relevance purposes. For example, the opportunity to provide a situated navigation service that adds value to the user by proposing alternate routes to someone who is driving somewhere ends when the exit for that alternate route has just passed. Over time, in the same scenario, if the interventions by the navigation service often, or worse, always, make the same recommendation but that alternative is never chosen by the user, an otherwise potentially useful computer-mediated solution becomes, perhaps, an annoyance, perhaps even one that gets uninstalled from the device.

Much of this processing is a function of artificial intelligence, which is the science and engineering of building intelligent machines, specifically for the purposes of situational computing via intelligent computer programs (McCarthy, 2007, p. 2). Intelligence, in this context, is the computational ability to generate the mechanisms of reasoning through computational procedures (McCarthy, 2007, pp. 2-3). These are procedures that focus on a specific domain of knowledge and/or inquiry, like getting somewhere in the most efficient way possible both immediately and, over time, as we continually approach the same situation.

## Artificial Intelligence and Machine Learning

According to McCarthy (2007), the field of artificial intelligence is the science and engineering of machines with the intelligence to solve problems and achieve goals in similar ways that humans do (pp. 2-5). Artificial intelligence is a vast field, one where modern computing capabilities are rapidly catching up to what has been a long-standing area of scientific inquiry. By "thinking" in an artificial, technological manner, computing systems learn and adapt within a contextual setting rather than just perform pre-programmed actions.

Using artificial intelligence and machine learning, computing systems can now reliably learn within reasonably defined interactivity constructs and, then, become more useful given both immediate and accumulated knowledge. These constructs of human interaction with computing systems provide data (e.g., a string of text in a Google search, sensory input values from a wearable device or smartphone) which can then be analyzed, even deeply, over time. In this way, data can even be used to identify and build an affective understanding of a user's emotional expression and its generating state (Picard, 1995, p. 3). As they have been applied in commercial and consumer ways, these concepts can help productively frame how to develop computing systems that incorporate a machine-based situational understanding and used for inspiring solutions in an instructional context for the modern workforce that alters their interactivity methods within that contextual understanding.

The artificial intelligence upon which situated computing systems function is created by converting massive amounts of raw data (e.g., sensor data) into symbolic representations that are evaluated by computational procedures (i.e., machine learning) relative to a variety of known and derived relationships and associations (Sheth, 2010, p. 89)—a collection of well-defined rules for manipulating symbolic representations (Dawson, 2013, p. 7). Examples of artificial intelligence and machine learning capabilities include pattern recognition, image analysis, text processing, and sentiment analysis (Sheth, 2010, p. 89), which can be used to build computing solutions that, for example, recognize speech, understand natural languages (e.g., search engines), can see, provide expertise (McCarthy, 2007, pp. 8-9), and even beat humans when playing games like chess (McCarthy, 2007, p. 6).

These computing systems can contextualize interactions within a cognitive setting by, for instance, combining sensory inputs (e.g., ambient noises), artificial intelligence, and machine learning to process, represent, and reason over data points, leveraging that contextual understanding to improve human activities and experiences (Sheth, 2010, p. 89) in many ways. For instance, these types of systems can detect that we are driving home from work and recommend an alternate route due to traffic conditions. They can recognize how fast we are driving and provide subtle, or even not so subtle, alerts or recommendations to slow down. They can recognize that we are entering a secure facility in a workplace, where confidential information is handled, and remind us about policies that are central to interacting with and protecting that information.

As these computing systems detect and interpret aspects of the user's environment and experience, using, for example, even just the types of sensors in the earliest generation iPhone, they can understand and respond to events as they occur (Hull, Neaves, & Bedford-Roberts, 1997, p. 146). At any given time, these responses can be tailored to our multitude of intentions, both conscious and unconscious, to which we assign varying levels of both importance and relevance (Gershman et al., 1999, p. 1). The landscape of potential uses for situated computing solutions is vast, including use as tools for public education that could change some aspects of the culture of a country—of its politics—and its global relationships. Or even, just for the betterment of a modern workforce.

## Intuitive and Appropriately Applied Functionality and Interventions

The possibilities with situated computing solutions and their unique perceptual affordances may seem endless, which is good. Still, a level of intuitiveness and appropriateness must be integral to their function if they are to be considered useful and intelligent—they must reflect that in whatever we are doing, we are psychologically tuned into the connections that matter (Turkle, 2008, p. 122)—for instance, using commercial examples: (1) Localized information about nearby restaurants could be provided at any time but should reflect our interests, budgets, and, perhaps, what time it is, and do so in a culturally-aware manner. For example, typical meal times can vary considerably in different worldwide regions. Additionally, social, cultural, and religious norms can vary significantly as well, making a seemingly straightforward situational context considerably complex. (2) Contextually rich information about an artist could be presented while we are standing in front of their work in a museum, but the system better be finely tuned enough to know, with certainty, where we are. (3) Alerts from integrated, connected monitors can be provided to report on physiological matters like a person's pulse, activity level, or blood sugar. But the alerts need to be considerate, able to additionally discern where we are and what we are doing, and only be disruptive if it is absolutely necessary (Hull et al., 1997, p. 151), functioning in a manner that ensures privacy and confidentiality.

The boundaries between solutions that are helpful versus inappropriately infringing on privacy must be intentionally balanced and respected when developing these types of situated computing systems. These examples of situated computing solutions may seem straightforward, but they are also not necessarily as simple as they sound from a design, algorithmic, data engineering, and computational standpoint. Yet many innovative enterprises are finding ways to provide direct, personalized services using situated computing systems, so much so that, while still simple and basic, these solutions are becoming quite common and even relied upon.

There are also plenty of examples where situational computing has failed to achieve its desired outcome. Microsoft for example, developed Clippy, the animated paperclip—their first automated office assistant which would exhibit joyful expressions right after annoying people, perhaps while they were even searching for how to turn it off (Picard, 2003, p. 61).

It's almost difficult to remember that as much as every car once held a map, now drivers rely on their nearly ubiquitous GPS systems or GPS applications on their phones. While the foundational technology constructs for developing and providing these situated computing solutions are cutting edge and relatively new, they are also already largely understood and reasonably accessible, especially given the availability of cloud computing.

## Cloud Computing

In simplistic terms, cloud computing is a systems engineering approach where a collection of configurable computing resources (e.g., networks, servers, storage systems, applications, services) can be rapidly provisioned, released, operated (Lewis, 2017, p. 8), and accessed over the Internet. As an approach, cloud computing is still new and emerging but it is also mainstream and accessible at the same time, building on decades of prior and evolving systems design methods.

Three aspects of cloud computing are especially relevant to building situated computing systems: (1) Computing infrastructure can be provisioned in small increments, providing flexibility regarding infrastructure costs, especially upfront infrastructure costs. (2) Massive amounts of computing infrastructure are available for provisioning, enabling systematic functions like processing large amounts of sensory information accessible. (3) Many services are offered by cloud infrastructure providers that implement complex system capabilities like machine learning, a form of artificial intelligence. Instead of building an entire machine learning system, including the infrastructure, these services make it possible to build solutions on an existing system provided by the cloud platform rather than dealing with the deep system engineering complexities of that infrastructure, including the scalability and security of the infrastructure.

## Summary

While, at this point, many of the current, prominent situated computing solutions are consumer-focused in nature, these systems will, in time, change the way we work as well as how we learn. Many disciplines are adapting—most assuredly fundamentally changing—in the process. And many opportunities remain, including the use of situated computing systems for learning.

## Computing Solutions for Education in the Modern Workforce

Creating realistic contexts and situations for learning must be emphasized if learners are to build authentic knowledge from their participation in workforce education and training programs (Park, Kim, & Yu, 2011, p. 37). Additionally, as with conventional academic settings, workforce learners bring their experiences—but within the context of their work and the workplace—to the instructional intervention (Tracey & Morrison, 2017, p. 156).

This work and the workforce context further enhance the need for education and training that is built to serve realistic, relevant purposes. It can necessitate, for example, not subjecting all learners to all parts of a learning intervention by using a form of personalization, which can be very effectively mediated with computing-based educational programs. And there are many options when deciding how to proceed with workforce education programs that use technology to facilitate and support learning within those programs.

### Simulation Technologies

Simulation technologies are, perhaps somewhat obviously, at the very highest end of the options for technology-based, situated workforce education when considered in terms of scope, cost, and, likely, also in terms of results. There is, for example, a long history of effectively using simulators for flight training. These simulation technologies have been in use for more than half a century and are used to improve planning, analysis, and training for flight test operations (Vitsas, 2016, p. 1). Some of a pilot's initial instructions on the normal operation of an aircraft can be primed through situated learning methods. Then, continued education on more advanced situations where the operating conditions are more extreme can also be effectively simulated. This will allow pilots to safely experience unusual situations so that they are better prepared for them in the event they encounter similar conditions in actual flight.

Simulation technologies are also commonly used in military field training. Sensors—called inertial measurement units—are used for evaluating human movement under the many stressful, situated conditions that are simulated in military training exercises (Davidson et al., 2016, p. 28). The simulation serves as a realistic encounter where sensory-based input and computational analysis can help determine who is best suited for roles in this context and to better equip them for success through realistic, but still only simulated, experiences. In a less technical example, IBM developed a learning program, called Basic Blue, which used simulation modules in an e-learning environment to replicate real-life scenarios to convey critical information to new managers (KPMG, 2015, p. 17).

### Classroom and Online Training

In a more business setting, formal education programs—in classroom settings—can be very effective. But they are also expensive to develop, purchase, staff, and maintain. Many, if not most, classroom-based programs became impossible to conduct in-person during the coronavirus pandemic, causing—whether ready or not—an immediate shift to digital alternatives.

There is also a significant cost when considering these training programs in terms of the lost productivity when employees are away from their primary work responsibilities. It is, in a way, for example, expensive in the immediate term for a salesperson to be away from selling things in order to learn about how to sell things. The investment in time, expense, lost productivity, etc. should work out when viewed over a long period of time—it, in fact, has to for the training program to be useful—but may not be of apparent benefit in the immediate term.

Online training programs, where there is no physical classroom but still the structure of classroom training programs, can be used as part of formal workforce education programs as well. They are less expensive but still carry many of the same characteristics as classroom training programs in terms of benefits and downsides. In this way, for example, an employee looking to develop a needed skill might browse through content from Coursera, Udemy, Udacity, and many others to instantly access a lecture, course, or workshop ("Global Human Capital Trends," 2016, p. 59). But the opportunities for incorporating situated learning methods in these educational settings—physical and online environments—are very limited.

### Computer-Based Training

On a much smaller scale than simulation and classroom environments, Computer-Based Training systems (CBTs) are also widely used for workforce education, especially for regular and ongoing training on company policies, legal and regulatory matters, and many other legal and human-resource practices (Hawkins, 2011, p. 4). CBTs are non-interactive, self-paced forms of instruction delivered by digital media (Hawkins, 2011, p. 3). CBTs are the least expensive option for workforce education. And while they are highly scalable in terms of reach, and as training programs sit at the lowest end in terms of scope and cost, they are also the lowest in terms of results. Because they are static, there is no opportunity for incorporating situated learning methods in CBTs, other than the use of storytelling, narration, and other more informal methods.

## Situated Workforce Education with Personal Mobile Device and Intelligent Personal Assistant Technologies

Given the examples of workforce education and training solutions in the previous section, simulation systems, like aircraft simulators, are the only type that directly situate the instruction. Classroom educational programs—including online programs—can leverage situational mechanisms like the case study method first introduced by Harvard University to provide a more realistic educational setting. These case studies are based on the understanding that problem-solving is at the core of professional experience (Breslin & Buchanan, 2008, p. 37) and can be used, for instance, to describe real-world situations so that the instructor can use these scenarios as a teaching method for creating a conceptual environment for the analysis and decomposition of a situational construct. But, even then, the situational aspects of the experience are just narratives—real or fictitious stories that can be used to portray situations for discussion purposes.

And, lastly, there is nothing situational about Computer-Based Training systems (CBTs). The content is presented arbitrarily, individually, and in a controlled setting. It is possible, using artificial intelligence-based computing methods, to create a synthesized exchange between the learner and the computer for a more elaborative form of instruction. But, otherwise, there is no real opportunity for interaction—for discussion and topical expansion—except for quizzes, rote forms of testing that serve little more than to exercise a learner's short-term memory. Using CBTs does, of course, allow companies to add an employee's name to a compliance checklist for legal and audit purposes to represent that specific areas of training are provided to workers on an ongoing basis, which is valuable, but not from the standpoint of situated education.

On the other hand, the use of personal mobile devices and intelligent personal assistant technologies offer exceptional opportunities for situated workforce education because of their many sensory capabilities and their ubiquity and accessibility. These amazing computational machines are in our hands, or at least nearby, all the time. They are loaded with an impressive collection of sensors that provide the inputs for advanced, perceptual computing solutions.

These personal mobile devices and intelligent personal assistants are connected to the Internet and are likely also connected to a company's internal networks as well. These devices can be backed by the affordances of high-end computational infrastructure, cloud or otherwise. This infrastructure affords us the capability of processing massive amounts of information about a given situation and can use artificial intelligence and machine learning to develop an understanding of a given situation and grow from that point—the more data, the more a machine learning algorithm can expand and shape the landscape of potential responses and the choices involved. These devices can also be used to intervene in clever ways as learners—learners in the modern workforce—go about their roles and responsibilities in the workplace, physically and virtually.

## Situated Computing for Education in the Modern Workforce: A Simple Example

A large, global company in the information sciences business provides highly confidential, private, and sensitive information that is used, for example, by law enforcement agencies for criminal investigation purposes. In addition to other security measures, the company must secure specific areas within its buildings and must make certain that its workers, who are cleared for access to any of these secure areas, know and comply with the policies for accessing those controlled areas.

During onboarding, new employees attend an orientation program in a classroom setting—however more recently, during the coronavirus pandemic, in an online setting—during which there is a briefing on the policies and procedures for accessing secure, controlled areas. All new employees attend this training program, not just those who will have access to secure areas within the company's buildings.

Ongoing, all employees are required to take 3-5 Computer-Based Training (CBT) courses annually, as is common across industries for policy compliance training (e.g., data protection, confidentiality). One of the courses includes information and serves as a refresher on the policies for accessing secure facilities. These courses include several quizzes that test each employee's immediate-term knowledge of the subject matter. At the end, there is a procedural step where employees acknowledge that they have completed the course, understand the policies, and agree to them as a matter of continued employment with the company. This acknowledgment is logged for audit and compliance purposes.

### *A Common Workplace Situation*

Authorized employees regularly enter, work in, and later exit secure areas in the company's buildings. For these employees, the situation—entering, working in, and exiting the secure areas—is an everyday part of working for the company. Their workplace just happens to be a secure area. They may or may not think much about the importance of the locked doors, badge-access controls, the presence of security officers, and/or any other heightened security measures. Their only specific reminder about the security policies, which they have acknowledged and agreed to, is during their annual, compulsory CBT course.

### *Using the situation as an instructional opportunity*

Something as simple as an occasional reminder on an employee's personal mobile device as they are passing through the entrance to a secure area could provide a situationally significant reminder about the policies for accessing secure areas and the importance of those policies. In this situated context, it may be reasonable to ask that they elaborate on the policy and indicate their experiences, preferences, and reflections of the policy.

Further, it may be interesting to share anecdotal information about things that have happened—or could happen—if the security of the area is not preserved. If something bad has happened previously—maybe, even, somewhere else, at a different company, for legal concerns—it may be possible to ask if employees are aware of the situation and the consequences. Or, it may be possible, as a form of simulation, to present a situation and ask if employees consider it acceptable under the terms of the policy, even potentially in a way that encourages collaboration through integration with a social media platform or in a gaming type of interactivity that encourages a competitive response. Any of this would be much more memorable than what a disconnected, arbitrary training exercise like a compulsory CBT, could provide.

### *Developing a personal mobile and/or intelligent personal assistant device learning system*

According to Lee (2017), digital technology has mostly removed any meaningful physical constraints from a broad class of engineered systems (p. 47), including situated learning systems. "Innovation, therefore, is less limited by the physics of the technology than it is by our human imagination and ability to assimilate new paradigms" (p. 47). A situational learning solution of the types described in this chapter will require implementing and integrating of many system capabilities. But at the time of this writing, existing technologies can be used to do so and, depending on the scope, a solution can be built relatively inexpensively. We just have to imagine the possibilities and make something happen.

At a high level, the system must gather and process perceptual data, essentially using direct input from personal mobile devices and derived data to understand the user's situational considerations. In this way, the system will interact with the user's surrounding environment to collect relevant data to understand the outside world, meaning that it will be interpreting and exploring whatever activities are taking place (Sheth et al., 2016, p. 65).

The sensory data must then cycle through an appropriate number of computational processing steps to evaluate what the sensory data indicates, what the user's preferences are in that regard, and what the system knows, ideally using machine learning techniques that learn and adjust over time. From there, the system can intervene with the user for interactive purposes, meaning that the system can prompt, signal, interrupt, etc. and do so in an intelligent, relevant, and resourceful manner. In this way, the training system can equip learners with feedback so that they can experience the best and worst-case scenarios relative to the situation.

There are many options for presentation, interaction, and intervention within most situational contexts—like banner notices and alerts—and many options for programming these parts of systems (e.g., open source frameworks, code libraries). But balancing these options, and getting the most of what each offers, is actually the hardest part. If the information is presented that is out of context or incorrect, or if the interactions are presented in an annoying manner, they will be summarily dismissed. Most of this is a matter of design, creativity, and empathy—artistic creativity—versus a technical or engineering matter.

Google, around 2015, began experimenting with messaging solutions for situated notifications that are integrated with Google Maps. Based on perceptual computing inputs—information from proximity sensors, geolocation data, pattern analysis, and predictive modeling services to name a few—solutions are being built and released that, for example, recognize that a user is in their car and about to drive home from work.

At that time, Google is positioned to make recommendations on the best route based on traffic conditions, construction activity, weather, etc. This solution, although not an educational use of technology, illustrates how situational events can be targeted for informational purposes and in a very simple, concise, and brilliantly situated manner. This Google service can be considered a perceptual computing exemplar relative to the theoretical basis presented and discussed in this chapter. It can be used conceptually to model any type of situated computing solution, including solutions for situated education that are, again, very simple, concise, and brilliantly situated.

## Limitations, Risks, and Other Considerations

The affordances of perceptual and situational computing solutions may seem like a technology opportunity at the surface. But, more so, these solutions are potentially an opportunity to touch lives and inspire people on the upside or to violate privacy and trust on the downside. To think that we now have both a massive amount of computing capacity and a remarkable tool for connectedness on a personal device that for many people is never more than a few feet away is, to say the least, a new frontier. Building a computing system, for commercial use or otherwise, that operates on a device that will spend a lot of time in someone's pocket or next to them while they work is a big responsibility.

The implementation of any instructional technology is a complex and multidimensional process including many dynamics involving not only technology but also stakeholders and culture (Akbiyik, 2010, p. 1). Additionally, how a technology solution takes shape is often a matter of compromise (Baym, 2010, p. 40) and the mediation of limitations. While the introduction of technological ideas like situated computing may be exciting to some people, not everyone will jump on board quickly and willingly. There are, of course, good reasons for skepticism and there are certainly reasonable concerns within an educational setting that must be resolved or mediated.

Building workforce education solutions on personal mobile-device and intelligent personal assistant technologies—and doing it well—will, of course, require integrating perceptual capabilities like the many sensor technologies in personal mobile devices with data analytics, cloud infrastructure, artificial intelligence, machine learning systems, etc. But, more importantly, the solutions must be designed in a way that emphasizes an understanding of how people think, behave, and interact while they are using these computing systems.

The design must incorporate and accommodate the implications of the many important, personal norms and expectations different people have from the standpoint of culture, society, and human cognition, including how those interactions may vary in different worldwide regions. Leveraging personality, for instance, as a situational aspect of what a certain learner needs in a situation—even going so far as considering auditory or visual learning abilities and limits—can be accomplished by integrating perceptual capabilities.

Also, the current state of artificial intelligence, according to Lee (2017), is primarily a great triumph in pattern recognition. These technologies (e.g., image recognition services) are very task-focused. They lack contextual awareness and the learning flexibility that humans have (p. 26). As reported by Somers (2017), humans make sense of new phenomena in terms of things they already understand, breaking the domain down and learning the pieces in a flexible manner. Computers don't do this, and that is a big part of the reason they are actually pretty stupid (pp. 34-36). We have to be smart when we build these solutions; the computers play an important part, but it's up to us to make them functional in very specific situational-computing settings.

Solutions for workforce education that leverage personal mobile-device and intelligent personal assistant technologies must do so in an appropriate manner, which can be challenging. What may seem like good information may play out as an annoyance, depending on how people view it. Replacing something compulsory, like annual CBT courses, with situated personal mobile-device and personal digital assistant interactions may not be well-received if they are compulsory interruptions. If someone must regularly stop what they are doing to read an alert, answer a question, and/or acknowledge a message, the interruption might not be viewed as productive or useful. The interactive nature of design must be emphasized in order to create an experience that is useful, non-disruptive, informative, and personalized. Personalization should also include the ability to delay and/or opt-out of the service.

Since artificial intelligence systems are learning, rather than having been explicitly programmed to do something, it may be difficult or even impossible to actually understand inherent biases, or even to identify them in the first place. For example, in 2016, Microsoft released a chatbot named Tay, which was corrupted within a day by a Twitter bot and turned into, in effect, a robot parrot with an Internet connection—characterized by the media, very appropriately, as a very misogynistic and racist robot parrot—which Microsoft had to promptly and permanently take offline (Vincent, 2016). Something like this situation would be a disaster in a workforce educational setting.

Additionally, in learning systems, while knowledge resources improve the extent and accuracy of a computational solution, some of these resources often will contain demographic information to classify an audience into age, gender, race, income, location, political orientation, and other categories (Banamara et al., 2016, p. 239). This form of data and personally identifiable information must be managed and used carefully (i.e., permissibly used in accordance with laws, policies, etc.), especially in a workforce educational setting.

Another important consideration in successfully developing a situated computing system for workforce education is balancing the amount of surveillance and tracking that is part of the system. Just as how badge systems keep offices and schools safer than they would be otherwise, people don't typically appreciate when badge access reports are used to see where they have been and when. This type of surveillance isn't necessarily bad or offensive. While possibly counterproductive, it must be used appropriately, disclosed, and used in a matter-of-fact manner relative to that disclosure.

In many, if not most instances, employees are also using their own personal mobile devices and intelligent personal assistants. This situation means that they are likely not obligated to participate in a workforce education program like the situated learning systems discussed in this chapter. Given that reality, there must be a draw or incentive for workers to participate in the program, for instance, in exchange for something of value, or because there is a gaming or social component that serves as a draw, or maybe because the subjects are interesting and compelling in and of themselves. The important thing is to find something that will work, devise a quality solution for it, and implement it in a way where its use is desired.

## CONCLUSION

When Apple released the iPhone in 2007, the company changed the computing landscape in dramatic ways. Those three sensors in the first model were just a glimpse of what was to come in this area of technology. Many visionary ideas like those from the MIT Media Lab Wearable Computing Group took a large step forward.

With the introduction and many advancements of the Android operating system, the proliferation of this new class of personal mobile-device technology has become central, shaping people's expectations of technology in their everyday lives. These expectations include having the ability to access the Internet remotely, device affordability and accessibility, and the intuitiveness of the products and systems built on them. Then, we saw the development and proliferation of intelligent personal assistants like Amazon Alexa and Google Home.

Artificial intelligence in its many forms is a hot topic at the time of this writing. There are many potential opportunities to leverage it to completely or partially automate manually performed work, or just to assist in human activities—to make those activities better in function, more efficient, or both. "The partnership of computers with humans is the real source of their power" (Lee, 2017, p. 176). The unique, unprecedented quality of the Internet—our newest of new media—is its programmability, the code that underlies its digital communication mechanisms (Bolter, 2007, p. 40), which offers a seemingly endless array of possibilities to apply artificial intelligence, such as machine learning, to improve the human condition.

As computing systems have become perceptual, the intersection between technology and human behavior has become increasingly important and will become even more so in the future. The use of perceptual and situated computing will continue to develop and proliferate, including within an educational context. There are many opportunities to innovate and improve workforce education in that regard by leveraging the power and affordances of technology to turn everyday activities into everyday learning opportunities.

## REFERENCES

Akbiyik, C. (2010). Can affective computing lead to more effective use of ICT in education? *Review of Education*, *352*(4), 181–185.

Anderson, J. R. (2015). *Cognitive psychology and its implications*. Worth Publishers.

Arenas, N., & Silver-Malyska, T. (2021). Imagining the unimaginable: Best practices for returning to work post-COVID-19. *Benefits Quarterly*, *37*(1), 45–57.

Baber, C. (2003). *Cognition and tool use*. Taylor & Francis.

Banamara, F., Taboada, M., & Mathieu, Y. (2016). Evaluative language beyond bags of words: Linguistic insights and computational applications. *Computational Linguistics, 43*(1), 201-264. doi: a 00278 doi:10.1162/COLI

Baym, N. (2010). *Personal Connections in the Digital Age*. Polity Press.

Beaudouin-Lafon, M., & Mackay, M. (2000). Research directions in situated computing. In *CHI'00 Extended Abstracts on Human Factors in Computing Systems* (pp. 369–369). ACM. doi:10.1145/633292.633516

Bolter, J. D. (2007). Remediation and the language of new media. *Northern Lights: Film & Media Studies Yearbook*, *5*(1), 25–37. doi:10.1386/nl.5.1.25_1

Bransford, J. D., & Schwartz, D. L. (1999). Rethinking transfer: A simple proposal with multiple implications. *Review of Research in Education*, *24*(1), 61–100. doi:10.3102/0091732X024001061

Breslin, M., & Buchanan, R. (2008). On the case study method of research and teaching in design. *Design Issues*, *24*(1), 36–40. doi:10.1162/desi.2008.24.1.36

Carliner, S. (2017). Informal learning. In R. A. Reiser & J. V. Dempsey (Eds.), *Trends and Issues in Instructional Design and Technology* (pp. 142–151). Pearson.

Centers for Disease Control and Prevention. (2019). *Basics of COVID-19*. U.S. Department of Health and Human Services. Retrieved from https://www.cdc.gov/coronavirus/2019-ncov/your-health/about-covid-19/basics-covid-19.html

Clancey, W. J. (1995). *A tutorial on situated learning*. In J. Self (Ed.), *Proceedings of the International Conference on Computers and Education* (pp. 49-70). Charlottesville, VA: AACE.

Davidson, S. P., Cain, S. M., McGinnis, R. S., Vitali, R. R., Perkins, N. C., & McLean, S. G. (2016). Quantifying warfighter performance in a target acquisition and aiming task using wireless inertial sensors. *Applied Ergonomics*, *56*, 27–33. doi:10.1016/j.apergo.2016.03.001 PMID:27184308

Dawson, M. R. W. (2013). *Mind, body, world: Foundations of cognitive science*. AU Press.

Driscoll, M. P. (2017). Psychological foundations of instructional design. In R. A. Reiser & J. V. Dempsey (Eds.), *Trends and Issues in Instructional Design and Technology* (pp. 52–60). Pearson.

el Kaliouby, R. (2017). We need computers with empathy. *MIT's Technology Review*, *120*(6), 8–9.

Emotion. (n.d.). Retrieved February 23, 2018 from https://en.wikipedia.org/wiki/Emotion

Ertmer, P. A., & Newby, T. J. (1993). Behaviorism, cognitivism, constructivism: Comparing critical features from an instructional design perspective. *Performance Improvement Quarterly*, *6*(4), 50–72. doi:10.1111/j.1937-8327.1993.tb00605.x

Gershman, A. V., McCarthy, J. F., & Frano, A. E. (1999). Situated computing: Bridging the gap between intention and action. In *Wearable Computers, 1999. Digest of Papers. The Third International Symposium on Wearable Computers* (pp. 3-9). IEEE.

Global Human Capital Trends. (2016). *The New Organization: Different by Design*. Deloitte University Press.

Hawkins, J. B. (2011). *Bridging the knowledge gap: The effectiveness of compulsory computer-based training in federal employees' professional education* (Doctoral dissertation). Retrieved from https://search-proquest-com.ezproxy.cul.columbia.edu/docview/916240004?accountid=10226

Hennessy, J. L., & Patterson, D. A. (2019). *Computer architecture: A quantitative approach* (6th ed.). Morgan Kaufmann Publishers., doi:10.1145/3282307

Hull, R., Neaves, P., & Bedford-Roberts, J. (1997). Towards situated computing. In *Wearable Computers, 1997. Digest of Papers. The First International Symposium on Wearable Computers* (pp. 146-153). IEEE. 10.1109/ISWC.1997.629931

KPMG. (2015). *Corporate digital learning*. Retrieved from https://assets.kpmg.com/content/dam/kpmg/pdf/2015/09/corporate-digital-learning-2015-KPMG.pdf

Lee, E. A. (2017). *Plato and the nerd: The creative partnership of humans and technology*. The MIT Press., doi:10.7551/mitpress/11180.001.0001

Lee, E. A. (2020). *The coevolution: The entwined futures of humans and machines*. The MIT Press., doi:10.7551/mitpress/12307.001.0001

Lee, F. F. (2017). Q+A. *MIT's Technology Review*, *120*(6), 26.

Lewis, G. A. (2017). Cloud computing. *Computer*, *50*(5), 8–9. doi:10.1109/MC.2017.141

McCarthy, J. (2007). *What is artificial intelligence?* Retrieved from http://www-formal.stanford.edu/jmc/whatisai/whatisai.html

McDermott, I. E. (2016). Fun with virtual and augmented reality. *Online Searcher*, (Nov-Dec), 27–29.

Ortigosa, A., Martin, J. M., & Carro, R. M. (2013). Sentiment analysis in Facebook and its application to e-learning. *Computers in Human Behavior*, *31*(1), 527–541. doi:10.1016/j.chb.2013.05.024

Picard, R. W. (1995). *Affective Computing-MIT Media Laboratory Perceptual Computing Section Technical Report No. 321*. Cambridge, MA: MIT.

Picard, R. W. (2003). Affective computing: Challenges. *International Journal of Human-Computer Studies*, *59*(1-2), 55–64. doi:10.1016/S1071-5819(03)00052-1

Robbins, P., & Aydede, M. (2009). A short primer on situated cognition. In P. Robbins & M. Aydede (Eds.), *The Cambridge Handbook of Situated Cognition*. Cambridge University Press.

Sheth, A. (2010). Computing for human experience: Semantics-empowered sensors, services, and social computing on the ubiquitous web. *IEEE Internet Computing*, *14*(1), 88–91. doi:10.1109/MIC.2010.4

Sheth, A., Anantharam, P., & Henson, C. (2016). Semantic, cognitive, and perceptual computing: Paradigms that shape human experience. *Computer*, *49*(3), 64–72. doi:10.1109/MC.2016.75

Somers, J. (2017). Is AI riding a one-trick pony? *MIT's Technology Review*, *120*(6), 29–36.

Turkay, S., Hoffman, D., Kinzer, C. K., Chantes, P., & Vicari, C. (2014). Toward understanding the potential of games for learning: Learning theory, game design characteristics, and situating video games in classrooms. *Computers in the Schools*, *31*(1-2), 2–22. doi:10.1080/07380569.2014.890879

Turkle, S. (2006). Tethering. In C. A. Jones, B. Arning, & J. Farver (Eds.), *Sensorium: Embodied Experience, Technology, and Contemporary Art* (pp. 220–226). The MIT Press.

Turkle, S. (2008). Always-on/always-on-you: The tethered self. In J. E. Katz (Ed.), *Handbook of Mobile Communication Studies* (pp. 121–137). MIT Press. doi:10.7551/mitpress/9780262113120.003.0010

Vincent, J. (2016, March 24). *Twitter taught Microsoft's AI chatbot to be a racist asshole in less than a day.* Retrieved from https://www.theverge.com/2016/3/24/11297050/tay-microsoft-chatbot-racist

Vinh, T. L., Bouzefrane, S., Farinone, J., Attar, A., & Kennedy, B. P. (2015). Middleware to integrate mobile devices, sensors, and cloud computing. *Procedia Computer Science*, *52*, 234–243. doi:10.1016/j.procs.2015.05.061

Vitsas, P. A. (2016). Commercial simulator applications in flight test training. *Journal of Aerospace Engineering*, *29*(4), 1–12. doi:10.1061/(ASCE)AS.1943-5525.0000589

Wilson, B. G. (2017). Constructivism for active, authentic learning. In R. A. Reiser & J. V. Dempsey (Eds.), *Trends and Issues in Instructional Design and Technology* (pp. 61–67). Pearson.

Yoo, Y. (2010). Computing in everyday life: A call for research on experiential computing. *Management Information Systems Quarterly*, *34*(2), 213–231. doi:10.2307/20721425

## KEY TERMS AND DEFINITIONS

**Anchored Instruction:** An instructional method employed to focus (i.e., anchor) learning within problem solving in a real or simulated situational context.

**Experiential Computing:** An approach for implementing computing systems in which computational abilities are embedded into the interactions between people and many common, everyday items. This computing approach is central to the rapidly developing Internet of Things.

**Informal Learning:** An educational process which takes place outside a conventional learning environment. The process is typically self-directed and can be structured or unstructured.

**Intelligent Personal Assistant:** A stationary computing device with specialized hardware and software for connecting to the Internet, listening to foreground and ambient sounds, measuring environmental conditions, and providing human interaction capabilities.

**Machine Learning:** A type of computing system in which algorithms learn as they process data within a given context. These systems then use that derived knowledge to deepen their level of understanding of what is happening within the system.

**Perceptual Computing:** A computing system where sensory inputs measure the physical characteristics of a situation to assess and assign meaning given those inputs.

**Personal Mobile-Device:** A handheld computing device with specialized hardware and software for connecting to the Internet, measuring environmental conditions, and providing human interaction capabilities.

**Situated Computing:** A type of computing solution that functions within a specific situational context to intelligently intervene.

**Situated Learning:** A learning theory basis through which instruction is designed to take place within a real or simulated situational context.

**Workforce Education:** A form of education and training designed for the needs of learners in a work environment.

Chapter 5

# Using Online Digital Data to Infer Valuable Skills for the Modern Workforce

**Sofia Strukova**
*University of Murcia, Spain*

**José A. Ruipérez-Valiente**
https://orcid.org/0000-0002-2304-6365
*University of Murcia, Spain*

## ABSTRACT

*This chapter uncovers the opportunities that online media portals like content sharing and consumption sites or photography sites have for informal and formal learning. The authors explored online portals that can provide evidence of evaluating, inferring, measuring skills, and/or contributing to the development of competencies and capabilities of the 21st century with two case studies. The first one is focused on identifying data science topical experts across the Reddit community. The second one uses online Flickr data to apply a model on the photographs to rate them as aesthetically attractive and technically sound, which can serve as a base for measuring the photography capabilities of Flickr users. The presented results can serve as a base to replicate these methodologies to infer other competencies and capabilities across online portals. This novel approach can be an effective alternative evaluation of key 21st century skills for the modern workforce with multiple applications.*

## INTRODUCTION

In today's context, there are more people that strongly believe that a significant proportion of learning, both intentional and unintentional, is happening online. They believe online learning is increasing due to two different reasons: the ever-growing popularity of internet usage by all segments of the population and the appearance of more and more socio-political and climate displacements as well as health emergencies like COVID, that are demanding remote work and education modalities. According to the

DOI: 10.4018/978-1-6684-3996-8.ch005

UNESCO report regarding the impact of COVID-19 on education (UNESCO, 2021), almost half of the world's students are still impacted by partial or complete school closures. In this sense, the education and training stakeholders have had to adapt to students' new needs and abilities by creating modern new media and online training techniques to provide flexible and personalized educational approaches. Moreover, the pandemic has caused traumatic circumstances in many people's lives, making it harder for learners struggling to adapt to online learning (Carter et al., 2020). One of the solutions to this problem is to create easy-to-access, engaging, online educational opportunities, including resources like electronic books, recorded lectures, quizzes, podcasts, discussion forums, engendering social connectedness and/or facilitating one-on-one check-ins or group interviews. Even with the latter list, finer nuances are needed to be investigated, implemented, monitored, and evaluated for successful educational engagement.

Due to the pandemic context, many schools and universities around the world are integrating online learning into their courses, starting from formal and structured Learning Management Systems (LMSes), such as Moodle or Sakai, to informal social networking sites (SNSs), such as Facebook, Pinterest, Reddit, YouTube, or Flickr (Ulla & Perales, 2021), Question and Answer (Q&A) portals like Quora, and many others. The use of these environments is becoming more common as it can help improve missing social aspects and academic social connectedness (Mentor, 2018), which refers to a sense of affiliation, belonging, and not working alone (Thai et al., 2019; Turki et al., 2018). However, many LMSes do not provide the functionality to facilitate engaging ways to interact with peers, cultivate and maintain academic social connectedness (Mentor, 2018), or exchange feedback synchronously. More than that, with the use of SNSs, students can present themselves, articulate their thoughts to their social networks, develop or preserve connections with peers and share information, knowledge, and artifacts within a community. Moreover, SNSs promote the creation of shared interest groups that make users feel a sense of community engagement (McCarthy, 2017).

Therefore, if research thus far has shown that students benefit from learning methods that involve the use of SNSs as part of their curriculum (Shih, 2012), could users learn in these and similar sites without being part of a formal educational program? In this chapter, the researchers will focus their attention on a trending and controversial issue of particular importance related to the informal learning happening across various online portals capable of hosting evidence of users' developing competencies and capabilities. The authors believe that learning online, interpreting, or analyzing photographs as forms of media that can be transferable to other aspects of learning and working life, and data science, and self-directed learning capabilities are important to successfully function in the 21st- century society. Therefore, this chapter will discuss the opportunities that online digital media provide to evaluate and generate online learning, self-directed learning, offer formative assessments and feedback on learners' skills. The purpose of this study is to solicit discussion and will help to deliberate the affordances of engaging with new online media tools to transfer 21st-century skills and show how the modern workforce can benefit from these approaches.

Thus, the objectives of this chapter are as follows:

1. To explore online portals that can provide evidence of users accessing in a self-directed manner, transferring, measuring skills learned, and/or contributing to the development of competencies and capabilities for the 21st century workforce.
2. To analyze if it is possible to identify topical experts across the Reddit community by examining comments of the selected subreddit.
3. To inspect if it is feasible to measure photography capabilities of Flickr users.

The remainder of this chapter is structured as follows. First, the researchers will focus on reviewing related works of this study that have explored online portals, which have already shown evidence of transferring users' developing competencies and capabilities. Second, the authors will describe two case studies that they have performed: a case study focused on data science competencies in Reddit and a case study focused on measuring photography capabilities through image quality and aesthetics in Flickr. Third, the researchers will present a detailed section discussing the possibilities that some online portals have, to enhance education and learning, as well as depicting potential applications of the data from online digital media to evaluate and provide feedback on 21st-century skills. Finally, the authors of this chapter will draw their conclusions and offer future research directions.

## BACKGROUND

An ever-changing society and technology influencing one another, is resulting in a disruptive transformation of the 21st-century workforce in terms of the needs and capabilities to which people are adapting and/or needing to adapt to at a rapid pace. Now more than ever, society needs to re-envision new ways of training and evaluating the skills required for the population to function in the modern world successfully. Luckily, multiple new organically grown technological communities, approaches and new digital media have emerged over the last decade, generating opportunities for novel teaching and learning approaches. These have empowered traditional educational environments where these tools have been incorporated responsibly with proper vetting processes to check for factual accuracy and strengthened knowledge acquisition through informal learning with innovative technologies and services in the new digital world (Strukova et al., 2022). In this way, this section will provide a discussion of diverse online digital media that have already proved to be able to generate rich informal learning experiences for their users. The authors in this study are especially interested in internet portals where users can interact with content and other peers. Naturally, the users leave traces of their behavior within these digital environments, and the researchers argue that these interactions hold the potential to help evaluate the aforementioned critical capabilities for modern society.

Within the myriad of internet websites that the researchers found online, they are specifically interested in photo and video sharing platforms (e.g., Pinterest and YouTube), as well as Q&A portals which can be represented, for example, by forums (e.g., TripAdvisor forum), an access point to news (e.g., Financial Times), or content sharing and consumption portals (e.g., Reddit). These online forums can provide valuable information on a topic, information about the proficiency of users in specific skills and knowledge using the traces of the interactions performed by the users online, as well as the rating systems that act as a vetting of accuracy. In portals such as the ones previously mentioned, the authors detected the following commonalities: the users are responsible for both consuming, generating, and sharing the content; they can interact with other peers, follow existing topics of interest, or create communities around niche-based topics, connecting with professionals in the selected industry, broadcasting live videos and even to finding inspiration. Most importantly, by completing the actions mentioned earlier like creating communities of various topics or following existing ones, the users can learn a wide range of valuable skills and competencies, from soft skills to knowledge of a particular topic as found in research literature on online crowdsourced or community sourced information requests and responses.

The authors found in the literature several studies that focused on the approach of analyzing the competencies of users by processing their online traces in a way that could provide evidence of them developing new or enhancing existing knowledge and skills, and/or contribute to the development of competencies and capabilities of the 21st century. For example, Packiam and Geoffrey (2012) performed research aiming to investigate the effect of SNSs engagement on cognitive and social skills. They examined the use of three SNSs, namely Facebook, Twitter, and YouTube, in a group of young adults testing their working memory, attention skills, and levels of social connectedness. The authors concluded that certain activities on Facebook, such as checking friends' status updates and on YouTube, such as sharing a video with a friend, positively influenced working memory test performance. On the other hand, the results indicated that active and passive SNS users had qualitatively different profiles of attention control (Packiam & Geoffrey, 2012).

Alternatively, Pal et al. (2016) presented an approach to find topical authorities in Instagram. Their method relied on the self-described interests of the list of users following popular accounts. The authors inferred regular users' interests from their self-reported biographies that are publicly available and used Wikipedia pages to ground these interests as fine-grained, disambiguated concepts. The authors concluded that individual user biography-based interests provided strong evidence to infer the topical authorities (Pal et al., 2016).

Also, Vesselinov and Grego studied the effectiveness of Duolingo, an online gamified platform for learning languages (Vesselinov & Grego, 2012). As participants of the Duolingo effectiveness study announced on its web, the authors analyzed a random representation of native English users who studied Spanish. The participants took a placement Spanish language test at the beginning of the study and one test at the end of the study. The authors concluded that after using Duolingo, language proficiency improved significantly. Also, this study estimated that a person with no knowledge of Spanish would need around 34 hours on average to cover the material for the first college semester of the Spanish course. Moreover, the main factor for higher effectiveness was the participants' motivation, which highlighted the strong interest of users to study for traveling. Another catalyst of the higher effectiveness was the initial language knowledge level, indicating that beginners were the ones that improved the most.

The final example is the work done by Yan et al. focused on the professional social network LinkedIn (Yan et al., 2019). In their paper, the authors developed a framework for collecting validations for members' skill expertise at the scale of billions of member-skill pairs and a machine learning (ML) model to make suggestions to collect validations more efficiently. They discovered insights on how users evaluated their mates in professional social networks. For example, juniors often were getting better evaluations than the members with higher seniority. The authors evaluated their model by predicting who was hired for a job requiring a particular skill. After all, the experiments estimated the members' skill expertise accurately at a large scale and offered a benchmark to validate social theories on peer evaluation.

All the examples presented above have several common characteristics:

- All the previously mentioned portals on the web (language learning portal, professional social network, photo, and video sharing platform, SNS) generate large amounts of data stemming from the interactions carried out by their users in such contexts.
- All these studies performed a measurement of what they considered essential competencies or capabilities necessary in the 21st century (language proficiency, social and cognitive skills, topical expertise).
- The users whose data was analyzed across these studies were responsible for consuming and generating the content.

After analyzing the existing studies, the researchers of this chapter found that many of the current higher education academic environments do not necessarily use or discuss using the evidence of the online digital portals to measure modern competencies essential for the known and unknown future of the 21st century. These portals hold the potential to do so since they contain a large load of data that can be easily accessed through Application Programming Interfaces (APIs), by scraping the public domain digital databases, and/or by having direct access to the databases. Therefore, in this chapter, the researchers will interrogate two case studies representing a couple of these portals - the photography social network and the Q&A portal, which will be described next.

## CASE STUDIES

### Identifying Experts in Question & Answer Portals: A Case Study on Data Science Competencies in Reddit

#### Context and Motivation

There is a growing popularity of Q&A portals that have become the leading platform for all kinds of users to share information, ask questions, and comment on the doubts or questions of others. Users help each other by providing, for the most part altruistic responses, making the resolution of doubts and questions across many topics much more straightforward. However, many questions are never answered because the question statement lacks a good structure, or an appropriate expert did not see it. Users can read and reread their questions before posting them on the platform, which could help turn a poor-quality question into a sound quality question and in this way, helping not only the user but also the community. Unfortunately, in many Q&A portals, there is not a rating system or metric that suggests whether the questions or answers are of a poor-quality or high-quality. This is due to the fact that it is not a trivial task to interpret the human language, or to ask questions that deal with complex, multilayered, and/or dependent and co-dependent issues. On these grounds, natural language processing (NLP) is trying to fill this gap by focusing on creating models that can understand and interpret human language.

On the other hand, data science is the study of the generalizable extraction of knowledge from data. It is an emerging discipline that combines expertise across various domains, including software development, data management, and statistics (Saltz et al., 2017). A data scientist requires an integrated skill set spanning mathematics, ML, knowledge of digital artificial intelligence, statistics, databases, and optimization, along with a deep understanding about the craft of problem formulation to engineer effective solutions (Dhar, 2013). In various fields such as computer science, computer engineering, business administration, and business management, a subset of courses focus on skills that are essential for being a data scientist. However, still, there is a need to introduce the integration of other skills needed to function as a data scientist. Additionally, data collection within educational environments that can be used as data learning analytics still fall short within many schools and universities around the world.

Furthermore, there is enormous interest in identifying experts in the data science field, and the online Q&A portals as well as SNS bear evidence to it in terms of aggregating additional layers of data for better vetting and verification of false information. Therefore, the researchers of this study will first will inspect several Q&A portals and their main characteristics in order to choose the most appropriate one for developing a case study within this gap. Secondly, they will introduce the methodology for the identification of data science experts. Finally, the researchers will present preliminary results and discuss future steps.

## Question and Answer Portals

Q&A portals can be defined as online discussion sites where users can post messages asking questions or replying to others' questions. In other words, they are crowdsourcing information through collective and collated knowledge creation sites where users contribute to generating the content while many users access these questions and responses by searching online. All users' activities are usually incentivized by reward or penalty with gamification features (like points or badges) that are triggered based on their actions or on the reviews given by other users through voting or choosing favorites (Raj et al., 2011). Next, the researchers of this research project explored the most popular Q&A portals.

- Answers.com, formerly known as WikiAnswers, states its goal as to help students of all ages learn, study, and connect in an online community. Therefore, Answers.com can be considered an encyclopedia-type Q&A portal. Across it, anyone can pose an inquiry, answer a question, or improve a previous response to a question.
- AskFm, unlike the rest of the Q&A websites, is a social networking platform, which uses a Q&A format to connect users through conversational exchanges (Farrugia et al., 2019). Questions and answers become public on a user's profile only once they are answered. Also, users can configure the settings in such a way that they do not allow anonymous questions. Moreover, users can refuse to reply or delete questions they do not like.
- Quora is an innovative Q&A site with a rapidly growing user community that differs from its competitors by integrating a social network into its basic structure (Wang et al., 2013). Users sign in and can immediately start searching for answers to specific questions or topics, which are subject headings assigned by users. Each Quora question has its own page, which includes a list of its answers and a list of related questions. Users can add new answers and comment, edit, and vote on existing answers. Users can follow topics that allow them to see all questions from a given topic in their feed. Also, users can have contacts, and their questions will appear on the Quora feed. Unlike in other Q&A portals, Quora allows users to follow each other (social connections in Quora are directional) to form a social network. As a result, Quora focuses on leveraging social connections to get questions answered by encouraging users to post Quora questions to SNSs, giving the question more exposure (Ovadia, 2011).
- Reddit reports more than 52 million daily active users who contribute to more than 100 thousand communities of an enormous variety of topics. One of the portal's strengths is its sense of community. There are already many specific online communities in Reddit (called subreddits) for a diverse range of topics, and otherwise, it can be easily created. Within each of these subreddits exists a unique community with a distinct subculture. Users are attracted by the sense of belonging the platform creates, as well as a feeling of validation when a submission or a comment is upvoted. There is a hierarchical nature in the portal due to the earning of karma points. Reddit created its etiquette— motivating community members to respond to rudeness, trolling, or spam with downvotes and reporting of the guilty parties.
- StackOverflow is a portal mainly for computer programmers' and developers' questions. The users who ask the questions can add unique tags to help others discover what the question is about.

The questioner can select one answer as the most helpful one (called the accepted answer). At the same time, other registered members can vote on questions and answers. The positive and negative votes (called upvote and downvote, respectively) show how helpful that question/answer was for the audience. Each site member has a reputation score which changes as users participate in different activities across the website, such as posting questions, answers, or comments. A higher reputation value also means more privileges for a user member, such as the ability to edit questions or answers or close a Q&A thread. The interactive nature of StackOverflow makes it possible for both questioners and responders to clarify the vagueness in a question or answer. Moreover, StackOverflow has three properties of new social learning technologies. Firstly, it supports learners to find the right content using natural language, not just relying on keywords. Secondly, users can connect with the right people. Lastly, it motivates them to learn by encouraging them in the question/answer game with the reputation incentive gained from votes.

- Yahoo! Answers has shut down as of May 4, 2021 (Yahoo Answers Has Shut Down, 2021). However, it was one of the most important Q&A portals facilitating the preservation and retrieval of answered questions aimed at building an online knowledge base to encompass any topic (Gyongyi et al., 2008). In order to post a question, a registered user had to provide a short question statement, an optional longer description, and had to select a category to which the question belongs. A question could be answered over a seven-day open period, and then the user who asked the question could pick the best answer or put the answers for a community vote. Questions that remained unanswered or ended up with the majority vote on "No Best Answer" were deleted from the system. When the best answer was selected, the question became resolved and was stored permanently in the system. However, users of Yahoo! Answers could not answer their own questions; thus, an honest discussion could not emerge. Yahoo! Answers had no support for threads that would be essential for diverging discussions (Gyongyi et al., 2008). Finally, it is essential to mention that users were accumulating points through their interactions with the system which was explicitly demonstrated in the leaderboard.

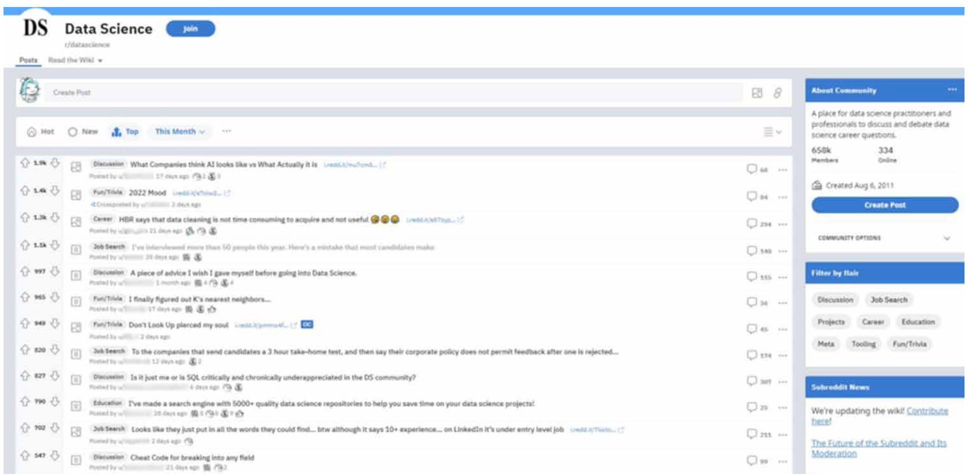
**Summary**. After exploring the above-mentioned portals as researchers, it was decided to focus on working with the most active Q&A portal, namely Reddit, being visited by 430 million active users every month. Across Reddit, there are many subreddits focused on diverse topics of interest. This makes Reddit more attractive for research because the results can serve as a base for identifying topical experts in other subreddits. Moreover, the portal provides an API[1] that can facilitate the step of downloading the required data.

## Data Science Experts and Methodology for their Identification

**Target.** Figure 1 shows an example of the "Data Science" subreddit describing itself as "A place for data science practitioners and professionals to discuss and debate data science career questions," numbering up to 658,000 members. The posts are chosen for the month of January 2022 and sorted by the "Top" criteria, which takes into consideration the most upvotes regardless of downvotes, while "Hot" counts the most recent upvotes, meaning that the content is rapidly becoming in demand and "New" shows the most recent posts. Next to each post, a score can be seen, which is counted as the number of upvotes minus the number of downvotes, along with the arrows for upvoting or downvoting, the number of comments, the nickname of the author, and the user's awards. It is also feasible to filter posts by 'flair'. A flair in

Reddit terms is considered to be similar to or somewhat of a ‘tag’ that one can add to posts or usernames within a subreddit (Long et al., 2017). With millions of posts, a flair is often used to help readers filter information they wish to see and can show it visually, or filter and hide elements for a specific type of post. With a flair, a user can start suggesting the following keywords: “Discussion,” “Job Search,” “Projects,” “Career,” “Education,” “Meta,” “Tooling,” “Fun/Trivia.” Most importantly, at the top of the page, every user can ask a question by clicking on “Create Post,” where it is possible to provide a title of the question, elaborate with a more detailed text related to the question the user is posting, attach an image, a link, or a poll, and choose a flair.

*Figure 1. Data science thread on Reddit*




**Data collection.** The authors downloaded all the posts and the respective comments and subcomments (comments to comments) of the “Data science” thread in Reddit from May 2020 to April 2021, a representative data set for identifying experts in the data science field. They decided to use Python’s Python Reddit API Wrapper (PRAW)[2] package because it eases Reddit’s official API access. The total number of posts that the authors downloaded is 16,436, and the total number of comments is 100,052 (44,029 comments and 56,023 subcomments). On average, every post has six comments, including subcomments. The semi-supervised ML method started with unlabeled data and adopted a data-driven approach to label expert, non-expert, and out-of-scope comments. Two data scientists with relevant experience following the methodology described by Gobert et al. (Gobert et al., 2013) manually labeled approximately 1,000 random comments into these three categories. The labeled data will be used as ground truth and will be needed for ML models to learn the underlying patterns.

An example of one thread that has at least one comment of each type is as follows (the punctuation and spelling of the authors are retained):

Post*: “Best software for large tables?”*

Expert comment*: “Pandas will work as long as you have more RAM than data which if it’s 2 only gb shouldn’t be a problem. If you get too big for that you’ll have to switch to sql.”*

Non-expert comment: *"SQL database"*

Out-of-scope comment: *"Now that I'm asking, what software would be best for analyzing adjacent tiles on a 2d grid? I have a dataset with x and y coordinates, and I feel like there should be a more efficient way to do this than editing and merging tables using a single processor core."*

**Model training.** The authors trained the following multi-class supervised models based on the created labels: Logistic Regression (LR), Random Forest (RF), and Decision Tree (DT). At each step, the researchers performed 10-fold cross-validation on the test set. The features that they used for training the ML models are divided into the following three groups:

- **NLP features.** These are the ones that can be extracted from words, sentences, and phrases. This group of features includes comment length, word count, character count, sentence count, average word length, average sentence length, the average number of subjective words in posted answers, several readability scores, readability time, and term frequency-inverse document frequency derived features.
- **Crowdsourced features.** These involve information or opinions from a group of people who submitted their views via the Reddit site. These features include the karma of the comment and its score (the number of upvotes minus the number of downvotes).
- **User features.** These aim to gauge the activity level of the users who wrote the initial comment on Reddit. This group of features is limited compared to other Q&A portals because the API of Reddit allows getting only the awardees' karma, the awarded karma, a verified account boolean, a verified email boolean, total karma, and comment karma. Recently, Reddit introduced the ability for users to see the names of their followers instead of the number of followers. However, the list of users' followers is not publicly available. Thus, the authors could not include the number of followers or the percentage of bidirectional friends. Additionally, the researchers decided to make use of the rest of the comments that were not used for manual labeling. For each user whose comments happened to be labeled, the authors computed the number of comments and the number of posts throughout the stated timeline. Also, they computed the average score per author, the average number of words in posted questions and posts, account age, average response time, and average upvotes.

The authors used several feature selection methods to be able to compare results across various groups of features.

**Model evaluation.** ML models are parameterized so that their behavior can be tuned for a given problem. Supervised learning is a family of ML algorithms that focus on finding patterns between input variables and their respective labels. In this way, a supervised learning algorithm analyzes the labeled data and produces an inferred function, which can be used for mapping new cases. An optimal scenario will allow the algorithm to determine the class labels for unseen instances correctly. There is a wide range of supervised learning algorithms, each having its strengths and weaknesses. These models can have many parameters, and finding the best combination of parameters is a separate task. To do so, the authors measured the performance of the models using two standard measures: accuracy and Area Under Curve (AUC). Accuracy is the total percentage of correctly classified elements. AUC is a more comprehensive measure of how well the classifier can distinguish between classes. In other words, AUC is equal to the probability that a classifier will rank a randomly chosen positive instance higher than a randomly chosen negative example.

## Preliminary Results and Future Steps

According to these metrics, the RF is the best algorithm (Table 1) to predict if any given comment is an expert comment, a non-expert comment, or an out-of-scope comment. The two other models, namely LG and DT, also show decent results displaying accuracy scores as 0.78 and 0.74 and AUC scores as 0.91 and 0.87, respectively. RF shows an accuracy equal to 0.83 and AUC equal to 0.93, which proves its better performance and means that it has a very high precision. To obtain these results, the following features were selected as the best features: the response time of the user who left the comment, the number of words per post and comment for the author, and posts per user, the number of programming terms, the subjectivity of the comment, several readability scores and the reading time of the comment, and the term frequency-inverse document frequency derived features. These exact features are important to detect experts because they represent essential characteristics of the user who performed the comment and the comment itself. As said, the response time, along with the number of posts of the author with the corresponding number of words, show the activity that this concrete user performed on Reddit and how detailed their answers were. In contrast, the rest of the best features pertain to the NLP group, emphasizing the fact that the comment content itself is quite important.

*Table 1. Comparison of LR, RF, and DT algorithms by accuracy and AUC metrics*

| | Logistic Regression | Random Forest | Decision Tree |
|---|---|---|---|
| Accuracy | 0.78 | 0.83 | 0.74 |
| AUC | 0.91 | 0.93 | 0.87 |

The authors believe that the obtained results prove the potential that Q&A portals open data have to support finding topical experts as it has been done in Reddit. By estimating the user expertise, it is also possible to infer the quality of the content because expert users have a higher probability of producing better quality content. Moreover, through the detection of user expertise of content authors, it is feasible to predict the information quality of the content despite the lack of user votes as well as match open questions to potential experts. Also, Q&A sites are a primary source of news and information that can be steered, distorted, and influenced. In this way, potential malicious or unreliable users can be detected, and their influence can be reduced. From another perspective, the prediction of content information quality could then be applied to improve the curriculum and formative evaluation of academic programs. Finally, effectively identifying the expert in each domain is key to better understanding user engagement.

## Identifying Experts in Photo and Video Sharing Portals: A Case Study on Photography Capabilities in Flickr

### Context and Motivation

Digital photography technology has advanced substantially during the last decade. With this progression, the photography capabilities of people are also being developed and enhanced. Concretely, nowadays, people are more willing to improve their photography capabilities and publicly share their pictures. In this way, the authors investigate the possibility to measure the photography capabilities of photo and video sharing platform users through the guiding principles of photography, namely, image aesthetics and its technical quality.

Photo and video sharing platforms are widely used in present times. Users can upload their video or photographs, discover the content of others, evaluate, share and save it, be members of interest groups, and provide valuable feedback to other users. However, content with many comments or likes does not necessarily mean that it is considered high-quality content. Therefore, much research focuses on identifying technically good and aesthetically attractive pictures. Unfortunately, it is not a trivial task because photography skills are subjective. Thus, the authors will aim to fill this gap by making an exploratory analysis of how deep learning models can help identify professionals in this field through photo-sharing platforms.

### Photo and Video Sharing Portals

This section will review several photo and video sharing sites.

- Flickr is a cloud storage portal not only for storing but also for sharing photographs. Its audience includes diverse profiles of both professional and amateur photographers who want to share their portfolios. Flickr is also geared toward beginners and enables them to edit the photos directly on the platform, such as adjusting brightness and contrast and applying various filters. Flickr provides a unique cloud storage feature to share photos with the public or in subject groups. Flickr users can upload their own photos, post them in galleries and groups, add photos to favorites, write comments, or follow other users. Moreover, the portal offers a Pro account that provides the ability of an unlimited number of uploads, while the free version of Flickr allows 1000 photos. Flickr is different from other photo-sharing websites due to its large community.
- 500px is an appropriate portal for serious photographers, offering an image-focused design and providing a clean and elegant way to display their best shots. It is a portal where photographers can gain exposure, connect with other professionals, or find inspiration. Users can organize their pictures into sets of a particular theme or stories of a particular event. The free version of the service allows users to upload up to seven photos per week. Once the user uploads a photograph, it will have a 24 hours lifespan in order to gain popularity measured in likes and comments. If it does not get enough reputation, the photo will have no chance of appearing in the popular feed.
- Instagram is a favorable place to edit, showcase, and share photos with friends or the world. It offers a surprisingly good set of photo storage, sharing, and editing tools. This portal provides filters that anyone is able to edit their photos instantly. To utilize the power of the Instagram community,

its users can use hashtags to get more exposure. However, there is no opportunity to share the original-size photo.

- 1x.com is curated by a group of professionals. As said, the uploaded photograph is going to be approved or disapproved by a group of professional photographers. Since only a small percentage of pictures is authorized, getting pictures published on this portal can play a good role for the resume. Other valuable features of this platform include critique, tutorials, and right-click download prevention.
- SmugMug is a design-focused photo storage site with a custom homepage and many design templates, allowing professional users to build an online gallery. This portal is designed to meet the portfolio needs of photographers wanting customizability, presentation, and e-commerce. It follows the fact that there is no free version of the subscription. Regardless of the plan, users get unlimited storage of photos up to 500MB in size and a wide range of editing tools.

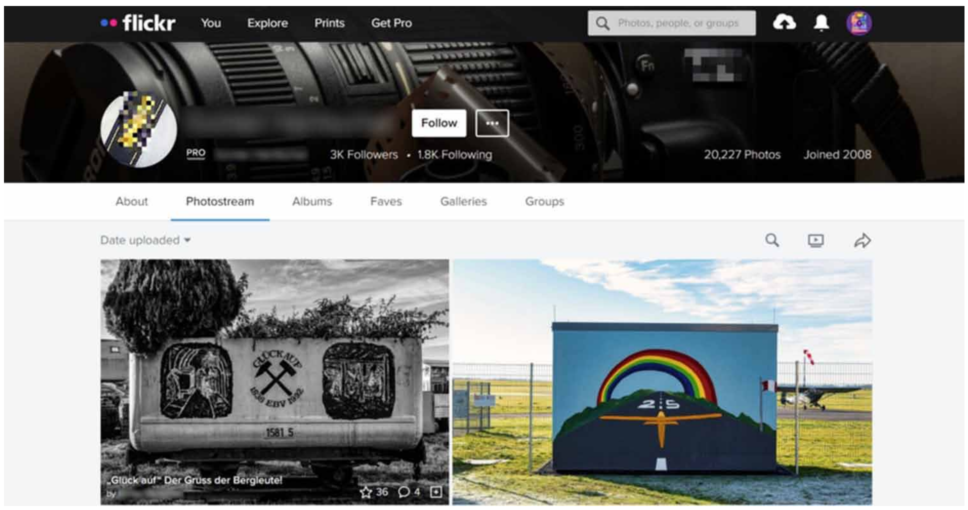
**Summary**. According to Rahayuningsih and Yuniarti (Rahayuningsih & Yuniarti, 2017), professional photographers and photography aficionados with a deep interest in photography prefer to upload their shots to professional portals such as 1x.com or Flickr in order to obtain criticism and advice and encouragements from fellow photographers about the pictures they take so they can improve their knowledge and quality of the photographs. After exploring and testing several photo and video sharing platforms presented above, the authors decided to work with the data from Flickr users. Since it was important to obtain photos from both professional and beginner photographers for this study, the authors selected Flickr because it provides features for all types of users, and the authors were able to accomplish their primary goal of getting diverse types of pictures for further evaluation. The researchers believe that the user data from Flickr has a great potential to infer the photography of its users.

## Professional Photographers and Methodology for their Identification

**Target.** This case study aims to detect which images a typical user would rate as looking aesthetically attractive and technically good, which will serve as a base for measuring the photography capabilities of users. Applying Convolutional Neural Networks (CNN) to the aesthetic quality categorization task is not straightforward since it is challenging to perform automatic feature learning with regard to both the global and the local views of the input images (Lu et al., 2014). By good fortune, there are several already existing approaches of deep CNN trained with human-labeled data, which will serve as a base to measure the photography competencies of users. One can argue that photography skills are something subjective. However, an expert is pre-planning the shooting, all possible lighting approaches, composing the scene, forecasting the character modeling, and all this determines the final effect of a photo (Zhao, 2017).

An example of a users' profile photostream is represented in Figure 2. There also can be observed basic information of the user profile, including the joining year, the number of photos, followers, and following. In the "About" section, the users can provide their occupation, hometown, current city, country, and website. It also shows the number of views, tags, geotags, how many users added their pictures to favorites, and how many groups the user is a member of. The "Photostream" section shows all the user photos sorted by the date uploaded or date taken, while the "Albums" section represents how the pictures are distributed by particular topics. Moreover, users can mark content of other users as favorites and organize photographs to galleries that are publicly available as well. Finally, Flickr gives its users an opportunity to be members of groups to share photographs with other like-minded members, which can be seen in the "Groups" section. Accordingly, there are communities for professionals and amateurs; some of them are moderated, meaning that there is a need for the approval of every picture. These groups will serve as a base for the data collection.

*Figure 2. Photostream of the user v230gh on Flickr under CC BY-ND 2.0 license*




**Data collection.** To accomplish the goal of this case study of detecting which images a typical user would rate as looking technically good or aesthetically attractive in Flickr, the researchers downloaded 1,900 images of the Flickr professional group and 1,900 images of the Flickr amateur group.

**Selected model.** From the deep learning models, the authors will use Neural Image Assessment (NIMA), which is a deep CNN that is trained to predict which images a typical user would rate as looking good (technically) or attractive (aesthetically) (Talebi & Milanfar, 2018). NIMA authors explored several classifier architectures and replaced the last layer of the baseline CNN with a fully-connected layer with ten neurons followed by soft-max activations. Baseline CNN weights were initialized by training on the ImageNet dataset (Krizhevsky et al., 2012). Unlike other models, this one produces a distribution of ratings for any given image - on a scale of 1 to 10, assigning likelihoods to each of the possible scores. In this way, the authors can use NIMA to rank photos technically and aesthetically through various functions of the NIMA vector score (such as the mean), which can serve as a base for training a ML model to identify professional photographers in Flickr.

**Model evaluation.** The authors applied the previously explained deep learning NIMA model to solve the regression problem of predicting the technical quality and aesthetic attractiveness in Flickr that serve as features. The authors normalized the computed features between 0 and 1 in order not to have distorting differences in the ranges.

## Preliminary Results and the Following Steps

In Figure 3, there are normalized distributions of the aesthetic and technical scores across the obtained data set. These distributions have Gaussian shapes with a mean of 0.4 for the aesthetic score and 0.52

for the technical score. Figure 4 represents two examples of the photos that the NIMA model ranked as most and least aesthetically attractive with scores of 0.84 and 0.12 points, respectively. Even though many photos get an average score, these can serve as important features for training the model because there are still outliers.

*Figure 3. The distributions of aesthetic (a) and technical (b) NIMA scores across the data set of photos*

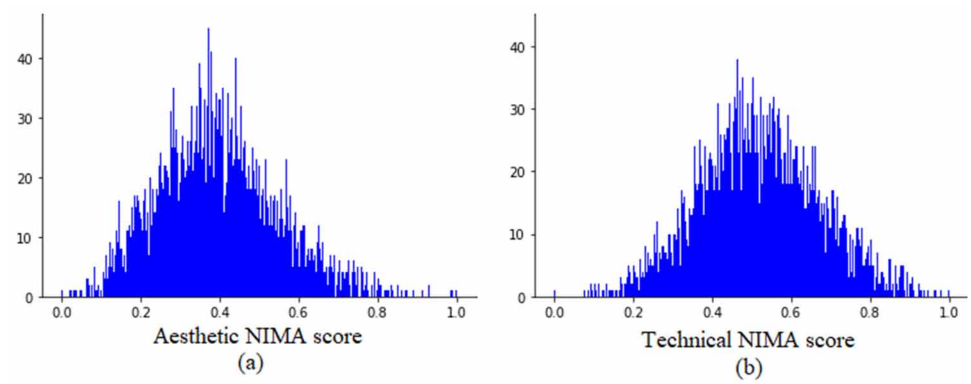



*Figure 4. The examples of high (a) and low (b) ranked aesthetic scores by the NIMA model: (a) nima_score = 0.84 (picture taken from the user 194391943@N08[3] under CC BY-NC-SA 2.0 license), (b) nima_score = 0.12 (picture taken from the user geralddeschain[4] under CC BY-NC 2.0 license)*


On these grounds, NIMA can infer aesthetical and technical scores of photographs, meaning that it can recognize users capable of taking photos that a typical user would like. Moreover, the model can be applied to the entire portfolio of users' photographs. In this way, the authors believe that this exploratory analysis has proved that Flickr online photos can serve as a base to measure the photography capabilities of users. Additionally, computing the following features with Flickr API would be beneficial to train the final ML model for evaluating photography quality:

- **Photography features.** These are the ones that can be extracted from the photos. This group of features includes the output of the NIMA model (aesthetic and technical scores) and Exchangeable

Image File Format (EXIF) data which is specific information stored as part of the file when a photo is captured using a digital camera such as camera settings and adjustments, date/time of capture or copyright ownership.

- **Crowdsourced features.** These involve information or opinions from a group of people who submit their data via the Internet. These features include the number of users who added the photo of the user to their favorites, the number of views the photo had, the number of the comments which were written, the number of groups in which the photo appeared, the difference between the upload date, and the last update of the metadata.
- **User features.** These aim to gauge users' activity level who wrote the initial comment on Reddit. This group of features includes occupation, the number of following users, join date, a profile description, and the number of groups of which the user is a member.

The authors of this chapter are of the opinion that the initial investigation already proves the potential that photo and video sharing platforms have to support finding professional photographers. It can be beneficial to understand the proportions and distinguish photography experts and amateurs in order to maintain the groups of interest really well through engagement and reduce the amount of work of group administrators approving pictures in moderated groups. Moreover, it can be possible to detect sensitive and inappropriate content.

## DISCUSSION

The case studies presented here shows that digital media portals hold evidence of users' competencies and capabilities that are important in the 21st century. In this section, the researchers will question the underlying rationale of why these platforms generate support for providing informal learning opportunities and enhancing the educational process. They will also explore different applications of the presented case studies.

### Where can Informal Learning Happen?

In modern society, Q&A websites and SNSs have gained much interest among people due to their support in solving different kinds of problems. Over the recent years, swift growth in the number of users of these networks has been tracked. Moreover, with the growth of information availability, Q&A websites provide users with a valuable platform for information sharing and searching where they can contribute and interact by posting questions and answers, commenting, and voting. Besides, a large part of the population uses SNSs, across which behaviors, motivations, and user profiles differ (Hellemans et al., 2020). These sites attract diverse groups of people who want to belong to a specific group, consume, and share information. The authors believe that precisely these types of platforms, Q&A portals, and SNSs, can provide opportunities for informal learning . The authors elaborate on the potential reasons next.

First of all, both Q&A websites and SNSs are widely used by many people every day. It is a reality of the 21st century that most people have become very dependent on their smartphones. Indeed, this fact can be seen negatively in certain aspects. However, here the authors want to focus on the potential affordances that this online activity can have, for example, in the context of learning and education. Secondly, the users are creating and consuming a lot of content. Evidently, it is the responsibility of every individual as to what content to get and produce, therefore requiring to filter out low-quality content or misinformation appropriately. However, there is no doubt that recently, many forums have emerged that could be beneficial for learning, and the number of people that learn online keeps growing and growing. Finally, it is also important to mention that Q&A portals and SNSs keep their users motivated to maintain an engaging atmosphere. This fact can be decisive for choosing informal learning opportunities.

## Practical Applications

The authors are of the opinion that the case studies that they exemplified in this chapter can have various applications across several domains.

Firstly, the results presented above can be used as part of the hiring processes of companies. It is not a secret to anybody that from a long time ago, recruiters have been utilizing information online about the candidate as part of the screening process, not only by monitoring the behavior of the potential candidates across professional social networks like LinkedIn but also in other SNSs. There are several motivating reasons why employment services prefer online screening methods over traditional methods. Firstly, nowadays, it seems like a natural impulse to investigate more about the prospective candidates' online identity insights that could reflect some work qualities not presented in the resume. Moreover, online monitoring is cost-effective, does not require much time, and foresees easy data processing. That being in the case, a company could benefit from employing an expert who has proved to be active online in career-related portals by showing interest in getting or providing feedback to colleagues or displaying other necessary dynamic capabilities that exhibit the person's potential. Above all, socio-technological environments are able to contextualize the capabilities and efforts of users empowering prospective employers to avail themselves of vast amounts of intentionally and inadvertently disclosed applicant information (Karriker, J. H., & Hartman, 2018). However, job hunters should not be deceptive in advancing their social media employment profiles; instead, they should build their resumes matching the job offers and be cognizant of the influences of their contextual information reflecting their potential (Karriker, J. H., & Hartman, 2018).

Furthermore, the performed case studies can be used as a part of formative assessment, providing ongoing feedback to teachers to improve their teaching and to students to boost their self-awareness. This can help enhance their learning process by recognizing their strengths and weaknesses in order for learners to put the focus on areas that require more consideration and for instructors to identify the tangled topics and address the problems immediately. Formative assessment typically involves qualitative feedback focused on the details of the students' work, performance, and actions under students' control, rather than on the students themselves. It is vital that high-quality, consistent, and timely feedback is sufficient in frequency and detail in order to provide the foundations for learner autonomy and a framework for high achievement.

Content sharing and consumption portals facilitate a kind of collaborative learning and peer feedback where equal status users, namely peers, provide opinions and critiques on other users' submissions by giving upvotes and writing comments. Peer feedback has proved to be beneficial for student learning, including enhanced knowledge of the subject matter, feedback from a range of sources, constructive reflection, attention to detail, critical analysis, critical thinking, and improved quality of work area (Jacoby et al., 2014; Mora, Signes-Pont, Fuster-Guilló, & Pertegal-Felices, 2020). To this extent, this kind of feedback can provide users with more informal learning opportunities.

Finally, the results that the researchers provided can contribute to the literature on self-regulated or self-directed learning, influencing self-efficacy, motivation, and effort towards academic success. This skill and honing this ability is crucial because self-regulated learners are able to meet the demands of many situations, including academic tasks, by actively controlling their active, goal-directed, self-controlled behavior, motivation, affect, time, and cognition. Self-regulated learners view the acquisition of skills as a systematic and controllable process, and they take greater responsibility for their achievement outcomes. Self-regulation reflects the idea of being able to develop knowledge, skills, and attitudes that can be transferred from one learning context to another (Al Mamun, Lawrie, & Wright, 2020; Pintrich, 1995). Along these lines, self-regulated learners solve educational tasks with confidence, diligence, and resourcefulness; moreover, they are aware when they know a fact or possess a skill and when they do not. On top of that, when they encounter obstacles such as poor study conditions, confusing teachers, or abstruse textbooks, they find a way to succeed (Bonk, & Lee, 2017).; Zimmerman, 1990). The good side is that students can learn to self-regulate regardless of age, gender, ethnic background, actual ability level, prior knowledge, or motivation. Therefore, the case studies presented in this chapter hold the potential to be used for developing self-regulation.

## CONCLUSION

Social media and content sharing and consumption portals are now so integrated into people's daily life that many possibilities have emerged for online learning across them. In this chapter, the authors discussed the characteristics of these online platforms and the reasons why informal learning is happening precisely across SNSs, Q&A portals and photo and video sharing platforms. They then presented two case studies, one focused on detecting data science experts across the Reddit community by examining comments of the respective subreddit thread and another one measuring the photography capabilities of Flickr users. The presented results proved that it is possible to identify experts in specific fields by analyzing users' open online traces. Moreover, these approaches can serve as a base to replicate these methodologies to infer other competencies and capabilities across online portals.

The authors believe that there are several promising applications of the case studies presented in this chapter, including the implementation of these models as part of the hiring processes to improve candidate selection, their application in the educational context of formative assessment, and to improve the self-regulated learning capacities of students to obtain higher performance and motivation. Also, there is no doubt that the digitalization impact from 2010 has proved that there is a need to reform the formal education approaches. In this way, the official syllabus of the courses must include and adopt diverse teaching strategies, for example, by making use of various online teaching platforms, promoting informal and self-regulated learning. With this in mind, teachers, learners, and education stakeholders, in general, will be better prepared for the times of crisis and the need for new competencies required to function in the 21st century successfully.

## ACKNOWLEDGMENT

This study was partially funded by the COBRA project (10032/20/0035/00), granted by the Spanish Ministry of Defence and by the SCORPION project (21661-PDC-21), granted by the Seneca Foundation of the Region of Murcia, Spain.

## REFERENCES

Al Mamun, M. A., Lawrie, G., & Wright, T. (2020). Instructional design of scaffolded online learning modules for self-directed and inquiry-based learning environments. *Computers & Education*, *144*, 103695. doi:10.1016/j.compedu.2019.103695

Bonk, C. J., & Lee, M. M. (2017). Motivations, achievements, and challenges of self-directed informal learners in open educational environments and MOOCs. *Journal of Learning for Development*, *4*(1), 36–57.

Carter, R. A. Jr, Rice, M., Yang, S., & Jackson, H. A. (2020). Self-regulated learning in online learning environments: Strategies for remote learning. *Information and Learning Science*, *121*(5–6), 311–319. doi:10.1108/ILS-04-2020-0114

Dhar, B. V. (2013). Dhar_Data_Science_Prediction. *Communications of the ACM*, *56*(12), 64–73. doi:10.1145/2500499

Farrugia, L., Lauri, M. A., Borg, J., & O'Neill, B. (2019). Have You Asked for It? An Exploratory Study About Maltese Adolescents' Use of Ask.fm. *Journal of Adolescent Research*, *34*(6), 738–756. doi:10.1177/0743558418775365

Gobert, J. D., Sao Pedro, M., Raziuddin, J., & Baker, R. S. (2013). From Log Files to Assessment Metrics: Measuring Students' Science Inquiry Skills Using Educational Data Mining. *Journal of the Learning Sciences*, *22*(4), 521–563. doi:10.1080/10508406.2013.837391

Gyongyi, Z., Koutrika, G., & Pedersen, J. (2008). Questioning yahoo! answers. *Www2008*. http://ilpubs.stanford.edu:8090/819

Hellemans, J., Willems, K., & Brengman, M. (2020).. . *Daily Active Users of Social Network Sites: Facebook, Twitter, and Instagram-Use Compared to General Social Network Site Use.*, *1*, 194–202.

Jacoby, J., Heugh, S., Bax, C., & Branford-White, C. (. (2014). Enhancing learning through formative assessment. *Innovations in Education and Teaching International*, *51*(1), 72–83. doi:10.1080/14703297.2013.771970

Karriker, J. H., & Hartman, N. S. (2018). Social Media and Dynamic Capabilities: Mining Millennial Resources. *Journal of Organizational Psychology, 18*(4), 43–56.

Krizhevsky, A., Sutskever, I., & Hinton, G. E. (2012). ImageNet Classification with Deep Convolutional Neural Networks. *Communications of the ACM*, *60*(6), 84–90. doi:10.1145/3065386

Long, K., Vines, J., Sutton, S., Brooker, P., Feltwell, T., Kirman, B., Barnett, J., & Lawson, S. (2017). *"Could You Define That in Bot Terms"?* Academic Press.

Lu, X., Lin, Z., Yang, J., & Wang, J. Z. (2014). RAPID : Rating Pictorial Aesthetics using Deep Learning * Categories and Subject Descriptors. *ACM Multimedia*, 457–466.

McCarthy, J. (2017). Enhancing feedback in higher education: Students' attitudes towards online and in-class formative assessment feedback models. *Active Learning in Higher Education*, *18*(2), 127–141. doi:10.1177/1469787417707615

Mentor, D. (2018). TLC for MOOCS: Teaching and Learning Communities for Computer Programming. In Computer-Mediated Learning for Workforce Development (pp. 93–110). IGI Global.

Ovadia, S. (2011). Internet connection quora.com: Another place for users to ask questions. *Behavioral & Social Sciences Librarian*, *30*(3), 176–180. doi:10.1080/01639269.2011.591279

Packiam, T., & Geoffrey, R. (2012). The impact of engagement with social networking sites (SNSs) on cognitive skills. *Computers in Human Behavior*, *28*(5), 1748–1754. doi:10.1016/j.chb.2012.04.015

Pal, A., Herdagdelen, A., Chatterji, S., Taank, S., & Chakrabarti, D. (2016). Discovery of Topical Authorities in Instagram Categories and Subject Descriptors. *Www*, 1203–1213.

Pintrich, P. R. (1995). Understanding Self-Regulated Learning What Is Self-Regulated Learning? *New Directions for Teaching and Learning*, *63*(63), 3–12. doi:10.1002/tl.37219956304

Rahayuningsih, H., & Yuniarti, K. W. (2017). *Balancing Development and Sustainability in Tourism Destinations*. Balancing Development and Sustainability in Tourism Destinations.

Raj, N., Dey, L., & Gaonkar, B. (2011). Expertise prediction for social network platforms to encourage knowledge sharing. *Proceedings - 2011 IEEE/WIC/ACM International Conference on Web Intelligence, WI 2011, 1*(September), 380–383. 10.1109/WI-IAT.2011.93

Saltz, J. S., Shamshurin, I., & Crowston, K. (2017). Comparing data science project management methodologies via a controlled experiment. *Proceedings of the Annual Hawaii International Conference on System Sciences,* 1013–1022. 10.24251/HICSS.2017.120

Shih, R. (2012). Can Web 2.0 technology assist college students inlearning English writing? Integrating Facebookand peer assessment with blended learning. *Australasian Journal OfEducational Technology*, *37*(2), 36–39.

Strukova, S., Ruipérez-Valiente, J. A., & Mármol, F. G. (2022). A Survey on Data-Driven Evaluation of Competencies and Capabilities across Multimedia Environments. *International Journal of Interactive Multimedia & Artificial Intelligence*.

Talebi, H., & Milanfar, P. (2018). NIMA: Neural Image Assessment. *IEEE Transactions on Image Processing*, *27*(8), 3998–4011. doi:10.1109/TIP.2018.2831899 PMID:29994025

Thai, M., Sheeran, N., & Cummings, D. J. (2019). We're all in this together: The impact of Facebook groups on social connectedness and other outcomes in higher education. *Internet and Higher Education, 40*(February), 44–49.

Turki, F. J., Jdaitawi, M., & Sheta, H. (2018). Fostering positive adjustment behaviour: Social connectedness, achievement motivation and emotional-social learning among male and female university students. *Active Learning in Higher Education*, *19*(2), 145–158. doi:10.1177/1469787417731202

Ulla, M. B., & Perales, W. F. (2021). Facebook as an integrated online learning support application during the COVID19 pandemic: Thai university students' experiences and perspectives. *Heliyon*, *7*(11), e08317. doi:10.1016/j.heliyon.2021.e08317 PMID:34746477

UNESCO. (2021). *Education: From disruption to recovery*. https://en.unesco.org/covid19/education-response

Vesselinov, R., & Grego, J. (2012, December). Duolingo Effectiveness Study. *City University of New York, USA*, *28*, 1–25.

Wang, G., Gill, K., Mohanlal, M., Zheng, H., & Zhao, B. Y. (2013). *Wisdom in the social crowd*. Academic Press.

Yahoo Answers has shut down. (2021). https://help.yahoo.com/kb/SLN35642.html

Yan, X., Yang, J., Obukhov, M., Zhu, L., Bai, J., Wu, S., & He, Q. (2019). Social skill validation at LinkedIn. *Proceedings of the ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*, 2943–2951. 10.1145/3292500.3330752

Zhao, Q. (2017). Summary of Commercial Photography Skills in the Context of Visual Communication. *DEStech Transactions on Social Science, Education and Human Science,* 102–107.

Zimmerman, B. J. (1990). Self-Regulated Learning and Academic Achievement: An Overview. *Educational Psychologist*, *25*(1), 3–17. doi:10.120715326985ep2501_2

## ADDITIONAL READING

Durães, D., Toala, R., Gonçalves, F., & Novais, P. (2019). Intelligent tutoring system to improve learning outcomes. *AI Communications*, *32*(3), 161–174. doi:10.3233/AIC-190624

Gomez-Uribe, C. A., & Hunt, N. (2015). The netflix recommender system: Algorithms, business value, and innovation. *ACM Transactions on Management Information Systems*, *6*(4), 1–19. doi:10.1145/2843948

Patil, S., & Lee, K. (2016). Detecting experts on Quora: By their activity, quality of answers, linguistic characteristics and temporal behaviors. *Social Network Analysis and Mining*, *6*(1), 5. doi:10.100713278-015-0313-x

Pham, P., & Wang, J. (2015, June). AttentiveLearner: improving mobile MOOC learning via implicit heart rate tracking. In *International conference on artificial intelligence in education* (pp. 367-376). Springer. 10.1007/978-3-319-19773-9_37

Raikos, A., & Waidyasekara, P. (2014). How useful is YouTube in learning heart anatomy? *Anatomical Sciences Education*, *7*(1), 12–18. doi:10.1002/ase.1361 PMID:23564745

Strukova, S., Ruipérez-Valiente, J. A., & Mármol, F. G. (2021, September). Data-Driven Performance Prediction in a Geometry Game Environment. In *Proceedings of the Conference on Information Technology for Social Good* (pp. 283-288). 10.1145/3462203.3475905

Wong, M. M., & Csikszentmihalyi, M. (1991). Motivation and academic achievement: The effects of personality traits and the duality of experience. *Journal of Personality*, *59*(3), 539–574. doi:10.1111/j.1467-6494.1991.tb00259.x PMID:1960642

Yin, C., Okubo, F., Shimada, A., Oi, M., Hirokawa, S., & Ogata, H. (2015, November). Identifying and analyzing the learning behaviors of students using e-books. In *Proceedings of the 23rd International Conference on Computers in Education* (pp. 118-120). Hangzhou, China: Asia-Pacific Society for Computers in Education.

## KEY TERMS AND DEFINITIONS

**Application Programming Interface (API):** A set of functions that allows building and integrating applications' software.

**Data Science:** An interdisciplinary field whose objective is to extract and interpret knowledge and insights using scientific methods, processes, algorithms, and systems.

**Formative Assessment:** A wide variety of methods that teachers use to evaluate students' comprehension, learning needs, and academic progress during an educational process.

**Informal Learning:** Learning happening outside of a structured, formal classroom environment.

**Information Retrieval:** An automatic process, methods, and procedures of searching and obtaining data that are relevant to an information need.

**Machine Learning (ML):** A branch of computer science that uses data and specific algorithms to imitate how humans think and learn.

**Self-Regulated Learning:** the ability of individuals to understand and control their learning environment.

## ENDNOTES

[1] https://www.reddit.com/dev/api/

[2] https://github.com/praw-dev/praw/

[3] https://www.flickr.com/photos/194391943@N08/51789666311

[4] https://www.flickr.com/photos/99614740@N07/20094364928

# Chapter 6
# TLC for MOOCs:
## Teaching and Learning Communities for Computer Programming

**Dominic Mentor**
*Columbia University, USA*

**Rizqarossaa Darni**
*Cambridge University, UK*

**Anna Cho**
*Teachers College, Columbia University, USA*

## ABSTRACT

*This chapter reports on a sustainable model created to increase engagement, success, and retention in a MOOC for learning computer programming within a United States-based national vocational program. The training organization was one of 10 national and regional organizations awarded scholarships by American-based information and telecommunications companies to participate in a MOOC to introduce and learn computer programming. The curriculum was informed and designed by multinational software technology corporations to address the dearth of computer programming talent in the USA. The academic unit set out to convert the poor state of MOOC completion rates, to convert the online opportunity into an active, supportive, and an engaging virtual space with a view to increase completion. Theoretical frameworks of scaffolding the learning and leveraging zones of proximal development were employed with precursor courses to help ramp up knowledge of an unknown subject area and skill. Social connectedness methods were also used to create teaching and learning communities (TLC) of support.*

## INTRODUCTION

Massive Open Online Courses (MOOCs) offer digitized courses for the masses. MOOCs are still highly popular as indicated by the number of people who register for them (Schulze, Leigh, Sparks, & Spinello, 2017). However, less than 5% of people who register, complete the MOOC course (Dillahunt, Wang,

DOI: 10.4018/978-1-6684-3996-8.ch006

& Teasley, 2014; Evans & Baker, 2016; Rai & Chunrao, 2016). From the education field, for-profit companies, like Coursera and Udacity, who offer MOOCs, at times in partnerships with universities, are looking at ways to disrupt the global education industry (Verger, Lubienski & Steiner-Khamsi, 2016). EdX, founded by the Massachusetts Institute of Technology (MIT) and Harvard, in partnership with 90 universities and schools, according to their own press release, grew from 81 million total global enrollments in 2019, to over 110 million global enrollments in 2020, a record 29 million increase (Shah, 2020). Udemy claims to offer more than 50,000 online courses on its platform, where professors and instructors can design and offer courses at a rate of their own choosing (Epelboin, 2017; Gaebel, 2014; Täuscher & Kietzmann, 2017). Some claim that workers are increasingly adopting MOOCs as a route to further their professional development and skill set (Milligan & Littlejohn, 2017; Yuan, Powell & Cetis, 2013; Savino, 2014). Commercial departments engaging with learning and development in workplaces across the world are increasingly incorporating digital learning to provide on-demand, ongoing, and self-directed learning that is aligned to the needs of a rapidly changing workforce, often at lower costs compared to the conventional face-to-face delivery models (Wildi-Yune and Cordero, 2015; Deloitte: Pelster, Haims, Stempel & Vyver, 2016).

Using Gartner's hype cycle of emerging technologies, a methodology that postulates how technology will evolve within their context of an industry and business goal (Flenn & Blosch, 2018; LeHong, Fenn, & Leeb-du Toit, 2013), the verdict seems to still be out on whether it has hit its peak or levelled off at the trough of disillusionment. EPICC, a technology training organization, was invited amongst 20 others to participate in a sponsored participation of MOOCs on computer scripting and programming. The invitation stemmed from various technology companies and the Obama administration to address the dearth of computer programming talent. Each of the participating organizations worked on their own as they approached the opportunity and challenges of having their young talent participate in a forum that sees massive attrition. Gomez Galan et al. (2019) argued that even though we may not perfectly predict what MOOCs would be like in future universities, we know that the concept of MOOCS will "remain in the panorama of higher education" (p.105).

There are many challenges with participating in MOOCs. Separately from high attrition and maintaining interest, other challenges within this specific MOOC endeavor ranged from an intensely high and rapid learning curve, inconsistent practice and quality of course content, untrained trainers, lack of, or rather less than a desirable insight of learning, and progress transparency (Kennedy, 2014; Castillo et al. 2015; Gómez-Galán, 2019). There was a need to address the challenges as well as the other general MOOC stumbling blocks, which ranged from significant drops in engagement, inability to retain the initial number of participants who registered, as well as a lack of drive to complete the course. These difficulties were further compounded by the physical distance between trainees and their on-the ground-support staff (Atlanta), and the project managers and tutors (New York) guiding and supporting the effort. The latter is important to mention because apart from this being the first time these students/trainees were (i) participating in a MOOC, (ii) learning how to learn online, (iii) this was the first time that these students/trainees were getting remote support from a team situated in another city.

To address and to overcome these challenges; the rapid and intense learning curve, untrained or lack of Subject Matter Expertise (SME), and lack of learning transparency, some aspects of social connectedness were employed. Other theories that informed the practical pedagogy were cognitive constructivism in the form of building on prior knowledge and utilizing zones of proximal development methods with collaborative learning engagements. Additionally, a schedule was set up for in-person contact time as well as contact time with the virtual tutors and project managers. The virtual meetings were between the virtual tutors and the on-the-ground instructor, and separately with the students and MOOC trainers. The theoretical lenses applied to the methodologies were social connectedness (Mentor, 2012; 2017) while the methodologies and practices implemented, were informed by computer mediated collaborative learning (Beetham & Sharpe, 2019; Beetham & Sharpe, 2013; Majchrzak, Rice, King, Malhotra, & Ba, 2014; Walther, Hoter, Ganayem, & Shonfeld, 2015), otherwise also known as computer supported collaborative learning theories (Andriessen, Baker, & Suthers, 2013; Fischer, Kollar, Stegmann, & Wecker, 2013; Goodyear, Jones, & Thompson, 2014).

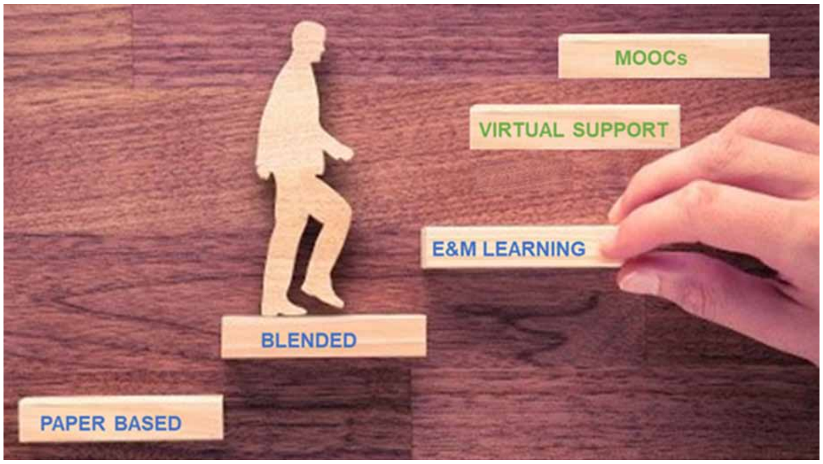
## BACKGROUND

This chapter reports on methodologies used to cultivate social connectedness for a learning community participating in a MOOC. The participating urban young adults were part of a workforce training program trying to expand its curriculum offerings to target the labor market need for computer programming. The trainees had little to no computer programming knowledge or skill. Data from a preliminary survey indicated that only a few of the 21 students had some HTML exposure, but have not necessarily fully built out a website with HTML and CSS, nor have any JavaScript or Java exposure. This first phase of 21 students were part of an initial pilot to determine the viability of a concept product and process. If successful, a larger scale second phase of hundreds of students would be considered to participate in similar MOOC models to learn programming skills.

The modus operandi of the national training organization was to offer a six-month, intensive training program, followed by a six-month internship. The Learning and Development (L&D) organization provides urban young adults, ages 18-24, with a combination of technical and professional skills, college credits, an educational stipend, and an internship. At the time of the TLC MOOC effort, the organization operated in 14 cities, with 8 of those cities having their own instructors. The L&D organization was invited to participate in the MOOC with the backdrop of trying to provide a workforce with skills to meet current and future labor market programming needs.

Further background information includes that the national training organization had been in existence for about 12 years, and only partially piloted blended e-learning models in 2012, with a 100% soft roll-out of blended e-Learning and mobile Learning (e-&m-Learning) and in 2013 to eight of its eight training sites (Mentor, 2016). Blended learning is the thoughtful integration of classroom face-to-face learning experiences with online learning experiences; it integrates the strengths of synchronous (face-to-face) and asynchronous (online learning that can happen within a flexible time set framework and not be restricted by learners or teachers needing to be in one place at the same time) learning activities (Saliimah, 2021). After introducing a blended e-&-m-Learning approach as part of its academic vision and strategy (Mentor, 2016; 2017), the national training organization could execute a nimble curriculum alignment as well as the start of exploring, deploying and expanding its e-Learning initiatives. Through simulations, the organization was also able to incorporate social collaboration, m-Learning, and interoperable learning tools connected through pre-existing Application Protocol Interfaces (APIs) between online learning support software, that cultivated and accommodated differentiated learning styles. Ultimately, the organization was able to grow an ecology of collaboration, share material, and plant seeds for further growth and innovation needed by the training organization. Further, it set itself up to introduce and utilize distance learning for workforce training.

*Figure 1. Step-by-step academic vision and digital strategy mapped out by National Academic Department*




In 2014, the entry level national training organization (NTO) piloted participation in a MOOC prompted by scholarship offerings from major telecommunications, and technology companies, as well as long-standing MOOC service providers. The telecommunications and technology company worked with the MOOC service provider to design the curricula content that they identified as needed from labor market data.

The technology companies involved in funding the effort hailed the endeavor as preparing the workforce of the future (Smith, 2013). These companies stated that they were "moving to a software-defined, mobile-first environment" (ibid), and the need for employable talent in this regard was considered "more critical than ever" (ibid). Hence, this resulted in the need to develop a pipeline of employees with the skills to succeed, be retained, and to aid the technology companies in their desire to have skilled talent to address the current dearth of programmers in the workforce as well as the anticipated labor market needs. This view was part of an even broader scope and need, and that was to "prepare students, as well as those already in the workforce — no matter where they work — for success in 21st century careers" (ibid).

*Figure 2. Rationale for agreeing to accept invitation to participate in Computer Programming MOOC*

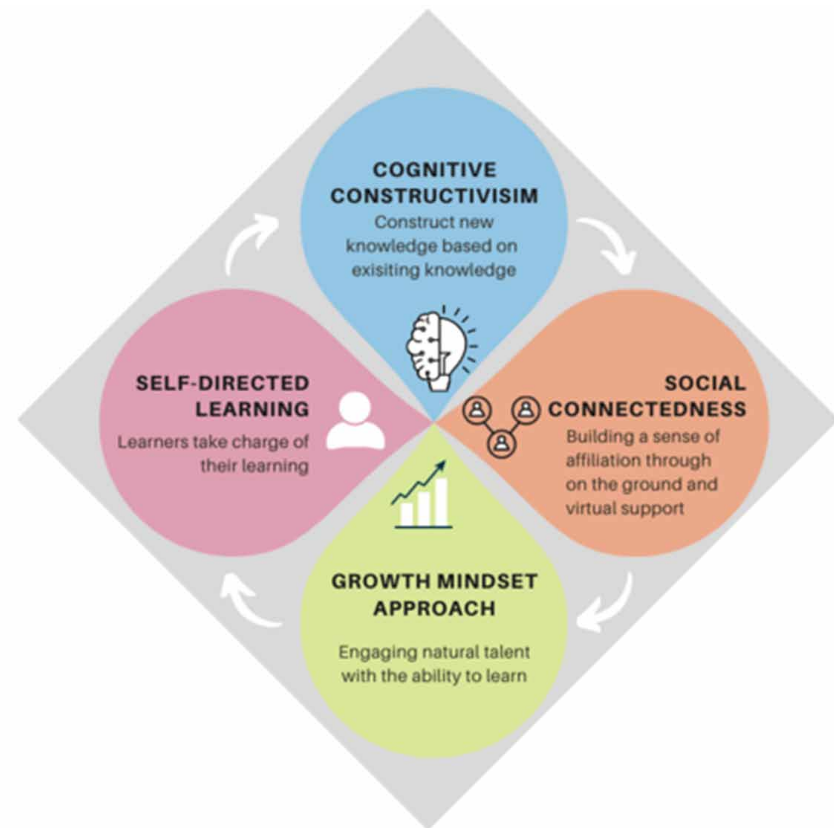
The labor market needs served as the push for the technology companies to partner with one another to seek out a MOOC service that would write, review, or contract the construction of computer programming curricula. The MOOC service was hosted by MOOC service provider who, in conjunction with the technology companies, helped launch what they termed a Nanodegree credential for the basic skills needed for the Software Economy (Smith, 2013). A Nanodegree credential is a credential that is project and skills-based, and it would be awarded when one completes a set number of projects that demonstrate their mastery of the skills (Watkins, 2016). It must be noted that at the launch of, and at the time of writing this chapter, the Nanodegree was not a recognized credential by higher education (Guzdial, 2014; Lazaroiu, Popescu, & Nica, 2016; Popenici, 2015), but was instead envisioned to become a key part of the telecommunication and technology companies' training and talent acquisition model. Furthermore, the concept of a nanodegree, while useful to illustrate earning smaller credits towards a bigger credential, still resounds as mere marketing rhetoric than becoming a realizable credential. Additionally, given the successful participation, higher retention, and completion of the national workforce development organization trainees, the organization was again invited to participate in a MOOC funded by a multinational conglomerate to increase their diversity (Tansey, 2018; Van Kleef Conley, 2018).

## THEORETICAL FRAMEWORK

The national workforce development organization was invited amongst other regional and national non-profit after school and training organizations to participate in a funded MOOC on computer science to grow entry level computer scripting and programming talent. The theoretical concepts of self-directed learning (Candy, 2004), cognitive constructivism, social connectedness, and a growth mindset approach was used to head off potential high attrition of MOOCs as well as to foster higher engagement, learning success, and completion. Social connectedness speaks to the sense of affiliation that the students had gained through on-the-ground and virtual remote support, whereas the growth mindset, challenged trainees about concepts of natural talent and the ability to learn (Hsu, Baldwin, & Ching, 2017; Loksa, Ko, Jernigan, Oleson, Mendez, & Burnett, 2016; Mercer & Ryan, 2010).

To overcome the high and rapid learning curve for these students who had never participated in any computer programming training, had minimal online learning, or participated in a MOOC for that matter, a learning ramp was created to cultivate a supportive zone of proximal development (Smagorinsky, 2017). The learning ramp consisted of pre-work that was specifically created from pre-information supplied by the technology and MOOC companies. The pre-work consisted of virtual and on-the-ground support structures. One may ask why was this attractive? The baseline was that the national academic training department knew that the learning ramp in preparation and support of participating in a MOOC could be a scalable solution to develop highly marketable skills in a way that reduces the organizational cost and investment in curriculum development with a clear connection to internships and jobs. The ramp-up was attractive because it included informal learning and professional development of the on-the-ground facilitators. The ramp-up period was also intended to potentially help interested students ascertain whether they have an interest, affinity, or proclivity for learning and working with computer scripting and programming languages. The ramp-up period was set up to act as an empowerment training force, to establish with students and teachers that they could reach out to the provided virtual support at any time, without fear of mockery or signals of their reaching out was a bootless errand.

*Figure 3. Teaching and Learning Communities for MOOCs Theoretical Framework Design*




The MOOC service provider indicated they would provide two virtual Coaches who would work with students during scheduled hours or by appointment. Coaches could be contacted by email or web conference, and they may possibly provide support by hosting class forums or webinars for larger groups. It was envisioned that the Coaches would help with the following aspects of the program:

- Help students set the pace at which they want to work (e.g., set a date by which they want to finish the required courses completely) and help students stick to that pace by setting goals and benchmarks with them.
- Answer students' questions about the content or subject matter.
- Provide feedback on students' final projects as they build out their portfolio.

## MAIN FOCUS OF THE CHAPTER - ISSUES, CONTROVERSIES, PROBLEMS

There were many challenges that ranged from intensely high and rapid learning curves, untrained trainers, lack of teacher and learning support as well as progress and evaluation transparency of students' submitted work within the MOOC system. There were also anticipated MOOC challenges that needed to be combatted, like significant drops in engagement, high attrition, and lack of course completion.

To address and to overcome these challenges (e.g., ranging from the rapid and intense learning curve, untrained trainers, and lack of learning transparency), aspects of social connectedness were employed through digital means, for both remotely located trainers, students, and on-the- ground training staff. The methodologies and practices implemented aided the trainees who had never completed any computer scripting or programming, as well as the on-the-ground trainer, who had limited experience in this regard, but had a huge passion, and dedication to seeing the trainees succeed.

The proposed plan was to mitigate risks and the possible over exposure of slim resources was to host the MOOC as an elective, where a local branch could opt-in with full national support. The National Academic Department would offer valuable lessons and maximize value without creating a burden for national or local academic teams.

There were other broader challenges from an organizational point of view. The organization had a focus on hardware and desktop support and hired trainers in this regard. On a larger scale, outside of the training department, there was no subject matter expertise, nor knowledge of what computer programming or training entails. Some misunderstandings that needed to be overcome was that Information and Communication Technologies (ICT) was a massively wide field with specialized subject matter expertise. There was the assumption by non-academic teams that just because a trainer taught a course on hardware, it meant that they could teach computer coding. This lack of basic and deep knowledge had some narrow interpretations in that the learning and training of computer science elements could be put down to either critical thinking, music ability, or mathematical ability. The understandable inability to talk about a proper comprehension of computer programming, other than repeating or reciting some terminology that was heard, bled into the inability to articulate, and grow these new business opportunities at the rapid pace at which it was needed. This then fed into the inability to foresee or understand the needs or challenges shared by subject matter experts regarding required training within this specific context. Initially, due to this lack of knowledge within affiliated departments, it was also determined by other departmental stakeholders, that there was not enough information available to determine if, and how this curriculum may form the basis of a new career track or multiple tracks for the organization to offer the trainees, or for current and potential corporate partners. There was a need to build the understanding of the entire organization, and each department, on how much we needed to know and how much we could deliver in the short, intensive training period, as well as a need to know more about the skill sets required and career progression associated with possible full-time jobs in this regard. The latter information could aid the firming up of the number of corporate partner needs, over which time period and for how long, as well as the number of trainees needed per location. Furthermore, deeper knowledge and less of a superficial understanding of computer programming would also have helped identify the expansive scope of intern and internship commitments. From the many challenges and perceived limitations, two other channels of the organization were also considered, both of which consisted of alumni of the training program.

Notwithstanding the misperception that the consideration of the alumni of the program to make use of this opportunity, the notion was further predicated on the misunderstanding or rather limited perception that all ITC skills, be it hardware in this case, was easily and highly transferable to the training and learning of computer coding languages. But thankfully the alumni phase of the program was deemed by the National Academic Department to not be ready for this MOOC opportunity for a few reasons:

1. There was no proper infrastructure or processes in place yet to support the training and learning needs,

2. There was no subject matter expertise in these channels to execute on this opportunity that were initiated by technology companies, and
3. The participant, program, and organizational desired outcomes needed to be met were too diverse and diverged from being able to be interlinked in a seamlessly integrated manner.

Those organizational outcomes were paid internships, job placements from the main sponsoring ICT company, as well as other corporate partners. However, given the monitoring of labor market data and subject matter expertise by the national academic learning and development department, as well as an alignment with their vision and strategy of blended, mobile and eLearning, a rationale could be developed to proceed after an evaluation of the MOOC service provider and the course content.

## MOOC SERVICE PROVIDER AND COURSE ASSESSMENT

Comparing various MOOC vendors according to a criteria taxonomy helped decide between multiple requests from MOOC vendors to use their platform. Criteria used as part of the decision-making process ranged from user interface, user experience (UI/UX), pedagogical, and technological criteria (Yousef, Chatti, Schroeder, & Wosnitza, 2014) as well as evaluation from a Service Oriented Software (SOA) approach (Meinel, Totschnig, & Willems, (2013). In this context, the MOOC service provider's curriculum was also evaluated to assess whether it met National Academic Training Departments' (NATD) instructional design standards, and whether it matched the NATD's short and long-term goals in terms of online and blended learning.

Moreover, our assessment involved looking at whether the MOOC service provider and the course curriculum measured up to the National Training Organization's standards and needs. The hope was that we would be able to learn from the content and structural placements of the industry-informed MOOC courses and to evaluate our own courses against industry demands or guide our current in-development courses accordingly. We chose to evaluate the MOOC service provider's framework as a MOOC for blended and flipped learning by looking at the following aspects:

- Quality of course content
- Delivery and structure of online course materials
- Support from remote coaches provided by the MOOC service provider
- Formative and Summative Assessments

There were some who considered the MOOC provider as a market-leader and established further value from that notion to agree to, and promote the use of, resources to participate in the MOOC as a pilot project. Yet, further evaluation was needed of the en masse hypermedia for learning technologies being suggested for online learning to trainees that were just introduced to blended e-Learning. A MOOC, while similar to other technology enhanced systems, by definition includes a massive number of students, and adds multiple layers and dimensions to the teaching learning context. Which also then demands other considerations to ensure the learning is effective and goals are met. Hence, an evaluation of a MOOC requires additional sets of criteria (Yousef, Chatti, Schroeder, & Wosnitza, 2014).

## Evaluation of Students' Work

During participation with the MOOC, students would be evaluated based on project and portfolio work that they complete. The MOOC courses hosted project completion benchmarks. Some of the projects in the portfolios would include developing blogging and wiki applications, building websites, interactive resumes, single page applications, and computer games. The projects in the student portfolio would be informed by the learning objectives of the course.

Students would develop particular skills in Front End Development ranging from:

- Designing websites using the latest web standards.
- Testing user design and user experience to transform text into compelling web applications.
- Developing dynamic web applications using JavaScript.
- Using version control software to work effectively with other developers.

As well as in Back End Development, there would be a focus on:

- Developing technical projects that will connect the systems that power modern websites.
- Learning the necessary languages to communicate between clients and servers.
- Storing, manipulating, retrieving, and presenting data from a database.
- Developing APIs with effective patterns and techniques.

It was estimated by the industry and MOOC course developers that each portfolio project would require around 40 hours of work to complete. As a new training opportunity for EPICC, with our urban young adults, we needed to monitor the MOOC assessment system to see how it measured up in terms of fidelity and pedagogy, and added our own checks and balances of support, assessment, and feedback to students. The National Academic Team and the local site, along with the virtual TAs, would gather information about the course engagement and the progress of students. The data would be used to evaluate whether the MOOC course fits the short and long-term goals of setting our trainees up for success. The short-term goals included providing students with skills on how to learn online and finding other suitable online training in the computer programming field, so that they can acquire the necessary skills to find jobs in related fields.

The on-the-ground instructor could check in with students on a twice weekly basis to see what issues they have been dealing with or the concepts that are difficult for them to understand. These issues were then addressed during a Wednesday brown bag lunch meeting. From what the virtual staff also received or supported, the on-the-ground trainer could then address the concepts or specific problems in greater detail during the in-person Wednesday session. In addition, she identified students who have been understanding material at a greater pace to who became peer tutor leads. She then asked those students to demonstrate what they have learned and showcase their examples to the rest of the class or to those who are struggling with grasping the material.

Two virtual TAs were provided from the academic fellows' program as support from the National Academic team. The two graduate student TAs, Kristina, and Jenny (pseudonyms), served as an invaluable resource for the students and worked with Leslie (another pseudonym) the local site instructor, as well as the potential coaches who would be appointed by the MOOC service provider. The virtual TAs were available to further clarify course content to the students via email and Skype during scheduled hours, or by appointment. Responsibilities of the supporting fellows included:

- Observe the progress of students during the course by examining the submitted assignments and projects.
- Assist in clarifying to the students any of the course content available on the MOOC.
- Collaborate with MOOC Coaches and the local site instructor to better understand course content.
- Help students with any technical issues that they potentially had in accessing course content.
- Assess the MOOC's curriculum, as flipped and blended learning opportunities and environment, to see whether it meets the short term and long-term goals of the National Training Organization.
- Evaluate ways in which MOOC service provider's curriculum can be implemented in future courses on Schoology.

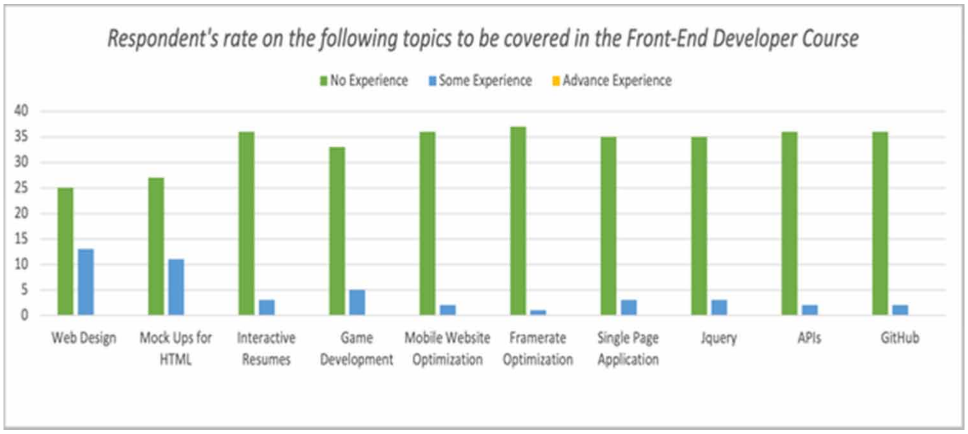
In addition, social connectedness (Mentor, 2011; 2017) was employed as part of the theoretical framework to offer trainees a sense of belonging and affiliation. Other theories that informed the practical pedagogy were self-directed learning (Candy, 2004) and cognitive constructivism in the form of building on prior knowledge and utilizing zones of proximal development methods (Davidson-Shivers, Rasmussen, & Lowenthal, 2018) with collaborative learning engagements. Often students came up with more effective solutions. The identification and use of students who worked at a faster pace within the self-directed learning framework and who understood the course work, were appointed as leaders within a zone of proximal approach. The aforementioned were combined with social anthropological elements to further establish a community of practice (Carter, & Adkins, 2017; Lave & Wenger, 1998; Wenger, 2010). The same theoretical framework was used to establish a teaching and learning community amongst the instructional staff across the national landscape through webinars. The framework was then used to create instructional quality review surveys (Sahin & Mentor, 2017) and to identify instructional talent and to disseminate that talent to the appropriate spaces.

To establish what cognitive resources and experiential knowledge we have within our trainer pool, the national academic department built a skills matrix based on the qualifications, knowledge, and expertise of their current instructional staff. It did so as part of its academic vision and strategy, future anticipated growth, and supplied a visual index of trainer talents. In this way, we were able to identify and leverage our instructors' strengths - their experiential knowledge, passion, and dedication, as well as their transformational power. From those evaluative frameworks, the national academic department and its local counterparts deemed it possible to pursue a short-term pilot program. Keeping in mind survey results to use as part of its practical application of theoretical frameworks of cultivating social connectedness combined with identifying students' level of development and progress.

## Rationale for Proceeding

An alignment check of organizational goals and mission was done by the national academic team and shared with the other departments, the CEO, President, and other senior leaders. Even though the MOOC program measured up to the training organizations goals and business objectives, it was reflective of previously monitored and shared labor market data and needs. However, while the MOOC standards and quality were high and informed by the technology companies, they alerted organizations that they did not offer a ramp up to the learning. For example, the standards did have a scaffolded construction,

*Figure 4. Students' responses to prior knowledge self-assessment*




but it did not necessarily truly match the prior knowledge or scaffolding of the trainees within this particular organization. Nor did it necessarily reflect the scaffolded approach from a delivery, support, or assessments perspective. There were no formative assessments built into the program and summative assessment of work produced was somewhat non-existent. Completion of tasks and projects was the only measuring tool within the MOOC's platform and was recorded by a simple upload of the assigned work. Personal development was reflected by a progress bar of completion on projects, but not by the quality or correctness of the work. However, there were still many transferable skills present in the MOOC program for students, and aside from extended internship sales opportunities and integrated ICT knowledge construction, the MOOC content offered valuable skills that could be transferred to job and life skills within the 21st Century economy. Our rationale needed the inclusion of surveying our departmental and organizational strengths, weaknesses, objectives, and targets in this regard.

Some believed that the primary value of participating in the MOOC was the potential of a trainee earning a nano-sized portion of a degree. Nevertheless, the courses were not accredited in any way, but college credit was promised if pursued by the student or organization itself. Some of the value in participating in the MOOC was having access to the ICT course content and program itself, as that was commissioned and informed by national telecommunication and multinational technology ICT companies. The MOOC participation created the opportunity to plant further seeds for our academic vision and strategy; first, to weigh our own course structures against industry demands, and second to affirm and develop our potential to close the gap of computer programming labor needs. The participation in the MOOC brought potential upsides for the work and mission of the organization to foster further partnerships and business opportunities based on the subject matter covered. In this instance, the organization had an opportunity in making a further impact in society by training disadvantaged and underrepresented populations, including women, for the computer programming industry. The opportunity had high potential for internship opportunities and converting those internships into employment for the entry level trainees with the national ICT corporations who funded the participation in the MOOCs and with many other potential employers.

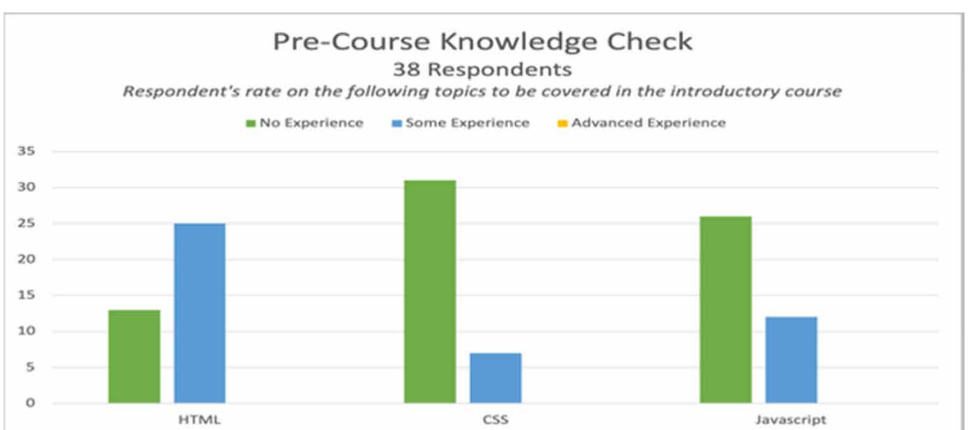
A MOOC also presented the idea that the talent organization could deliver the corporate or ICT business partners' required skills and labor market demands. For national telecommunication and technology companies, the training organization could achieve these goals by meeting these companies' entry level demands across the country in a standardized quality manner. Companies were often looking for the national training organization to prepare students with an identical skill set for similar internship roles across different cities. The claim was that the most effective way to deliver this consistency was with students who have studied in the same class together. Instead of working on constant alignment across sites, a MOOC also offered opportunities to deliver courses across training sites and deliver the same content with high-quality across dozens of cities. This approach could enable the talent development organization to scale up its partnerships with a few of its other national partners and presented other high value targets to pursue in line with its business objectives.

There were four other values taken into consideration as part of the rationale for proceeding. The MOOC opportunity presented:

1. Possible quality “elective” content for our young trainees, even if it was not currently tied directly to our contractual internship sales or possibilities of converting those internships into full-time hiring opportunities within our current employer partners.
2. Access to this content could serve as well in the future when we eventually have clients asking us to deliver entry level talent with these required skills.
3. The content in the MOOC program could serve as a foundation for several new computer programming developments as a pipeline of talent for an industry that needs diverse talent.
4. Opportunities to measure, expand, and hasten the testing of our e-learning, blended instruction, and flipped classroom training models.

The initial piloting of the program involved 20 new trainees from one training site. We latched onto the Front-End Web Development portion of the micro course program. In the Fall of 2014, the local academic team of a site and the National Academic team partnered to pilot the participation within one segment of the MOOC. To prepare the students for this new method of engagement, we put together an introductory course that would help acquaint students with the new material, as well as the type of learning material and assignments they would get. The preparatory course was formulated from prior knowledge surveys to help cultivate a social connectedness between the virtual tutors, students, and the on-the-ground instructors.

*Figure 5. Specific self-ratings on content covered during the pre-launch ramp up course*



## Preparatory Launch Ramp

From the entirety of the context described above, the national academic learning and development department of the program decided to construct a preparatory course. The course was to be considered a ramp-up platform for trainees, the virtual teaching assistants, as well as for the in-person instructor. The preparatory course allowed us to ask what do students, virtual assistants, the instructor, and the local site need during the ramp up stage? We correspondingly asked what would serve as lessons, and, what to cater for during the MOOC participation itself?

Participation in the MOOC courses was asynchronous with limited virtual support from the MOOC service provider. Trainees could begin and proceed on the course work and sections whenever they wished, and they could finish projects at their own pace. However, for the in-person support and to help prepare the trainees, and our own virtual teaching assistants, as well as the instructor for engaging with the MOOC content, we built in virtual, and in-person scheduled times for this support. During this time, the instructional staff will meet with the students to answer any questions that they have about the course content or MOOC service provider. The instructor scheduled once a week, hour-long slots for students to gather in-person, to check in on any challenges and work progress. After a video conference call kick-off meeting with the virtual assistants, a LMS was used as an engagement platform for the preparatory course and its communication spaces were highlighted in addition to email options.

We anticipated that there may possibly be some students who will progress further ahead than the rest, could either lean on the virtual teaching assistants for extra support, and/or be used as guides and peer tutors to others at their site participating in their MOOC. To accommodate all students and find a middle ground for the instructor to teach, she could suggest a pace at which she will instruct on components of the course or support the students with their individual progress. For example, she could say that she will answer questions about HTML and CSS during the first two weeks and then move on to answering questions about JavaScript in the third week. This could allow the trainees to progress in a more structured manner even though students might be at different points in the course. Students could then still be encouraged to go ahead with the course at a faster pace if they have the time and desire to do so, while receiving feedback on the work that they completed.

We envisioned that to foster a more balanced learning environment between the MOOC and face-to-face class time, the virtual teaching assistant could offer virtual "check ins." These would be accompanied by the weekly check-ins by the on-the-ground instructor. We asked ourselves, what type of preparation will the in-person instructor (Leslie) and the virtual tutors need to instruct or support in this elective? In terms of preparation, both Leslie and the two TAs would need access to the material to become familiar with the MOOC course content to act as subject matter supporters. Furthermore, if the coaches at the MOOC service provider had a long delay in responding or were unable to help the students with any specific problem or issue, Leslie and the TAs should be able to guide the students in a way that would help them arrive at a solution. Leslie and the TAs do not necessarily have to solve the coding problem for the students, instead they should act as a support by providing them with tools or options to explore in order to succeed. Also, the TAs should be able to reach out to the MOOC service provider's coaches and ask the students' questions differently or pick up on global student class issues that could be addressed more holistically by the Leslie, the virtual TA's, or the MOOC coaches.

From previous experience, the national academic department (NAT) deemed that it would be easier if Lesley sets a pace for the overall class, even though students would be progressing at their own pace. This was based on the fact that the content would be covered mostly in the MOOC provider's online classes. Leveraging Leslie's previous lunch room coding club set up, her in-person sessions would be structured like workshop sessions where she would be able to support the students interactively and listen as a whole group so each one can teach one in 'ubuntu' fashion from African indigenous knowledge systems (Mentor, TEDx Teachers College Columbia University (2012). Whenever possible, Leslie would provide support to students during class, but if she needed support from the virtual TAs, she could call on them beforehand or during the in-person session. If students have more intricate issues with coding, she could collaborate with the virtual TAs and possibly the MOOC provider's coaches, if they were available or were to respond. Moreover, student leads could be appointed as Leslie would see fit to assist with class facilitation.

Separately from the MOOC content and service provider evaluation, we needed to establish criteria on how to assess the success of the preparatory course. We needed to use that as a further check to see if our trainees would be able to succeed within the MOOC. Hence, we established that the preparatory course would be assessed on two levels. The students would be assessed on the content of the projects, their progress, and the successful completion of their short course portfolios.

## Operationalized

We established what the relationship between the virtual TAs, on-the ground instructor, and MOOC service provider partners would be and what the responsibilities of each would entail. The virtual TAs would lead the preparatory short course with the on-the-ground instructor in support. The on-the-ground instructor would lead the MOOC effort thereafter with the virtual TAs supporting the trainees with their online course work.

The preparatory course was launched by the national academic team with support from Leslie on the ground. A video conference call was arranged between the trainees, the virtual tutors, and Leslie where the short course was introduced via a LMS that consisted of social media characteristics. The short preparatory course was designed to introduce and mimic the MOOC material. Technology needs and lessons learned during the introductory course were addressed before the trainees commenced their participation within the MOOC.

The MOOC participation project was launched through the remote MOOC service provider and our own on-the-ground instructor, Leslie (a pseudonym), and the two remotely located TAs. There was a total of five team members who supported the students, initially including the two course designers, but eventually only one other appointed remote supporter from the MOOC provider. Their coaches operated from Silicon Valley and our two virtual TAs operated from the national headquarters in New York. Other than supporting the trainees, the virtual TAs also supported Leslie to help students work with the course content toward their portfolio and project goals. We correctly anticipated that the MOOC provided coach would primarily serve to provide general support with questions and assignments, but that there would be a significant lag time variance in their responses. For example, only a single person was appointed to facilitate and manage hundreds of organizations and thousands of people participating in the MOOC. Hence, we asked our virtual TAs to primarily monitor curriculum implementation, manage technical functionalities, and provide support with course content when needed.

The weekly contact was scheduled in staggered fashion which provided us with timely touch points. The staggered schedule resonated with one of the training organization's mantras which was high support, high expectations.

*Table 1. Schedule of touchpoints with students*

| Monday | Wednesday | Friday |
|---|---|---|
| Introductory Video Conference with Virtual Tutors | Check-in Call with Local Instructor after Working Lunch with trainees | End of Week program evaluation |
| Goal Setting | Blended Classroom Engagement | Goal Check & Reflection |
| Progress check on objectives | Weekly to bi-weekly student progress presentations | End of module project presentations |

We wanted to book-end the engagement on either side of the Face-to-Face (F2F) time to keep our finger on the pulse of virtual and in-person support of the instructor and the students. The book-ended schedule aided the monitoring of the self-directed progress of the students. The quality of their projects could be observed virtually as they uploaded their work, as well as when they presented their work and progress, informally to their fellow students through the MOOC.

## Results

Through the preparatory work and the remote virtual provisions, we were able to increase student engagement, retention, and completion. The constant, or rather regular, contact with the in-person instructor and virtual tutors, aided the trainees who had never engaged in any computer scripting or programming. So much so, that the cohort of 20 outperformed other trainees from other regional and national participating organizations. Building on a first pilot with 20 Atlanta students, the MOOC service provider and the telecommunications company sought to partner with the NAT to award them with 500 scholarships to participate further in their micro-degree program. Subsequently, they were awarded an increase from 20 to 500 scholarships to participate in further computer programming MOOCs at $2,000 per student. The scholarship sponsors also encouraged every other participating training organization and those that were to participate in the MOOC, to adopt these methodologies and practices.

The feedback model proved successful and set plans in motion for scaling to other city sites of the national training organization where, at other sites, there were similar teaching staffs without teacher training. Several partnership needs that emerged in the Atlanta pilot were raised and shared with the MOOC service provider. This included requests for additional virtual support, faster response times to students' queries, as well as feedback on students' project work. The competing demands from students in the MOOC initiative (e.g., their six-month intensive core training assignments, part-time work, and/or college course work), impacted participation, completion, and quality of work. However, stronger bonds between participating students and staff were observed. This resulted in a technological orientation, cultivating social connectedness as well as support for both on-the-ground training staff as well as the students.

The participation within the MOOC curriculum started creating a community of practice amongst other local instructional staff and students, which spread across sites around the country. A common ground of those who were studying the latest technical curriculum together, started with the adoption of the organization's LMS, and deepened for those who participated in the MOOC initiative. After a highly successful pilot, the MOOC approach was expanded and implemented to other cities in 2015. The MOOC enabled NAT to prepare students more efficiently and effectively, quickly equipping them

*Figure 6. Social connectedness within learning communities as key to the four reported bulleted results*


with the skills that corporate partners demand, while facilitating and incorporating faster feedback turn-around times. The feedback model proved successful and set plans in motion for scaling to other non-teaching program staff without teacher training. The model was shared with, and piloted at, one of the community college partners, with consideration for expansion to other community college partners.

With the extension of the MOOC approach, the NAT could explore the following:

- The scholarships could be allocated to any of the young adults in our network - including students and alumni across all markets.
- The telecommunications company and MOOC service provider envision awarding the scholarships over multiple years (current thinking is 3 years), and
- Would seek to determine the appropriate pacing with the non-profit training program's schedule.

There was consideration to expand the program to other available nanodegree programs which included Front-End Web Development, Back-End Web Development, Data Analyst work, and "Intro to Programming". The telecommunications company and MOOC service provider shared that they anticipated adding four or more new programs in 2015 that were likely to include: Java programming for Android, Entrepreneurship, Cloud/DevOps, Data Engineer in a junior role capacity compared to a full Data Analyst role requirement.

The MOOC approach also grew to other city sites. See below for a proposed list of eight city sites that was constructed as a strategic approach to scale the program based on the instructor skills matrix.

## SOLUTIONS AND RECOMMENDATIONS

While the organization's feedback framework enhanced the accountability contract between students and teaching staff, regular instructor evaluations were incorporated into the program. The evaluation

*Table 2. Strategic approach proposed based on instructor skills matrix*

| | City Sites | Number of Students & Instructors |
|---|---|---|
| 1. | San Francisco & Silicon Valley, California | 40 students split between two instructors and two sites. |
| 2. | Chicago, Illinois | 20 students working with one instructor and one tutor. |
| 3. | Atlanta, Georgia | 20 students with one instructor with computing coding experience, |
| 4. | Seattle, Washington | 0 at the time of the proposal, but with interest from two multinational ICT companies suggesting similar computer programming training initiatives, |
| 5. | Providence, Rhode Island | 40 students split between two instructors. There was a hope to coach Internship Sales Managers to be fluent enough to sell for these internship seats. It was also noted by the National Academic Director that there were many opportunities in the greater Boston area and closer Massachusetts region. At the time of writing, the two instructors added great value, insight, and expertise to the programming MOOC project for all sites to benefit from as a whole. |
| 6. | New York, New York | New York was dealing with a skills gap and change management at the time of the proposal. |
| 7. | Boston, Massachusetts | 40 students were divided between two instructors. |
| 8. | Arlington (National Capital Region), Virginia | 20 students with support from a national academic consultant, |

data offered instructors quicker insights into their practices and room for adjustments to differentiated learning styles. The accountability contract between students and staff in the MOOC initiative could be enhanced by the current instructor evaluation system to address, and to overcome, challenges ranging from untrained teaching staff, the intense learning curve with high expectations, and a lack of teaching and learning transparency. The MOOC initiative also offered other valuable lessons for the national training organization, that ranged from:

- **Opportunities to leverage instructional expertise across the organization** – The MOOC enabled NAT to leverage the unique talents of our instructors across the country, not just in any one city. With skills like scripting, programming, front end web development, and software testing in high demand, NAT needs to be able to train students in these areas as per the demand from corporate clients. With the MOOC approach, we can have one Java or SQL expert instructor anywhere in the country and train hundreds of students across cities. It could enable the NAT to make the most of their relatively lean instructional workforce.
- **Providing more support than a traditional classroom** – With an expert instructor online, on-the-ground support from a local instructor, and remote support from two academic fellows at NAT's National office, students receive far more support from the MOOC than they do in a traditional classroom or if they were participating in a MOOC through their volition. In addition to the many forms of staff support, there was moreover a great deal of community support from peers across the country. Students shared ideas and support around the clock and moved on pace together through the course work without lagging like the masses also in the MOOC. The response time from both instructors and peers is faster and this enables students to receive support from many different individuals with different perspectives and teaching styles.

These opportunities are to be explored further and will be worthwhile to interrogate as part of future research directions.

## FUTURE RESEARCH DIRECTIONS

Other than leveraging instructional expertise across the country and providing more support than traditional classrooms, there needs to be research on the initial selection of scholarship courses which will be informed by labor market data and existing subject matter expertise (SME) pool of talent. While the MOOC service provider's courses will be offered as an elective to L&D students, it will be dependent on research that establishes students and training sites' readiness. Specific cities could then possibly start as early as at the start of their L&D cycle.

In consultation with the involved instructional staff, a shorter and lower-level Introduction to Programming course was suggested as a better fit for trainees and to serve as an on-ramp to build interest, proclivity, and confidence in computer programming. This would be partly because of the lesser course content and time demands, but more so because of the intensive training demands of the national training organization and its program. Researching the impact of the Introduction to Programming course will yield valuable lessons, but also needs to be checked on whether that course would benefit trainees and position them for computer programming jobs with the requisite skills. The future potential that will also need to be researched and then explored, is whether to offer scholarships to graduates of the alumni program via their emerging Alumni Relations functions, as monetary support often positively impacts student motivation, and this supports retention throughout the course. Furthermore, future action research approaches would have aided the 2018 MOOC campaign. While there also needs to be a focus on future research and solutions regarding the digital divide in the rural USA which is still impacting MOOC program participation of this nature.

## CONCLUSION

From the MOOC service provider's perspective, a partnership with NAT will help advance their "completion agenda" (since most MOOCs have a 5% completion rate, and 95% drop-out rate) and position them well within then President Obama's "TechHire" initiative. For the telecommunications company, the partnership would be a highlight of a new corporate social responsibility (CSR) initiative focused on building out the nation's technology workforce and investing in youth training programs.

Their initial philanthropy with regards to this MOOC, lays additional groundwork for additional investments via grants, internships, and shadow training opportunities from the telecommunications and multinational technology company.

From an influence perspective, our MOOC initiative tangibly demonstrated our commitment to scaling innovative models for serving young adults with skills and knowledge to meet labor market demand opportunities. Whereas offering internship and employment opportunities, the partnership provided NAT with a valuable opportunity to advance our "pipeline of talent" discussions. Similarly, the scholarship program facilitated a major expansion of our students' skill sets and allowed NAT to increase agility in response to hiring needs in these software development areas.

## ACKNOWLEDGMENT

My utmost appreciation to the virtual tutors, Lesley, Kristina, and Jenny (pseudonyms), for their dedication and support. Thank you to Lesley, the on-the-ground instructor, for her willingness to give up an hour of her lunch every week and to be brave enough to say to a student, "I don't know – let's search for an answer together". Ultimate appreciation to the virtual tutors for building an amazing ramp-up course and for responding to students' questions in the absence of the MOOC provider's timely responses to students' questions. Gratitude to the CEO for his support in the face of the effort starting with no paid internships or job offers. At the end of the MOOC, the training organization that received 20 scholarships for the pilot phase, was awarded 500 scholarships over three years, and the organization was able to negotiate job shadow opportunities, 100 job opportunities, as well as paid internships.

## REFERENCES

Andriessen, J., Baker, M., & Suthers, D. (Eds.). (2013). *Arguing to learn: Confronting cognitions in computer-supported collaborative learning environments* (Vol. 1). Springer Science & Business Media.

AT&T. (2014, September 14). *Att_and_MOOC service provider_launch_online_training_program_nanodegree.* Retrieved from http://about.att.com/story/att_and_MOOC service provider _launch_online_training_program_nanodegree.html

AT&T and Udacity to Offer Scholarships to Underserved Students for New Online Tech Training Program. (n.d.). Retrieved December 10, 2017, from http://about.att.com/content/csr/home/blog/2014/09/at_t_and_udacityto.html#sthash.U0r03eEW.dpuf

AT&T Aspire. (n.d.). Retrieved December 10, 2017, from http://about.att.com/content/csr/home/people/at-t-aspire.html

Beetham, H., & Sharpe, R. (2013). *Rethinking pedagogy for a digital age: Designing for 21st century learning*. Routledge.

Beetham, H., & Sharpe, R. (2019). *Rethinking pedagogy for a digital age: Designing for 21st century learning*. Routledge.

Candy, P. C. (2004). *Linking thinking: Self-directed learning in the digital age*. Department of Education, Science and Training.

Carter, T. J., & Adkins, B. (2017). Situated learning, communities of practice, and the social construction of knowledge. *Theory and Practice of Adult and Higher Education*, 113.

Castillo, N. M., Lee, J., Zahra, F. T., & Wagner, D. A. (2015). MOOCS for development: Trends, challenges, and opportunities. *Information Technologies and International Development*, *11*(2), 35.

Davidson-Shivers, G. V., Rasmussen, K. L., & Lowenthal, P. R. (2018). Foundations of Online Learning and Instructional Design. In *Web-Based Learning* (pp. 43–79). Springer.

Dillahunt, T. R., Wang, B. Z., & Teasley, S. (2014). Democratizing higher education: Exploring MOOC use among those who cannot afford a formal education. *The International Review of Research in Open and Distributed Learning*, *15*(5).

Evans, B. J., & Baker, R. B. (2016). MOOCs and persistence: Definitions and predictors. *New Directions for Institutional Research*, *2015*(167), 69–85.

Fischer, F., Kollar, I., Stegmann, K., & Wecker, C. (2013). Toward a script theory of guidance in computer-supported collaborative learning. *Educational Psychologist*, *48*(1), 56–66.

Flenn, J., & Blosch, M. (2018, August 20). *Understanding Gartner's hype cycles*. Gartner. https://www.gartner.com/en/documents/3887767

Gómez-Galán, J., Martín Padilla, A., Bravo, C. B., & Meneses, E. L. (2019). *MOOC Courses and the Future of Higher Education : A New Pedagogical Framework*. River Publishers.

Goodyear, P., Jones, C., & Thompson, K. (2014). Computer-supported collaborative learning: Instructional approaches, group processes and educational designs. In *Handbook of research on educational communications and technology* (pp. 439–451). Springer.

Guzdial, M. (2014). Limitations of MOOCs for Computing Education-Addressing our needs: MOOCs and technology to advance learning and learning research (Ubiquity symposium). *Ubiquity*, *2014*(July), 1.

Hsu, Y. C., Baldwin, S., & Ching, Y. H. (2017). Learning through making and maker education. *TechTrends*, 1–6.

Kennedy, J. (2014). Characteristics of massive open online courses (MOOCs): A research review, 2009-2012. *Journal of Interactive Online Learning*, *13*(1).

Lave, J., & Wenger, E. (1998). *Communities of practice*. Academic Press.

Lazaroiu, G., Popescu, G. H., & Nica, E. (2016, July). The sustainability of udacity's business model of producing first-rate online content and incorporating interactive learning aspects into an online course. In *The International Scientific Conference eLearning and Software for Education* (*Vol. 3*, p. 40). " Carol I" National Defence University.

LeHong, H., Fenn, J., & Leeb-du Toit, R. (2013). *Hype cycle for emerging technologies*. Gartner Inc.

Loksa, D., Ko, A. J., Jernigan, W., Oleson, A., Mendez, C. J., & Burnett, M. M. (2016, May). Programming, Problem Solving, and Self-Awareness: Effects of Explicit Guidance. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems* (pp. 1449-1461). ACM.

Majchrzak, A., Rice, R. E., King, N., Malhotra, A., & Ba, S. (2014). *Computer-mediated inter-organizational knowledge-sharing: Insights from a virtual team innovating using a collaborative tool*. Academic Press.

Meinel, C., Totschnig, M., & Willems, C. (2013). openHPI: Evolution of a MOOC platform from LMS to SOA. In *Proceedings of the 5th International Conference on Computer Supported Education (CSEDU), INSTICC, Aachen, Germany* (*Vol. 5*). Academic Press.

Mentor, D. (2012). *TEDxTalks*. YouTube. www.youtube.com/watch?v=-I545RYiSjg

Mentor, D. (2016). EMxC3= e&mLearning Cultivating Connected Communities: Sustainable Workforce Talent Development. Handbook of Research on Mobile Learning in Contemporary Classrooms, 240-259.

Mentor, D. (2017, April 27). Cultivating Digital TLC Teaching and Learning Communities. In *ModSim 2017 International Congress on Modelling and Simulation - Modeling and Simulation in the Age of Data*. Retrieved December 24, 2017, from http://modsimworld.org/papers/2017/Cultivating_Digital_TLC_Teaching_and_Learning_Communities.pdf

Mercer, S., & Ryan, S. (2010). A mindset for EFL: Learners' beliefs about the role of natural talent. *ELT Journal*, *64*(4), 436–444.

Milligan, C., & Littlejohn, A. (2017). Why study on a MOOC? The motives of students and professionals. *The International Review of Research in Open and Distributed Learning*, *18*(2). https://doi.org/10.19173/irrodl.v18i2.3033

Montgomery, K. (n.d.). *Silicon Valley Now Selling Trade School Diplomas Called "Nanodegrees"*. Retrieved December 10, 2017, from http://valleywag.gawker.com/silicon-valley-now-selling-trade-school-diplomas-called-1638663780

Pelster, B., Haims, J., Stempel, J., & Vyver, B. (2016). Learning: Employees take charge. Global Human Capital Trends 2016. *The new organization: Different by design*. Retrieved from https://www2.deloitte.com/us/en/pages/human-capital/articles/introduction-human-capital-trends-2016.html

Popenici, S. (2015). Deceptive Promises: The Meaning of MOOCs. *Macro-Level Learning Through Massive Open Online Courses (MOOCs): Strategies and Predictions for the Future*, 158-167.

Rai, L., & Chunrao, D. (2016). Influencing factors of success and failure in MOOC and general analysis of learner behavior. *International Journal of Information and Education Technology (IJIET)*, *6*(4), 262.

Saliimah, F. R. (2021). The Influence between Synchronous and Asynchronous Learning Model toward Students' English Achievement at SMAN 1 Sambit (Doctoral dissertation, IAIN Ponorogo

Sahin, F., & Mentor, D. (2017). Creating Teaching and Learning Accountabilities Through Data Analytic Feedback Loops. In *ModSim 2017 International Congress on Modelling and Simulation - Modeling and Simulation in the Age of Data*. Retrieved December 24, 2017 from http://modsimworld.org/papers/2017/Creating_Teaching_and_Learning_Accountabilities_Through_Data_Analytic_Feedback_Loops.pdf

Schulze, A. S., Leigh, D., Sparks, P., & Spinello, E. (2017). Massive Open Online Courses and Completion Rates: Are Self-Directed Adult Learners the Most Successful at MOOCs? In Handbook of Research on Individualism and Identity in the Globalized Digital Age (pp. 24-49). IGI Global.

Smagorinsky, P. (2017). Deconflating the ZPD and instructional scaffolding: Retranslating and reconceiving the zone of proximal development as the zone of next development. *Learning, Culture and Social Interaction*.

Smith. (n.d.). *Operations*. https://about.att.com/category/all_news.html

Tansey, B. (2018, January 16). *Google Launches a MOOC to Train Entry-Level IT Support Staffers*. Retrieved December 30, 2021, from https://xconomy.com/san-francisco/2018/01/16/google-launches-a-mooc-to-train-entry-level-it-support-staffers/

The Economist. (2017, January 12). *Established education providers v new contenders*. Retrieved December 10, 2017, from https://www.economist.com/news/special-report/21714173-alternative-providers-education-must-solve-problems-cost-and

Udacity. (2014). *Nanodegree Programs*. Retrieved December 10, 2017, from https://www.udacity.com/nanodegree

Van Kleef Conley, N. (2018, November 27). *Closing the Skills Gap One MOOC at a Time: How Google is Transforming the Lifelong Learning Environment*. Retrieved December 29, 2021, from https://evolllution.com/revenue-streams/workforce_development/closing-the-skills-gap-one-mooc-at-a-time-how-google-is-transforming-the-lifelong-learning-environment/

Walther, J. B., Hoter, E., Ganayem, A., & Shonfeld, M. (2015). Computer-mediated communication and the reduction of prejudice: A controlled longitudinal field experiment among Jews and Arabs in Israel. *Computers in Human Behavior*, *52*, 550–558.

Watkins, C. (2016, July 28). *Nanodegree 101: What is a Nanodegree program?* https://blog.udacity.com/2016/07/nanodegree-101.html

Wenger, E. (2010). Communities of practice and social learning systems: the career of a concept. *Social learning systems and communities of practice, 3*, 179-198.

Wildi-Yune, J., & Cordero, C. (2015). *Corporate Digital Learning: How to Get It "Right"*. IMD-2015-1. Retrieved from https://www.imd.org/globalassets/publications/working-papers/docs/working-paper_corporate-digital-learning-final--05-05-15.pdf

Yousef, A. M. F., Chatti, M. A., Schroeder, U., & Wosnitza, M. (2014, July). What drives a successful MOOC? An empirical examination of criteria to assure design quality of MOOCs. In *Advanced Learning Technologies (ICALT), 2014 IEEE 14th International Conference on* (pp. 44-48). IEEE.

Zawacki-Richter, O., Bozkurt, A., Alturki, U., & Aldraiweesh, A. (2018). What Research Says About MOOCs – An Explorative Content Analysis. *The International Review of Research in Open and Distributed Learning*, *19*(1). https://doi.org/10.19173/irrodl.v19i1.3356

## KEY TERMS AND DEFINITIONS

**Application Protocol Interfaces (APIs):** Basically, a bridge or connection facilitated between two or more software applications that allow for exchange of data. Examples include, Single-Sign-Ons (SSOs) and Bank connections with payment systems like Venmo or PayPal.

**Back-End Development:** Refers to the programming languages that support the architecture and database aspects of say an interactive website or web applications, operating with code that connects the web page or website to a database, manages user connections, and information.

**Front-End Development:** Includes the development HMTL/HTML5 and Javascript, typically for a website with a graphical user interface with which a user can interact with a webpage or interconnected web pages.

**Micro-Degree Program:** A program granting certification or acknowledgement to a certain skill that can be used to advance a student's career, though not actually credentialed and may not be used in lieu of a full degree program to qualify for college or to apply to certain work roles or positions.

**Preparatory Launch Ramp/Room:** A prepared site for students to participate in prior to them joining the MOOCs and to serve as a pre-ramp to the MOOC as well as offer the space as an ongoing gathering support space for the instructor and remote teaching assistants for the duration of the designated time-framed MOOC.

# Chapter 7
# Librarianship Through Every Occasion:
## Staying Open and Online During a Pandemic

**Brennan M. Harris**
*Teachers College, Columbia University, USA*

**Christyn Rayford**
*South Holland Public Library, USA*

## ABSTRACT

*This chapter examines how a public library in the Midwestern USA adapted to the COVID-19 pandemic. Staff employed the research skills learned in their library science education to explore minimal-contact programming, through virtual and hybrid formats, and continued to provide library services to the community with minimal disruption. Following naturalistic observation of the library in its hybrid state and semi-structured interviews with its staff, the experiences of the librarians and community are considered through the theoretical lenses of social connectedness, the technology adoption model, and learning theory. Unique benefits of the public library, as a physical space, as a virtual destination, and as a hybrid between them are discussed.*

## INTRODUCTION

This chapter covers how a local USA community public library, responded to the COVID pandemic, continually adapting its methods to maintain its signature services to its community, even when it was not safe to operate in person and these services were delivered through novel online formats. The chapter is written as a collaboration between a library director and an aspiring research scholar who observed a suburban local library and its staff in the midwestern, USA in its response to the COVID-19 pandemic. Per state legislation, educational institutions, such as libraries are considered essential, and are expected to make every effort to remain open despite the pandemic (Illinois Department of Commerce, 2020).

DOI: 10.4018/978-1-6684-3996-8.ch007

However, the state could not provide detailed guidelines for exactly how every essential institution should continue its operations while keeping both patrons and employees safe, and village governance deferred to the library administrators on how to conduct their operation, therefore, the library was compelled to develop its own unique protocols. From interviews with various members of library staff, this chapter synthesizes how libraries can maintain service during a pandemic situation and the new media skills modern librarians can cultivate to be maximally effective in providing services through a hybrid library.

## BACKGROUND

To summarize the library, as a concept, is literally to summarize history itself. The first instances of a library, a designated place that contained written archives of information, was estimated to have existed around 2600 BC (Maclay, 2003). The practice of collecting and organizing information media has persisted in some form or another since, be it the clay tablets in the temple rooms of ancient Sumer, the hand-transcribed tomes of the Middle Ages' monastery libraries (Streeter, 2011), or the wealth of books, film, and media we enjoy from today's libraries.

The notion of the library as a place for the general public to seek knowledge arose around 1598 with the founding of the Francis Trigge Chained Library in Lincolnshire, England, the first that did not require patrons to belong to a particular college or church to gain access to its materials. Though, even this progressive library would not fit all the criteria a modern library-goer expects: as implied by the library's name, its materials were chained to the shelves, which prevented patrons from borrowing them (St. Wulfram's Church, n.d.).

From this point, publicly-accessible libraries progressed through several variations and membership models ranging from being available to only clergy and scholars, to being available to financially-invested patrons, to serving patrons who purchased library passes for the appointments to access the materials. Moreover, the nature of the materials available has gradually broadened from academic specializations, such as theology or biology, to provide materials on diverse nonfiction topics and eventually fiction. The public library, as the modern library-goer understands it, one that uses taxed funds to operate a local learning institution that is fully and freely available to the public, arose in the early 19th century in England and shortly thereafter in the United States (Kelly, 1966).

As public libraries and their collections expanded, the classification and organization of their materials became more important, a discipline that would come to be known as library science. In the mid-19th century, American library science pioneer Melvil Dewey created the famous Dewey Decimal System, which has been the industry standard for subject-based organization of library materials since (Richardson, 2010).

In the subsequent decades, many public libraries came to embody what is recognizable to the modern library-goer as a "public library". In the late 20th and early 21st century, libraries began to emphasize the aesthetics of their spaces and sought architects to design spaces with the express intent of making them comfortable places for the community to congregate. In 2007, the American Library Association officially included "safe and welcoming physical places to meet and interact with others or to sit quietly and read" in its Public Library Service Responses, a list of services patrons should expect from their public library (Garcia & Nelson, 2007, p. 3). While the majority of public libraries strive to include safe and welcoming places, the COVID-19 pandemic has complicated this objective significantly.

Despite the historical recency of the COVID-19 pandemic, some literature has arisen to examine its impact on libraries. Fernandez (2020) observed that the mere adoption of videoconferencing technology to deliver programming does not automatically create an informative and enjoyable experience for the patrons. This suggests that a significant part of the patrons' experience is contingent on library staffs' ability to engage them, even in a less-personal format. Bhati and Kumar (2020) further interrogated the evolving role of the library. Overall, its role remains as a "facilitator of knowledge", albeit with the scope of that knowledge now shifting toward pandemic awareness and pandemic-safe practices (p.35). Bhati and Kumar list several historically-key roles of the library and librarians, including conveyors of knowledge, teachers of information literacy and technology, experts on the catalogs contained within the building, and facilitators of community engagement. In the wake of the pandemic, these roles have become largely virtual and aim to leave no patron adrift in cyberspace. A modern partially-to-fully virtual library aims to keep its patrons feeling connected from their intellectual pursuits, as part of the community, and able to navigate the newly-emphasized digital world.

And with these considerations, we arrive at the present chapter, whose focus on a south suburban library provides a several distinct use case scenarios of the technologies for operating a library fully or partially online.

This chapter contributes to the literature by synthesizing from interviews about the lived experiences and technical growth of staff who worked through their library's transitions between in-person, virtual, and hybrid formats, paired with theoretical models to explain the nuances of the librarians' responses. This chapter aims to demonstrate how the library can enrich its community with any instances of face-to-face contact or continuing to cultivate social connectedness, a sense of belonging and community via digital service delivery with no in-person contact.

## THEORETICAL FRAMEWORK

This chapter approaches the library's functions through the lenses of Social Connectedness, the Technology Adoption Model, and Learning Theory.

### Theory of Social Connectedness

Social Connectedness, defined by Neves and colleagues (2019, p.50) is "meaningful social interaction", and provides benefits including: the reduction of loneliness, stress-buffering, building a network of social resources, and "Increasing a sense of social connectedness encourages healthier emotional well-being among people, reducing potential feelings of isolation and chances of faster recovery from illness" (Mentor, 2018, p.6186). The library's temporary shift to online, while still providing services, allowed the community to stay socially connected to their interests, books, library, and each other, even if the experience lacked physically face-to-face interaction. The newly-emphasized online and hybrid programming catered to a sense of affiliation between the library and its community of patrons all aided by technology adoption (Karg et al. 2021).

## Theory of Technology Adoption Model

The literature review by Lai (2017) synthesized the theoretical history of the Technology Adoption Model, described as a broad term to describe the decision-making frameworks proposed by various authors to explain individuals' willingness to employ novel technologies. While the specific models vary in scope, the exact nature of their explanatory components, and how those components influence one another, all aim to explain prospective users' intention to use a novel technology. Common components of the models that Lai examined are the prospective user's pre-existing attitudes toward similar technologies, in general, the prospective user's attitudes about personally using the novel technology, and the perceived usefulness of the novel technology for the task at hand.

With all of these attitudes in agreement, the models suggest the prospective user will develop an intention to use the novel technology, which will ultimately result in the behavior of doing so. Some models suggested that the individual's age would negatively impact their technology adoption attitudes.

In the context of the library, the Technology Adoption Model explains why the library employees' pre-pandemic skill sets did not need to include techniques for facilitating online synchronous interactions or creating asynchronous on-demand content. Furthermore, the Technology Adoption Model can also explain how the librarians could come to use these formerly foreign technologies regularly as tools for their job functions. In the past, librarians were expected to aid patrons' research and the navigation of collections, catalogs, and databases, create a friendly, inviting environment, and lead educational programs on subjects as varied as cooking, origami, and job-searching. Now, they are responsible for teaching themselves the computer-related skills to facilitate those classes, and to continue providing the human element of the library, even if through a screen (Karg et al. 2021).

## Theory of Learning

Illeris (2018) summarized the existing models of the Theory of Learning and distilled the concept to the concurrent processes of a learner feeling motivated to interact within a social or material environment to form impressions while simultaneously assessing and elaborating on those impressions to internalize them. Furthermore, Illeris described this process as the interaction of three components of learning: 1) the content dimension, 2) the incentive dimension, and 3) the interaction dimension.

Considered through such a framework, everyone connected to the library engages in learning. In the case of the patrons, they seek the library, interact with its materials, and add the information contained therein to their knowledge. For the employees in varying positions, they interact with the changing world the library exists in, seek the knowledge necessary to perform their job functions in it, and use that knowledge to enhance their own skill sets (Currie, 2001). In online formats, they continue to do so, but in novel ways. Youth librarians, in particular, took the shifting circumstances as opportunities to be creative in their programming. All of the library staff's creativity would be put on display during the observation and interviews.

# METHODOLOGY

Naturalistic observation was conducted to observe the hybrid library from the perspective of an ordinary patron in November 2021. Behaviors of other patrons and library staff were noted. In late December

2021, five members of the library staff participated in semi-structured interviews. These interviews used the questions in Appendix A to prompt conversations about the staff's experiences of working in the library through the COVID-19 pandemic.

The heart of this south suburban library cannot be expressed better than by its staff, who so graciously lent their perspectives to this chapter. Here, a few excerpts from the staff interviews indicate the broad range of services and community functions the library provides and demonstrate the staff members' personal missions in the library.

Mrs. L, Head of Public Services: "[The library] is a resource for patrons to get recreational, cultural, educational material in print and non-print formats. It is an essential resource building usable through all stages of life."

Mr. B, Librarian: "[The library is a place to] conglomerate, get work done. [It is a place to] find entertainment, books, fiction and nonfiction, scholarly literature, and have interactions with staff and patrons. It's a place where the community can come to find a home."

Ms. C, Librarian: "[The library is] so much more than a building… it's a community space [whose] mission is to provide a safe, comfortable environment for people to learn, gather, and achieve their goals."

Ms. A, Librarian: A place that provides access to everyone. It's trying to make access more widely available. The library provides access to games, audiobooks, technology, telescopes, meal programs, and a place to seek shelter if you can't do so easily at home."

These definitions demonstrate that the library's value to the community extends far beyond just the shelves of books within the building.

As said by every interviewee in some fashion, the library is an institution that responds to the unique needs and wants of its community by providing access to enriching information, media, and programming.

The south suburban library serves a village of approximately 21,000 people, with a significant proportion being senior citizens (U.S. Census, 2020). And so, the library must make every decision with regard to how it can best serve its unique community's population- especially in the midst of the COVID-19 pandemic, which is, especially dangerous for older populations (Centers for Disease Control, 2021a). Our semi-structured interviews and engagements with the librarians, was informed by theoretical lenses that offered us opportunities to interrogate community, connectedness, technology adoption and learning aspects.

## OBSERVATIONS: NATURALISTIC

Observations were recorded from the perspective of an ordinary patron on a Monday afternoon in November 2021. At this point, the library appeared to be functioning normally and had made its safety precautions as unobtrusive as possible. In the entryway, A-frame signs reminded entrants that facial covering is required for entry, and of the phone number to call for curbside pickup services. A heartily-stocked micro-pantry's sign read "Take what you need, leave what you can." Bulletin boards advertised upcoming programming from the library and other events occurring in the community. The majority of the events were to be held on Zoom and requested attendees to pre-register.

Moving beyond the entryway and into the main lobby, a hand sanitizer dispenser was immediately available, and a few paces forward, printing services. In the main lobby, the operations of the library appeared typical, aside from the face masks and plastic coverings over public computer keyboards. A staff member at the reference desk provided a friendly welcome and directions to the numerous tables and desks around the ground floor, all of which were well over six feet apart. Taking a table among the adult nonfiction bookshelves and within earshot of the reference desk provided a convenient means to observe how the other patrons interacted with the library.

Predominantly, the patrons that occupied the study spaces for prolonged periods, requested help with printing documents, or asked the reference desk for guidance for finding a specific material.

With the coming and going of people there were between six and ten patrons that were visible from the adult nonfiction section for the duration of this observation. There were two front-facing employees at the reference desk, another restacking the shelves, and one security guard standing by.

We noted that the library was quiet, but not silent. The reference desk answered phone calls and made casual conversation with patrons while directing them to resources. Occasionally, a patron answered a phone call, and most hushed their voices while doing so.

The naturalistic observation concluded that, from the materials still being provided in-person and online, the librarians' guidance on inquiries, and the ample no-cost work space, the physical library was still distinctly a library; but one that had made minor adjustments to the placement of its tables, desks, and couches to maintain social distancing.

## ADAPTATIONS IN SERVICES

From the interviews with the library staff, it became apparent that their library science education prepared them to deftly navigate their traditional resources (online databases, in-building collections, online means of information-gathering, etc.).This equipped them with the mindset to adapt to new applications with relative ease. An overarching theme in every interview was the librarians developing a vision of what service they aimed to provide or what programming experience they aimed to create, and working backward from that vision to translate it into a pandemic-safe version. Every staff member interviewed said they directed their programming, and personal skill acquisition to deliver that programming, to the wants and needs of the community. This resulted in each staff member self-directing their research skills to build on their existing strengths, and rapidly expand their skill sets to perform their specialties in new modalities. For example, Ms. A, as a youth librarian, specializes in guiding child and adolescent patrons through art projects, but had to practice the performance skills to thoroughly demonstrate this guidance for a camera, adapt to the circumstance of the new medium by inviting viewers to share their finished results via social media, and she had to learn the technical skills to trim her instructional videos into digestible clips.

### Lending Materials

The service most emblematic of a public library is the lending of materials- books, Compact Discs (CDs), videos, and other media to anyone with a library card. However, during the height of the pandemic, having the public freely coming and going presented a health risk to all parties. And so, novel strategies were necessary to maintain this service and the safety of everyone involved.

In March 2020, when local governance came to fully understand the severity of the pandemic, the library was compelled to temporarily closed its doors to strategize (State of Illinois Coronavirus Response, 2020). While the library staff, essential workers, were required to be in the building, their ability to assist patrons was restricted to answering phone calls and emails to direct them to online resources.

To restore some form of service as soon as possible, the library enacted a temporary strategy of offering virtual library cards that served as tokens of membership to the library and allowed patrons to access eBooks, audiobooks, periodicals, music, films, and television shows through web-based library lending services such as MediaOnDemand [© OverDrive, 2022], the Libby app [© OverDrive, 2022], the System Wide Automated Network (SWAN) Libraries app [© SWAN, 2019], and Hoopla Digital [© Hoopla Digital, 2018].

Shortly thereafter, the library leveraged its computer-based catalog of its on-site collections, and allowed patrons to browse the catalog online, then request curbside pickup of their desired materials-restoring community access to its wealth of information. After several weeks of curbside pickup, staff had grown accustomed delivering books to patrons' vehicles, but welcomed the reopening of their doors in July 2020.

## Printer Services

As one of the library's purposes is to remove barriers to patrons' engagement with information, printer services are among its most important (Eriksen & Watstein, 2022). Students need to print papers for classes, professionals need to print documents for their business, and community members who have no experience with printing need a place where experts can guide them through the process.

At the same time as the library was emphasizing curbside pickup for physical materials, curbside print job pickup was implemented. Patrons with their own wifi-enabled devices could connect to the library's network and send documents to its printers. However, it was impossible to maintain absolute privacy for the patrons' documents with the curbside service, and so they were cautioned against printing sensitive documents. Moreover, the stipulation of closed-door curbside printing, that it required the patrons to have their own wifi-enabled device, was exclusionary and ran contrary to the library's mission of providing access to all- which made reopening in some capacity a top priority.

When patrons could return to the physical library for printing, staff were instructed to maintain social distancing while providing assistance. Assisting from six feet away presented the challenge of communicating clear instructions for operating the computers and printers. Furthermore, patience and flexibility were necessary to accommodate patrons with varying levels of comfort with technology. Multiple members of the staff indicated that delivering clear instructions for using the library's resources had always been part of their duties, and now had become even more important.

## Connecting Patrons to Resources

As with helping patrons use the printers, the librarians also had to deliver clear instructions to help patrons navigate the onsite and online resources. According to the staff, the pandemic did not fundamentally alter this responsibility. The reference desk librarian remarked that she felt "like a flight attendant" pointing to different sections of the library and describing the materials housed in each. This same worker also responded to a phone call and readily recited the series of clicks the caller should make on the library website to find links related to their query.

Based on the fluidity with which all members of the staff referred to the specific online locations of materials (such as where to find the library newsletter on its website, or specific navigation paths to find library-produced YouTube videos or resources for home-schooling), it seems likely that they have become so practiced in navigating the hybrid space that they no longer consider it unusual or laborious. In the interviews, a common sentiment was that it is a librarian's responsibility to know his or her collections, including an intimate familiarity with the library's online resources, and that the pandemic simply emphasized this component.

## Classes and Workshops

Beyond simply making knowledge available by request, the library actively presented educational opportunities for patrons in classes and workshops, with topics ranging from Microsoft Office, job search clinics, and even cooking. Under normal circumstances, these workshops would occur in-person, in the public computing space or meeting rooms; however, the pandemic moved many of them online, primarily as on-demand recordings.

Producing these recordings required the staff to develop new skills that, previously, had not been in their purview. Video production, the staff learned, invokes a very different skill set from teaching live. Making recordings necessitated careful rehearsal and editing of the workshop script, and to be as clear as possible for an audience that would not be able to ask questions in the moment. For workshops on computer programs, such as Microsoft Word or Google Docs, the presenter needed to share their screen and make deliberate, well-paced movements of their cursor to avoid confusing the audience. Furthermore, asynchronous workshops also required becoming comfortable with speaking without feedback from an audience. After all the prep work and performance, the asynchronous workshops had to be uploaded, which required navigating the interface of a platform, such as YouTube or Facebook.

Synchronous remote workshops presented their own set of unique challenges. In a synchronous format, the presenters were less concerned with having an immaculate script and every word perfectly enunciated, but they faced the challenges of guiding virtual attendees through both the workshop's subject and the webinar platform Zoom.

Trusting in the employees' research expertise and commitment to quality workshops, the library management required staff members to learn the subject they would teach, self-evaluate, and improve their own workshops. Because the staff were accountable for their own products, they were expected to consult their colleagues if they needed additional personnel, creative input, or technical assistance for a program. Accordingly, multiple staff members expressed gratitude for the library's technology department and for state-wide listservs of youth librarians supporting one another.

## Storytime

Storytime is a recurring program where a librarian reads age-appropriate stories to the library's younger patrons. Storytime is one of the library's primary attractions for youths and one of its means to connect with collaborators in the vicinity. Prior to the pandemic, Storytime occurred in the youth section of the library and in places around the community, such as ice cream or coffee shops. Considering that children under 5 years of age are ineligible for COVID-19 vaccination, are generally prone to spreading germs, and are part of the primary audience for Storytime, this event stood to be one of the most precarious to hold in-person (Centers for Disease Control, 2021b).

Going virtual presented Storytime with many of the same challenges as the classes and workshops. To produce Storytime videos, the facilitating librarians needed to learn how to record themselves reading for a video, how to edit their videos, and how to deliver the videos to a publicly-accessible platform. For several librarians, the virtual format multiplied the time they needed to devote to one Storytime session.

In addition to reading the story, it was also necessary to ensure optimal camera angle and microphone feed, to edit out stutters or slips of the tongue, to curb perfectionism in the editing process, and to wait for the final product to upload.

As with other aspects of their online adaptations, the staff was given considerable leeway in how they acquired the skills to deliver their programs. Practice and repetition were the most commonly described strategy for learning to put Storytimes online. Ms. C conveyed in her interview that she was especially motivated to have her readings be as dynamic, vivid, and expressive online as in person. To that end, she tapped her personal network of performers and digital technicians for their expertise in their respective areas. With practice and her friends' insights, Ms. C came to develop an online Storytime technique that she considered comparable to her in-person delivery.

In contrast to the workshops, where the library staff produced all of the content, virtual Storytime was more likely to encounter legal complications from reading published works online. In-person, time-limited readings are readily accepted as part of the library's normal function, but book publishers were wary that online, permanent recorded readings of their materials would impact their sales, and were swift to issue copyright claims. Consequently, Storytime specialists learned how to contact publishers, and often found success in negotiating conditions to have the readings online until the pandemic remits. Unfortunately, the library discovered that music copyright holders tend to be less flexible and are quick to flag videos containing their content. As a result, further onus is placed on the librarians to provide their own energy and intrigue for the online audience.

In the past, when Storytimes could occur in various places around the community, they were a means for the library to connect and partner with local businesses and institutions. In the advent of the pandemic, public outreach and collaboration has required more creativity.

## Community Outreach/Public Engagement

For community outreach programming, a major guiding question, echoed in some form by multiple librarians, was "How creative can you get?" Smaller events such as workshops or Storytime could usually be orchestrated by one person, but bigger events required teamwork, collaboration, and inordinate creativity to bring the public into the physical library or to engage them in a hybrid format. Depending on the event, "hybrid" could mean an activity that could be performed synchronously in-person or asynchronously from a remote location or an event occurring live with the patrons having the option to attend in-person or virtually.

To exemplify the first type of hybrid, "Take-and-Make" kits became a standard practice for youths' arts and crafts programs. These kits, fully-equipped with the supplies for the project (common materials including paper, felt, scissors, and glue), allowed patrons to either work on the craft in the library, or bring the kit home and complete it on their own. Paying attention to the needs of the community, the library found Take-and-Make kits to be especially popular in the summer, recording that 800 kits were produced and distributed during August 2021. And in other months, it is uncommon their supply of kits will last longer than 48 hours after the event.

The programming staff carefully decided when to employ the other kind of hybrid, fully synchronous Zoom and in-person experiences. This format was predominantly used for events where the library did not have to provide materials, such as the adult's book discussion club.

In December 2021, when the library was practiced in adapting its space to accommodate social distancing during events, having more in-person events was possible, with the caveat that the promotional materials strongly recommended patrons' pre-registration, to aid with logistical considerations. Having estimates of how many to expect for the cookie-decorating workshop or the 'build-a-furry fluffy friend experience" allowed the library to prepare adequate supplies and arrange the meeting space to be as safe as possible.

Prior to the pandemic, the library had totally asynchronous outreach programs, primarily aimed at seniors, and in light of the virus, these became especially important for helping that segment of the community feel connected. Senior programs evolved to remain novel and retain local seniors' engagement. Mrs. L spearheaded these efforts by overseeing the "Seniors Connecting" program, which provides Grab-and-Go bags of mentally-stimulating materials, writing regular wellness check-in emails to community members in convalescent homes, and promoting the Homebody Workout exercise classes that the library produces and uploads to YouTube.

Rebuilding face-to-face connections within the community has been hampered by the uncertainty of whether previous collaborators, such as local businesses and schools, will have their doors open to the public, and be willing to collaborate. Mr. B lamented the difficulty of even finding a contact person amid the uncertainty. As a result, the importance of maintaining the library itself, the space that staff can count on being available for programming, is magnified.

## Providing Work Space

To fulfil the shared vision of the library as a welcoming, educational, community center, the library must first be a safe place, requiring a heightened attention to cleanliness. Ms. C described the employees' predicament in working for "a public institution, [the library's doors] are open to anyone [and them] bringing the germs from their journeys." Ms. A added that she felt it is "almost a full-time job to keep germs at bay, on top of being a librarian", and so the staff had to maintain close attention to their sanitation behaviors. Agreeing that sanitation was more than just the responsibility of the cleaning staff, employees of all job titles wore face masks, kept hand sanitizer near their desks, practiced social distancing, and carefully read disinfectant labels to determine which products were most appropriate for different surfaces. Starting in August 2021, the library, as an organization, complied with county-wide mandates to require face coverings in public places, and posted signs informing patrons of such in the entryways.

Overall, the interviews indicated that library science education provides a solid foundation for learning the technical skills necessary for the staff to perform their functions effectively when working remotely and safely in person. Considering the broad range of responsibilities and distinct technical skills each interviewee had to learn, there was no general consensus on a single most difficult part of moving online. Planning, promoting, and delivering programs for online formats became drastically different, relying heavily on social media, and online engagement, rather than the traditional printed newsletter. Patrons' engagement with these programs was now beholden to, not just their own personal interest, but also their willingness and ability to navigate the online formats, and to unpredictable technical difficulties. Considering these varying challenges, looking to this chapter's theoretical framework can shed some light on why individuals found certain aspects of the transition more difficult than others.

## FINDINGS FROM INTERVIEWS: THEORIES VERSUS PRACTICE

In facing the pandemic, moving online, and finally to hybrid, the library staff was both teacher and student- placing them, simultaneously in multiple positions in the conceptualizations of practically implementing Learning Theory, cultivating and engendering Social Connectedness, and through incorporating the Technology Adoption Model.

### Technology Adoption Model in Practice

The interviews conducted sampled only a seventh of the total library staff (5 of a total 35), but did sample a wide age range, wherein there was no discernible correlation between employee age and espoused willingness to embrace technology. Only one employee, a millennial, self-identified as a tech-savvy. Three more in a similar age range modestly considered themselves more technologically literate than their parents, and the staff member who boasted decades in the profession reported becoming technologically proficient for the work at hand. All participants agreed that practice made it easier to use the newly-essential technologies of Zoom and social media. Additionally, low in-person attendance afforded the staff time to hone their skills.

It is worth noting that, owing to the disparate specialties of all the staff interviewed, they all had different technological needs for their unique positions and, therefore, had to learn different skills. Each interviewee had different technology to be averse to or to adopt. The youth librarians emphasized the importance of creativity and for finding new ways to apply the interpersonal skills they had already honed, but now in computer-mediated formats. They also had to learn to navigate online directories of businesses to contact collaborators in the community and to use social media to promote their programming. Ms. A, a youth librarian, mentioned that she was devoting considerable amounts of energy to choosing the right graphic design software for creating promotional flyers that were attractive on computer screens, as opposed to the traditional cork bulletin boards. Mrs. L, the Head of Public Services, learned to evaluate computer programs and online services that could be useful to the library and community during the pandemic, such as Hoopla or the issuing of virtual library cards. She also learned that, when guiding patrons through technical difficulties, maintaining a patient attitude makes the experience painless as can be for everyone involved. Ms. R, who was promoted to Director during the pandemic, became proficient at communicating with the library staff through varying virtual formats, contracted new reading programs such as Beanstack [© 2022, Zoobean, Inc.] for the library, and constantly practiced empathy, to develop accessible workflows for the staff and ensure that patrons with all levels of technical expertise could participate in the library's programming. The newly-adopted technologies and technical skills the interviewees mentioned by name are presented in Table 1.

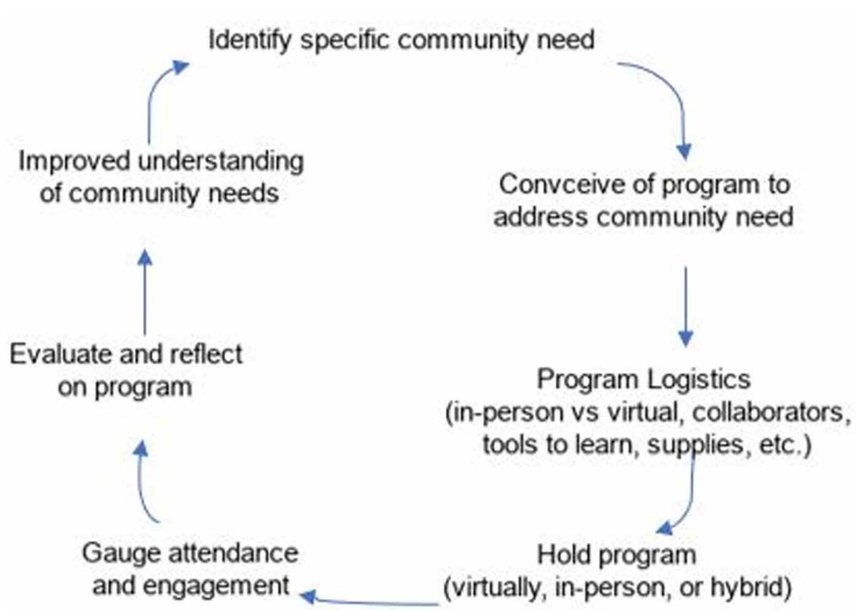
### Learning Theory in Practice

In terms of Illeris' (2018) conceptualization of Learning Theory, the employees' connection to the community instilled a sense of duty and provided the incentive to learn the content of new technologies' functions and new pandemic-safe workflows. Following these new procedures led to new interactions with the community and their colleagues, and the new methods were reinforced by positive responses to the resultant programs. Staff evaluated their programs by gauging patrons' engagement with the programming, such as how many attendees logged on to a Zoom session or how many Grab-and-Go bags were requested for a given month. In Mr. B's words: "It all goes back to programming. And getting back to that drawing board to figure out what your community still needs, and what it wants from its library." This iterative process is illustrated in Figure 1.

*Table 1. Interviewee pseudonym, job title, job overview, and technologies specifically mentioned as adopted*

| Interviewee Pseudonym | Job Title and Overview | Digital Technologies adopted |
|---|---|---|
| Ms. A | Youth Librarian: Specializes in art-focused programming aimed at library patrons under 18 years of age. Coordinates outreach events in the community. | YouTube, Facebook, Canva, Adobe Photoshop video editing |
| Mr. B | Youth Librarian: Assists younger patrons and their families in navigating the library's resources. Oversees the youth section of the library. Coordinates outreach events in the community. | Zoom, Facebook |
| Ms. C | Youth Librarian: Specializes in Storytime. Coordinates outreach events in the community. | Zoom, YouTube, Google Drive video editing |
| Mrs. L | Head of Public Services: Manages materials, programming for adult patrons. Approves public communications. Serves as liaison to the library's business association. Heads outreach programming for seniors in the community. | Zoom, YouTube, Facebook, Hoopla |
| Ms. R | Director: Oversees the operations of the library, created workflows procedures for others to follow, orchestrated employees' professional development. | Zoom, Google Voice, YouTube, Beanstack |

*Figure 1. Learning Theory as applied to library programming*



## Social Connectedness in Practice

Providing social connection was one of the employees' most cited benefits of the library as an institution, and was the most discussed topic for the library staff in their adaptations to their new working conditions. The sense of affiliation that social connectedness provides is readily apparent in the library's eager responsiveness to the community's wants in programming and materials, gleaned from the library's online "request a material" form and from librarians' interactions with the patrons. This dynamic allows the public to contribute to the enrichment of the library while the library enriches the public. In spite of the tribulations, Ms. R holds fast in her sentiment that the south suburban library is "still a great place to work, [and a] great community to serve."

The library's continued public service demonstrates social connectedness between the institution, the employees, and the patrons with the librarians' eagerness to reintegrate into the community with programming, which has been encouraged by the public's attendance to virtual events and the returning in-person events. The requisite components of the Technology Adoption Model are evident as everyone, including the less technologically-inclined staff, acknowledged technology as essential for their work, and have made it their business to use technology to perform their job functions. Learning Theory is present all throughout the interaction between the library, the patrons, and the librarians. The library, as an institution, provides a place for the patrons to pursue knowledge, and that pursuit impels the staff to continue learning, and adapt their expertise to the wants and needs of the community.

## Unique Benefits of a Library, Even During a Pandemic

Ms. R's modus operandi, in any question relating to the function of the library is "What is it that we do that can serve the best interest of our community?" And that guiding philosophy has led the library to provide several unique benefits to the community, even during a pandemic.

At its least functional, the library provided free public wi-fi to patrons in the vicinity. Two years of online programming has provided the community with information, and friendly familiar faces even when they were not accessible in person, and produced a large body of library-produced on-demand content.

With a hybrid library, patrons have unprecedented flexibility in how they access the library's materials; And for the staff, the shift to hybrid formats has presented more reason and opportunity to investigate creative delivery of their programming.

Overall, this library prefers in-person operation, because the ultimate goal is always to serve the local population. In this case, the local population is largely a senior, middle-class community. To be accessible for all levels of tech-savviness, to serve the absolute beginner, who may not even know how to turn on a computer, the library needs its physical space where the absolute beginner can receive step by step guidance toward whatever information he or she is pursuing. In addition, some of the library's services, such as scanning documents, or notarizing documents, can only be performed in person. Ms. R underscored the necessity of the physical space with her consideration of the absolute beginner: "Asking someone who has never been trained on how to make a Microsoft Word or Google Doc to live their entire life online is an unattainable task, which is why we reopened to the public in July 2020 and haven't closed our doors to patrons entirely since."

## DISCUSSION

This chapter described the experience of one public library as the world grappled with the COVID-19 pandemic. In semi-structured interviews, employees described how they adapted to the changing circumstances and which technological tools they used to continue serving their community and maintain pandemic safety. Zoom and Facebook were the most commonly cited technological tools, for the benefits of providing direct access to the community for synchronous programming and for asynchronous engagement, respectively. Video editing software and YouTube were also commonly mentioned: by producing and uploading original videos, library personnel created a body of media that will remain available on-demand even beyond the pandemic. As the library staff became acutely aware, gaining new skills in technology and knowing how to refine their existing skills will remain invaluable for serving the community's in-person, hybrid, and virtual needs in the future.

## FUTURE RESEARCH DIRECTIONS

This chapter described the experience of one suburban library, which may not be generalizable to all libraries, or all library systems. While this particular library's precise experience may be unique, it is probable that the experience of other libraries shared some commonalities. However, a larger sample with more interviews, ideally from a broad geographic distribution, and with quantitative data to support the qualitative data, would be necessary to confirm the uniqueness or ordinariness of the south suburban library.

## CONCLUSION

In conclusion, the south suburban library has adapted its operations and programming to the conditions of the COVID-19 pandemic. Staff employed their research skills they learned from their library science education to refine their strengths and their abilities, and developed new technical skills to help the library overcome the challenges of the pandemic, and will continue to be essential for their field in the future. In this process, they discovered new ways to leverage the flexibility of the online space, and serve the community's needs in new and innovative ways. The library has remained open (virtually) to the community, supported the needs of the community, and expanded its connection with the community it serves. At the time of writing, local rates of COVID-19 are rising, which will provide yet more opportunities for growth into, and further explore, the evolving landscape of the modern library.

## ACKNOWLEDGMENT

This chapter would not have been possible without the gracious cooperation of the library which has been referred to as "south suburban library" and the candid perspectives from the staff members who have been referred to by pseudonyms: "Director, Ms. R", "Head of Public Services, Ms. L", and librarians "Mr. B," "Ms. C," and "Ms. A."

## REFERENCES

Bhati, P., & Kumar, I. (2020). Role of library professionals in a pandemic situation like COVID-19. *International Journal of Library and Information Studies*, *10*(2), 33–48.

Centers for Disease Control. (2021a, August 2). *COVID-19 Risks and Vaccine Information for Older Adults*. https://www.cdc.gov/aging/covid19/covid19-older-adults.html

Centers for Disease Control. (2021b, December 13). *COVID-19 Vaccines for Children and Teens*. https://www.cdc.gov/coronavirus/2019-ncov/vaccines/recommendations/children-teens.html

Currie, C. L. (2001). Facilitating adult learning: The role of the academic librarian. *The Reference Librarian*, *33*(69-70), 219–231. doi:10.1300/J120v33n69_21

Eriksen, D., & Watstein, S. B. (2022). Collaborating to Remove Barriers to Success. *portal*. *Portal (Baltimore, Md.)*, *22*(1), 241–257.

Fernandez, P. (2020). "Through the looking glass: envisioning new library technologies" pandemic response technologies: remote working. *Library Hi Tech News*, *37*(5), 21–23. doi:10.1108/LHTN-04-2020-0039

Garcia, J., & Nelson, S. (2007). *Public Library Service Responses*. American Library Association.

Illeris, K. (2018). An overview of the history of learning theory. *European Journal of Education*, *53*(1), 86–101. doi:10.1111/ejed.12265

Illinois Department of Commerce. (2020, March 9). *Executive Order 20-10*. www.2illinois.gov. https://www2.illinois.gov/Pages/Executive-Orders/ExecutiveOrder2020-10.aspx

Kelly, T. (1966). *Early public libraries a history of public libraries in great-Britain before 1850*. The Library Association.

Lai, P. C. (2017). The literature review of technology adoption models and theories for the novelty technology. *JISTEM-Journal of Information Systems and Technology Management*, *14*(1), 21–38. doi:10.4301/S1807-17752017000100002

Maclay, K. (2003, May 6). *Clay cuneiform from ancient Mesopotamia to be placed online*. UCBerkeleyNews. https://www.berkeley.edu/news/media/releases/2003/05/06_tablet.shtml

Mentor, D. (2018). Micro to macro social connectedness through mobile phone engagement. In *Encyclopedia of Information Science and Technology* (4th ed., pp. 6184–6194). IGI Global.

Richardson, J. (2010). History of American library science: Its origins and early development. In Encyclopedia of library and information sciences. Academic Press.

St. Wulfram's Church. (n.d.) *The Trigge Library*. http://www.discoverstwulframs.org.uk/the-trigge-library.aspx

State of Illinois Coronavirus Response. (2020, March 16). *Gov. Pritzker's Coronavirus (COVID-19) Press Conference (3/16/2020)* [Video file]. Retrieved from https://coronavirus.illinois.gov/media/videos/2020/gov-coronavirus-031620-mp4.html

Streeter, B. H. (2011). *The chained library: A survey of four centuries in the evolution of the English library*. Cambridge University Press. doi:10.1017/CBO9780511920141

United States Census Bureau. (2020). *QuickFacts South Holland village, Illinois*. https://www.census.gov/quickfacts/fact/table/southhollandvillageillinois/INC110219

## KEY TERMS AND DEFINITIONS

**Asynchronous:** Unrestricted by time, allowing participants to engage whenever they like.

**Hybrid:** An operation or activity that has online and in-person components, allowing participants the option to engage with either.

**Learning Theory:** A framework that considers learning as the processes of a learner forming impressions about the environment, assessing, and elaborating on those impressions to internalize information about the environment.

**Programming:** Educational and recreational events organized by the library to which the community is invited.

**Semi-Structured Interview:** An interviewing procedure that poses the same base set of questions to multiple interviewees and adapts additional questioning to the organic flow of the resultant conversation.

**Social Connectedness:** Interactions that contribute to a sense of shared identity between individuals.

**Synchronous:** Occurring at a specific, fixed point in time. Conducive to activities that require real-time conversation.

**Technology Adoption Model:** A decision-making model that explains how an individual's preexisting attitudes toward technology influence their willingness to embrace new technologies.

## APPENDIX

### Semi-Structured Interview Questions

1. What is the library to you? According to state-wide mandates, the library is an essential institution, do you agree with this, why or why not?
2. Describe your job, and what functions of it have changed since the start of the pandemic.
3. Over the course of the pandemic, what unexpected skills have become a regular part of your work? Things that previously never crossed your mind when you think of your current position.
4. What was learning those skills like?
5. If someone were applying to the position you currently occupy, how would the job description differ from the one you read when you applied?
6. "Community" has come up a lot in the process of writing this chapter. How do you see "*community*" functioning in the library? How did you see your role in the community? How did "*community*" help you adapt to the ever-changing circumstances? ("Community" could include the public you're serving or your colleagues)
7. To what degree do you consider yourself a "technology person?" Has that changed in the past two years?
8. The chapter is in the works, so if something you've said is just perfect as a quote for something, do you have any ways you would not want to be identified? I'd mostly likely say "one librarian said..." or "[your specific job title] said..."
9. What generation do you consider yourself part of?
10. Do you have any final thoughts for "New Media, Training, and Skill Development for the Modern Workforce"?

# Chapter 8
# Use of Mobile Technology in Assessing Occupational Performance and Stress in Firefighters

**Jaron Ras**
*University of the Western Cape, South Africa*

**Lloyd Leach**
*University of the Western Cape, South Africa*

## ABSTRACT

*Firefighters are required to maintain all aspects of their health and wellness in order to sustain their fitness for duty. Heart rate variability (HRV) has been used as a reliable tool when assessing the stressors placed on firefighters, be it physical, emotional, or psychological. This review determined the usefulness of using HRV as a tool to determine the physical, physiological, and psychological health of firefighters at a more regular and frequent scale. HRV is a versatile technology with a plethora of uses, particularly in monitoring the cardiovascular strain as a result of firefighting and recovery post-fire suppression. In addition, the literature showed that HRV could be used to successfully monitor physical fitness, physiological stress, psychological stress, decision making, risk taking behavior and recovery in firefighters. The use of mobile technology measuring HRV may be used to successfully assess firefighter occupational performance. In future research, longitudinal studies investigating HRV use in firefighters are warranted.*

## INTRODUCTION AND BACKGROUND

All over the world, firefighting is a hazardous occupation that involves firefighters risking their lives in life-threatening situations, where they are exposed to severe temperatures, hazardous chemicals and fumes (Shin, Lee, Yang, Lee, & Chung, 2016; Smith, Barr, & Kales, 2013). This chapter reports on how mobile technology is used to assess and track firefighters' fitness for duty. New media can be crucial to

DOI: 10.4018/978-1-6684-3996-8.ch008

aid self-monitoring and could help with setting fitness exercise behavioral goals. Tracking and monitoring fitness exercise activity done through the use of portable and wearable devices like smart watches, fitness straps, as well as portable ECGs can all aid to monitor heart rate variability, but also help with exercise goal setting and fitness goal attainment (Bugajska, Zużewicz, Szmauz-Dybko, & Konarska, 2007; Chandel, Sharma, Kaur, Singh, & Kumar, 2021; Henriksen et al., 2018). This chapter reports on the applicability of these devices in determining firefighters at risk of poor physical fitness, cardiovascular disease, and psychological stress as they prepare for work in severe circumstances.

The dangerous conditions in which firefighters find themselves during emergency situations necessitate that firefighters' wear protective clothing and rescue equipment that is heavy and insulated, putting tremendous strain on the cardiovascular system (Smith, DeBlois, Kales, & Horn, 2016). Apart from extinguishing fires, firefighters also have additional strenuous work duties such as rescuing people in dangerous situations, performing emergency medical services, while working irregular hours and performing administrative tasks (Feairheller, 2015; Shin et al., 2016). These types of strenuous working conditions cause high levels of physical and mental stress, predisposing these individuals to higher risk of cardiovascular disease or sudden cardiac events (S. S. Al-Zaiti & Carey, 2015; Feairheller, 2015; Shin et al., 2016). Firefighters are required to maintain all aspects of their health and wellness in order to sustain their fitness for duty. Hence, underscoring the value of incorporating wearable and mobile devices to aid tracking and goal setting in this regard.

Firefighters who are not fit for duty are predisposed to significant morbidity and mortality, both on and off duty (Farioli et al., 2014; Smith et al., 2013, 2019; Smith, DeBlois, et al., 2016). In addition, firefighters are required to make life and death decisions while on duty, and their judgement may be negatively affected by undue physical and psychological stress (Clifford, Jung, Hoerrnann, Billinqhurst, & Lindeman, 2019; Jeklin et al., 2021; Prell et al., 2020). Cardiovascular measures, such as resting heart rate (RHR) and heart rate variability (HRV) are reported as significant predictors of cardiovascular diseases, specifically high blood pressure, hyperglycemia, diagnosis of diabetes within 12 years, and early mortality in firefighters (Wulsin, Horn, Perry, Massaro, & D'Agostino, 2015). An alarmingly high number of firefighters were found to have abnormal HRV readings, which identifies those at risk of cardiovascular disease (CVD) or sudden cardiac death (SCD) (S. Al-Zaiti, Rittenberger, Reis, & Hostler, 2015; Jeklin et al., 2021; Prell et al., 2020; Yook, 2019). The usefulness in monitoring of HRV and other psychophysiological measures with mobile technology highlight the need to better leverage new media portable technological devices that can aid in the monitoring of physiological data that can deliver associative data in this regard.

This review will, therefore, determine the usefulness of using HRV as a tool to determine the physical, physiological, and psychological health of firefighters at a more regular and frequent scale. By using HRV as a screening tool to assist in the early identification of at-risk firefighters, risk can be mitigated on an individual level. Subsequently, the institutional support of mobile and wearable technologies can assist in advocating for the early screening of firefighters and the implementation of appropriate health interventions as well as fitness goals.

## Heart Rate Variability Definition, Application, and Measures

Heart rate variability is the variation in the time interval between consecutive heartbeats in milliseconds (Billman, Huikuri, Sacha, & Trimmel, 2015; Shin et al., 2016). It has been shown that heart rate variability is directly related to autonomic functioning (Shaffer & Ginsberg, 2017). Increased sympathetic activity causes a direct decrease in HRV, and increased parasympathetic activity, results in an increase in HRV(Shaffer & Ginsberg, 2017). The increased sympathetic activity increases the heart rate (HR) and decreases the variation in the beat-to-beat interval, whereas the opposite occurs when the parasympathetic nervous system is stimulated and cause more variation as the heart rate drops and the beat-to-beat intervals (Shaffer & Ginsberg, 2017). The beat-to-beat intervals, though subtle, provide important insights into autonomic and cardiovascular functioning. These types of measures are referred to as time domain measures and defined as the numbers obtained from statistical analysis of the intervals between heart beats and are observed during monitoring periods that may range from ±2 minutes to 24 hours (Malik et al., 1996; Shaffer, Ginsberg, & Shaffer, 2017). The most common measures include the standard deviation of normal-to-normal sinus intervals (SDNN) which is influenced by both the sympathetic and parasympathetic nervous system activity and considered the "gold standard" in HRV analysis (Malik et al., 1996; Shaffer et al., 2017). The root mean square of successive differences between normal heartbeats (RMSSD) and reflects the beat-to-beat variance in HR and is the primary time-domain measure used to estimate the vagally mediated changes in HRV; and lastly, the average interval between normal beats (AVNN) (Malik et al., 1996; Shaffer & Ginsberg, 2017). Frequency domain analysis is an analysis technique that indicates how much of a signal lies within one or more frequency bands (ranges) (Almeida-Santos et al., 2016; Malik et al., 1996; Shaffer & Ginsberg, 2017). In the case of HRV, research has found that certain frequency bands correlate directly with specific physiological phenomena (Acharya, Joseph, Kannathal, Lim, & Suri, 2006; Oka, Sawaguchi, Kuriyama, & Ito, 2021; Sessa et al., 2018; Shaffer et al., 2017). Frequency domains are divided into High Frequency power (HF), which is represented by a frequency activity range of 0.15 - 0.40 Hz range and Low Frequency power (LF), represented by a frequency activity in the 0.04 - 0.15 Hz range (Acharya et al., 2006; Malik et al., 1996; Shaffer & Ginsberg, 2017). The LF band has been associated with baroreceptor activity, and HF bands are related to HR variations related to the respiratory cycle (Shaffer & Ginsberg, 2017). Another measure is the LF/HF Ratio, which represents the ratio of Low Frequency to High Frequency and is considered indicative of sympathetic to parasympathetic autonomic balance, where a low frequency dominated ratio indicates parasympathetic dominance, and a high frequency dominated ratio indicates sympathetic dominance (Acharya et al., 2006; Almeida-Santos et al., 2016; Malik et al., 1996; Shaffer & Ginsberg, 2017). High frequency dominance would indicate a high stress state, which is often seen in emergency personnel, such as firefighters (Jeklin et al., 2021; Prell et al., 2020; Shin et al., 2016; Tomes, Schram, & Orr, 2020). Although there are many interpretations of time domain and frequency domain in HRV, we have elected to only explain the most frequently used domains in research regarding firefighters. All other HRV measures are variations on the standard time and frequency domains.

## MAIN FOCUS OF THE CHAPTER

### Heart Rate Variability in Firefighters

The advances in technology measuring HRV has become increasingly simpler and cost effective (Liao, Al-Zaiti, & Carey, 2014; Shin et al., 2016). Previously, HRV would need to be measured using an ECG, however, with today's technological advances and shrinking of mobile devices to a wearable size, HRV has become somewhat of a ubiquitous mobile technology, being used in many smart watches, chest straps, and portable ECG monitors (Morresi, Casaccia, Sorcinelli, Arnesano, & Revel, 2020; Plews et al., 2017). This allows HRV and the autonomic functioning of the heart to be monitored on the move in everyday life cost effectively and conveniently.

Heart Rate Variability is determined by the parasympathetic and sympathetic autonomic balance. Physiologically, the parasympathetic nervous system is known as the "rest and digest" system and is indicative of the body being in a relaxed and calm state (Acharya et al., 2006; Malik et al., 1996; Shaffer et al., 2017). Alternatively, the sympathetic nervous system is known as the "fight or flight" system and is indicative of the human body being in a state of stress (Billman et al., 2015; Tomes et al., 2020; Vyas & Mcgregor, 2018). Increased stress, poor physical fitness and poor cardiovascular health cause an increase in sympathetic stimulation, decreasing the time interval between beats, which corresponds to a decrease in HRV (Acharya et al., 2006; Almeida-Santos et al., 2016; Schuster, Fischer, Thayer, Mauss, & Jarczok, 2016; Shaffer et al., 2017; Shin et al., 2016). Improved physical fitness, good cardiovascular health, and low stress levels increase the parasympathetic dominance, which corresponds to an increase in the beat-to-beat time interval, and subsequently, an increase in HRV (Acharya et al., 2006; Malik et al., 1996; Tomes et al., 2020; Yook, 2019). Monitoring HRV can be used to determine those individuals at risk for cardiovascular conditions, those with poor physical fitness, or those that have increased stress levels.

In firefighters, HRV has been used as a reliable tool when assessing the overall stressors placed on firefighters, be they physical, physiological, emotional, or psychological (Jeklin et al., 2021; Qiu et al., 2017; Schuster et al., 2016; Shin et al., 2016). Current research indicated that a relationship exists between HRV, cardiovascular health, mental health, and the physical fitness of firefighters, which may prove valuable in assessing underlying conditions present in firefighters (S. S. Al-Zaiti & Carey, 2015; Feairheller, 2015; Shin et al., 2016). A relationship that can further be strengthened in research and practice by utilizing mobile technology to collect data from mobile phones and wearable devices on a large scale, and more importantly, on an individual firefighter level. In addition, an alarmingly high number of firefighters were reported to have abnormal HRV readings (S. S. Al-Zaiti & Carey, 2015; Carlén, Nylander, Åström Aneq, & Gustafsson, 2019; Pillutla, Li, Ahmadi, & Budoff, 2012; Soteriades, Targino, et al., 2011). Having annual or routine physical check-ups using health screenings, in conjunction with HRV, can identify those who might be at risk of CVD or SCD and those who can benefit from preventive cardiovascular services. Moreover, the use of HRV may allow for the convenient monitoring of those firefighters at risk for cardiovascular disease, psychological burnout, and injury (Jeklin et al., 2021; Liao et al., 2014; Prell et al., 2020; Shin et al., 2016; Tomes et al., 2020; Yook, 2019).

## Developments in the Use of Heart Rate Variability in Firefighters

The use of HRV and other technology in the monitoring of firefighters have progressed rather slowly, when considering that the first reported study of measuring heart rates to alarm tones in firefighters was conducted in 1981 by Kuorinka & Korhonen, 1981. In their study, due to the incipiency of heart rate sensing technology, an ECG was required to monitor simple heart rate measures. The relatively low number of studies using technology in firefighters, and other emergency occupations, may, in part, be due to the relative scarcity of researchers interested in this specific research field. Without constant research driving these new ideologies, the potential for use in firefighters and other emergency personnel are merely theoretical and without any practical applications using hard scientific evidence goes, mostly, unaccepted. Although progressing gradually, the advancement of technology has allowed for more convenient monitoring of heart rates in firefighters in the early 2000's, which has ignited research interest in the application of technology in firefighters, particularly as a means to detect autonomic abnormalities and occupational stress in firefighters (Chuang, Chung, Shu, & Chen, 2007; Malik et al., 1996; Togo & Takahashi, 2009). Over time, research involving the multifaceted use of HRV in the general population investigating the relationship between HRV and physiological and psychological variables slowly trickled over to firefighter research. The use of HRV has now become a focal point in the endeavours to reduce the high cardiovascular related mortality, injury related early retirement and mental illness, often seen in this population (Jeklin et al., 2021; Meina et al., 2020; Prell et al., 2020; Shin et al., 2016; Yook, 2019). Researchers started applying the use of portable heart rate monitoring systems in the early-to-mid-2010s as a means to monitor heart rate responses, recovery, workload, and stress in firefighters (D M Baur, Leiba, Christophi, & Kales, 2012; Dorothee M. Baur, Christophi, Cook, & Kales, 2012; Dorothee M Baur, Christophi, Tsismenakis, Cook, & Kales, 2011; Yu et al., 2015). The incipiency of the HR technology, at the time, meant that standard heart rate was the preferred measure to assess firefighters physiological and psychological responses to emergencies. However, due to the current advancements, HRV monitoring has become readily available to the general population, and with modern HRV analysis advancements, the analysis of time-domains and frequency domains have become rather manageable.

Firefighters are often burdened by immense mental and physiological stress and the imposition of these new technologies may introduce an additional burden that many firefighters will not accept, especially if fire departments attempt to enforce this on a large scale (Bucala & Sweet, 2019; Carey, Al-Zaiti, Dean, Sessanna, & Finnell, 2011; Dobson et al., 2013; Jahnke, Poston, Jitnarin, & Haddock, 2012). Studies have shown that the majority of firefighters think of themselves as "tough guys" (Bonnell et al., 2017; Bucala & Sweet, 2019; Dobson et al., 2013). Firefighters with this mindset may ridicule the idea of having sensors or monitoring systems in place to ensure they avoid injuring or overexerting themselves. Although this mindset appears to be very biased toward the older, more experienced firefighters, the younger generation, as with general society, may be more accepting of the use of technology, especially in the workplace (Bonnell et al., 2017; Bucala & Sweet, 2019; Dobson et al., 2013). The younger demographic population of firefighters should be targeted for the initial and long-term application of this technology use, which could drive the acceptance of technology forward in firefighters.

## Use of Mobile Technology in Firefighters

In firefighter research, many different portable HRV monitoring systems have been used while firefighters are on duty to complete simulation protocols or to discern the physiological burden placed upon the cardiovascular system by firefighting (Biéchy et al., 2021; Marcel-Millet, Groslambert, Gimenez, Grosprêtre, & Ravier, 2021; Marciniak, Wahl, & Ebersole, 2021; Robertson et al., 2017; Schlicht et al., 2018). The most restricting HRV monitor appears to be the VitalJacket®. This portable HRV monitoring system fits over the torso as a conventional shirt and can be worn up to 72 hours continuously, and is noted to be unobstructive in performing everyday tasks (S Rodrigues, Dias, Paiva, & Cunha, 2018; Susana Rodrigues, Dias, Paiva, & Cunha, 2018; Susana Rodrigues, Paiva, Dias, & Cunha, 2018). Although the VitalJacket is a useful portable technology, the long-term use of these in firefighters may prove problematic, and inconvenient, due to the device needing cleaning after each use (Susana Rodrigues, Dias, et al., 2018; Susana Rodrigues, Paiva, Dias, & Cunha, 2018; Susana Rodrigues, Paiva, Dias, Pimentel, et al., 2018). In addition, the VitalJacket® may increase heat production and perspiration during intense firefighter related duties (Susana Rodrigues, Dias, et al., 2018; Susana Rodrigues, Paiva, Dias, & Cunha, 2018).

*Figure 1. VitalJacket®. © 2022, Biodevices, Biomedical Engineering Systems, S.A., Used with permission*


The Bodyguard® Firstbeat is another HRV product that has been used in firefighting research (Figure 2).

*Figure 2. Bodyguard Firstbeat. © 2022, Firstbeat Technologies Oy, Used with permission*

The Bodyguard® Firstbeat, although very accurate, uses electrodes to monitor HRV. This technology becomes problematic when attempting to monitor electrocardiographic signals over a prolonged period, especially when individuals are engaged in vigorous activities, such as firefighting. This technology may be beneficial for platoon officers, station commanders, or divisional heads that are not often engaged in vigorous activities. Many of these older firefighters have underlying health concerns and implementing a live monitoring system of these high-risk firefighters may prove quite important in preventing duty related deaths (Gendron, Lajoie, Laurencelle, & Trudeau, 2018; Ras & Leach, 2021; Savall et al., 2020).

The Hexoskin® t-shirt (Figure 3), similar to the VitalJacket® provides its wearers with a fully wearable "shirt" that is used to monitor HRV. The wearable shirt technology overcomes the burden of using electrodes which frequently become unattached. Unlike the VitalJacket®, the Hexoskin® does not use disposable electrodes to monitor HRV, rather using sensors that are manufactured into the shirt itself. This overcomes the issue of artefacts in the data, somewhat, due to the reliability of the electrodes remaining in the correct position and not becoming unattached while wearing the Hexoskin® t-shirt. The Hexoskin® shirt is not intrusive, however, may cause increase perspiration and, overtime, uncomfortability. For long term use, this equipment does not seem to be the most feasible option, but very useful for research purposes.

*Figure 3. Hexoskin® t-shirt © 2022, Carre Technologies inc (Hexoskin)© Used with permission*

The Holter Monitor (Figure 4) have been the most commonly used portable ECG tool to measure HRV in firefighters. As with the VitalJacket® and Bodyguard® Firstbeat, the Holter monitor uses ECG electrodes. Most studies using the Holter monitor used resting measures, and electrodes falling off were not an issue. However, when the Holter monitor is used to measure firefighting activities, the electrodes would often become unstuck, and corrupt the HRV readings. This becomes problematic when one would like to use the Holter as a long term HRV monitoring system. For resting measures, the Holter would represent the gold standard in portable technologies, however, once firefighters initiate movement, become considerably more unreliable.

*Figure 4. Holter monitor ©2022, ShutterStock, License purchased*


Polar has been producing mobile devices which are reliable and accurate in measuring HRV for an extended period of time already (Figure 5) (Caminal et al., 2018; Donovan, 2009; Plews et al., 2017; Wallén, Hasson, Theorell, Canlon, & Osika, 2012). The Polar V800 watch has been used extensively in research, as a non-invasive technology to monitor HRV (Caminal et al., 2018). On its own, the watch cannot measure HRV, and requires it to be linked to a chest strap, such as the Polar H7 monitor, to monitor HRV. Data corruption or loss of signal can occur if the monitors are placed incorrectly or become unattached. All Polar devices link up to a downloadable application to record and analyze HRV. The convenience and unobtrusiveness of using the watch smartwatch makes it a viable option. The Equivital™ EQ-02 Life Monitor sensor belts are an amalgamation of a conventional HR strap and a fully wearable shirt (Figure 6). This may form the most comfortable method which may be used to monitor firefighters while on active dut (Hinde, White, & Armstrong, 2021) y. The Equivital™ EQ-02

*Figure 5. Polar V800 wristwatch © 2022, Copyright Polar Electro Oy, Used with permission*


*Figure 6. Equivital™ EQ-02 Life Monitor sensor belts © 2022, Equivital™, Used with permission*

Life Monitor has been used in sport and military research previously and has been designed to produce accurate readings even in the most intense sporting or emergency situations (Cullen et al., 2015; Heesch & Slivka, 2015; Hinde et al., 2021; Levels, de Koning, Foster, & Daanen, 2012). However, firefighters often experience slips, trips and falls (Frost, Beach, Crosby, & McGill, 2015), which may pose a significant damage risk for these monitors, especially when firefighters are in emergency reduce situations, such as when evacuating civilians from burning buildings.

Although the large ECG equipment have been used often in research, smaller portable devices have become particularly popular in research involving HRV analysis (Choi, Ko, & Kojaku, 2017; Shin et al., 2016; Wallén et al., 2012). The Polar® RS800CX monitor is one such technology which have been frequently used in combination with the Polar Polar H7 chest strap (Figure 7).

*Figure 7. Polar RS800CX © 2022, Copyright Polar Electro Oy, Used with permission*


In terms of convenience, the wristwatches seem to be the best option to use in firefighters. However, the issue comes in when the watches need to be combined with the H7 chest straps. Although most ECG devices do use multiple devices to monitor HRV continuously, having to use the wristwatch and chest strap together may become cumbersome to firefighters. This may be attributed to firefighters having to ensure both devices are connected and functioning properly when needed during their shifts.

As previously mentioned, the Polar® H7 (Figure 8) HR monitor is the device which retrieves the HRV data when using the Polar smartwatches.

*Figure 8. Polar H7 heart rate monitor © 2022, Copyright Polar Electro Oy, Used with permission*


Due to the progression of the chest strap HRV monitoring technology, research have slowly moved away from using the smartwatches in combination with the chest straps (Hernández-Vicente et al., 2021; Hernando, Roca, Sancho, Alesanco, & Bailón, 2018; Plews et al., 2017). The chest straps, rather, are connected to a smart phone application developed by Polar® which monitors HRV in real time. This allows HRV to be analyzed while firefighters are on duty, if the device is in range of the smartphones Bluetooth range. Although very useful, using this mobile device on duty may be problematic if a smart phone would need to be on the firefighters person. Another issue may be long term comfort using these monitors while on duty.

*Figure 9. BioHarness3 HRV monitor, Awaiting permission from company to use image*


The BioHarness3® (Figure 9) HRV monitor has all the positive atttibutes of the Polar® heart rate monitors and makes up for the negatives by providing its users the ability to store HRV data that can be accessed at a later time. In terms of firefighting, the BioHarness3® appear to be the best option to use in firefighters while on active duty.

The development of wearable ECG wristwatches has progressed quite significantly over the past few years (Chandel et al., 2021; Henriksen et al., 2018; Isakadze & Martin, 2020; Morresi et al., 2020; Zimerman, Sheridan, Cooke, & Jena, 2020). These smartwatches may provide the best option available to use in all emergency occupations (Chandel et al., 2021; Henriksen et al., 2018; Hinde et al., 2021; Tomes et al., 2020). If provided to each firefighter, these can provide easy long term cardiovascular and physical activity monitoring in firefighters. Regularly checking these smartwatches or retrieving data is convenient, as these watches connect to downloadable applications for easy analyzes (Henriksen et al., 2018; Isakadze & Martin, 2020; Morresi et al., 2020; Spaccarotella et al., 2020). Due to the watches being located on the firefighter wrists, damage may occur relatively easily. More research should be conducted using these ECG smartwatches on firefighters while on duty to monitor their feasibility.

## Physical Fitness, Stress, and Heart Rate Variability in Firefighters

Firefighting, an often laborious and dangerous occupation, places many firefighters in harm's way due to the accompanying heat stress, dehydration, and physical exertion. The combination of these factors may cause acute sympathetic activation in firefighters (Larsen, Snow, & Aisbett, 2015; Pluntke, Gerke, Sridhar, Weiss, & Michel, 2019; Schlicht et al., 2018; Shin et al., 2016). However, as recommended by many researchers, policy makers, and fire departments, regular physical activity provides a cardio-protective effect, such as bradycardia, and improved cardiovascular fitness. Therefore, the reduction of cardiovascular strain results in autonomic adaptations leaning toward parasympathetic dominance (Marcel-Millet, Ravier, Esco, & Groslambert, 2020; Porto et al., 2019; Yook, 2019). Specifically, the augmented stimulation of the vagal nerve subsequently prolongs the beat-to-beat interval and ultimately decreases HRV (D M Baur et al., 2012; Lavie et al., 2015; Smith, DeBlois, et al., 2016). Consequently, fitter firefighters will have a lower HRV, thus, allows HRV to be used as a more convenient screening tool to estimate cardiovascular fitness and health in firefighters.

Porto et al. (2019) conducted a study investigating the relationship between cardiorespiratory fitness and HRV in firefighters. In the study, firefighters HRV was measured using a Polar© heart rate monitor in a resting supine and orthostatic position. The study found that HRV was significantly related to higher cardiorespiratory fitness, in both the supine and orthostatic positions in firefighters. Most firefighting departments use a cardiorespiratory capacity higher than 12.5 METs as the baseline cardiorespiratory fitness standard for firefighters to be deemed fit for duty. As seen in Figure 9, PNN50 and rMSSD was significantly higher in fitter firefighters and low and high frequency ratio was singingly more dominated by low frequency compared to higher frequency. Firefighters' cardiovascular fitness may be assessed using HRV as a preventative measure to determine the functioning of the cardiovascular system (Porto et al., 2019). The study by Porto et al. serves as a promising base to implement resting HRV testing as a simple measuring tool for fitness in firefighters, as non-invasive, time-sensitive measures throughout the year when firefighters are not required to undergo fitness testing.

A study by Marcel-Millet et al. (2020) investigated the relationship between firefighters' fitness and parasympathetic reactivation, using a Hexoskin® t-shirt. The study reported that physical fitness did not influence cardiac parasympathetic reactivation. The study noted that the Log transformed root mean square of successive differences (LnRMSSD) showed high accuracy compared to the criterion the researchers used, indicating the usefulness of a wearable HRV t-shirt in firefighters. Although the study did not find a significant relationship between physical fitness and HRV, it demonstrates the usefulness in monitoring parasympathetic modulation while firefighters are on duty (Marcel-Millet et al., 2020).

Figure 10 explains the relationship between heart rate variability in relation to performance and time demand, measured using the multi-dimensional NASA-Task Load Index (NASA-TLX). The study noted that specific HRV measures, such as LF/HF ratio, LF, and pNN50 was significantly predicted by performance on the tasks. In addition, time demand of the tasks could predict changes in HRV, specifically related to detrended fluctuation analysis (DFA1), pNN50 and rMSSD. These results may be useful in predicting the physiological strain on firefighters based on the task demand. This may provide an added benefit of physical fitness training in reducing these physical stressors using HRV.

*Figure 10. Difference between HRV measures according to physical fitness in orthostatic position*

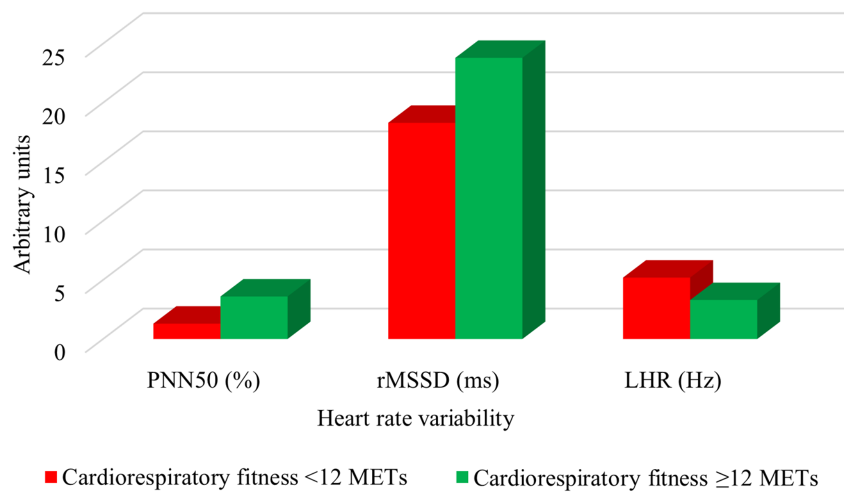
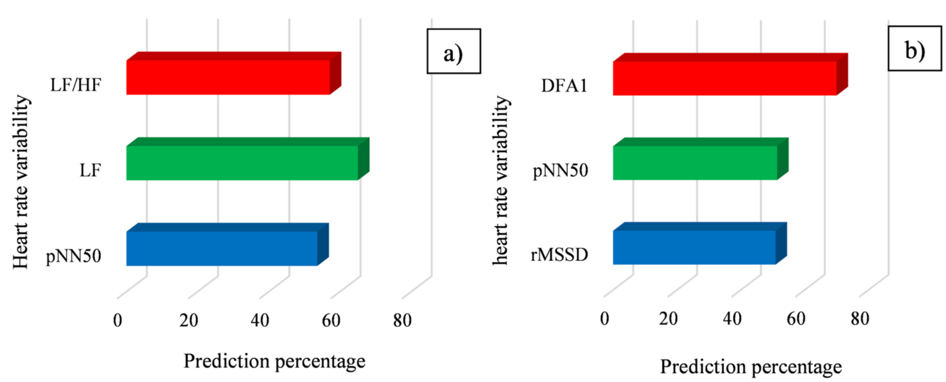



*Figure 11. Relationship between heart rate variability and physical load: a) – heart rate variability and performance; b) – heart rate variability and time demand*



Cilhoroz et al. (2021) conducted a study investigating the blood pressure and HRV responses in five firefighters exposed to sudden vigorous exertion who had hypertension. The researchers used a Polar® V800TM HR monitor and Polar® H7 chest strap to measure the firefighters' baseline HRV. The HRV data was exported onto the Polar Flow software (Version 2.3; Polar ElectroOy, Kempele, Finland) for further analysis. The results of the study showed that there was a significant trend of increased blood pressure and LF/HF ratio in firefighters after completion of the graded exercise stress test. The study noted that HRV and ambulatory blood pressure are significantly affected by vigorous intensity, which lasts throughout the 19-hour monitoring period. In the study, as blood pressure increased, HRV decreased, specifically the LF/HF ratio, which is consistent with previous research, (Almeida-Santos et al., 2016; Schuster et al., 2016; Shin et al., 2016; Wulsin et al., 2015), as this designates alterations in baroreceptor reflexes and increased stress on the body. Routinely monitoring HRV throughout firefighter shifts may provide valuable information regarding the physiological stressors' firefighters may experience through the shift.

Lyytikäinen, Toivonen, Hynynen, Lindholm, & Kyröläinen et al. (2017) investigated how aerobic fitness is associated with recovery, using the measurement of heart rate variability in firefighters over a 24-hour shift. The researchers recorded HRV using a portable Bodyguard, Firstbeat Technologies HR monitor. Stress and recovery were measured using salivary cortisol. The study reported that SDNN was lowest while firefighters were on shift and decreased during off-duty recovery. A similar decrease was seen in the baseline LF/HF ratio of off-duty firefighters. This indicates that while firefighters are on-duty, their stress levels are increased, causing a decrease in HRV and a general sympathetic dominance. Surprisingly, the researchers did not find a significant association between good cardiorespiratory fitness and HRV, however, there was a general trend toward increased RMSSD and SDNN with firefighters that had higher aerobic fitness levels (Lyytikäinen et al., 2017). Cortisol levels increased throughout the firefighters' work shift, which coincides with the decreased HRV measures, and remained elevated until the last day of recovery before the next shift (Lyytikäinen et al., 2017). The use of HRV and cortisol levels provide additional objective measures of monitoring HRV and stress in firefighters. Moreover, the combination of hormone monitoring along with physiological monitoring may provide additional benefits in ensuring long term health and fitness in firefighters, however, this approach may prove to be costly and considered implausible by fire departments.

An earlier study conducted by Marcel-Millet et al. (2018) investigated the relationship between parasympathetic reactivation, monitored with the Hexoskin® t-shirt, during rescue interventions while wearing a breathing apparatus. The Hexoskin® t-shirt successfully and accurately monitored the firefighters' physiological responses during the simulation protocols and reported that firefighters that wore the SCBA experienced more physiological stress and important post-exercise vagal perturbation. More specifically, the increased physiological stress of the SCBA gear increased the post-exercise vagal perturbations in firefighters (Marcel-Millet et al., 2018). The study highlights the versatility of using HRV to monitor the physiological stressors during specific firefighter duties, which may have a prolonged negative effect of the cardiovascular system, post-event. This provides useful information in the applicability of using HRV to monitor firefighters' physiological recovery after an extended time post the emergency event. In addition, this may discern firefighters that require stress relief interventions, or those who may benefit from exercise training to better cope with the stressors of the job.

## Heart Rate Variability and Reflection of Respiration

Heart Rate Variability have been used as a measure to relate to respiratory reflexes, which is a relatively new method of applying HRV. Reflection of Respiration (RIR) is an objective index illustrating cardio-respiratory load. This was described by Malik et al. (1996) that described respiratory reflexes at rest or during low-load activities are present primarily in the high-frequency (HF) band (0.15–0.40 Hz), which relates to parasympathetic activity. However, the effect of respiratory reflex in the continuation of high load activity are present in the very-high-frequency (VHF) band (0.4–1.0 Hz) rather than in the HF band and are indicative of sympathetic activity (Ito, Oka, & Kuriyama, 2020). The use of the RIR index, provides visualization of the cardiorespiratory state of firefighters without using a metabolic monitoring device, such as a mask and a gas analyzer (Ito et al., 2020; Oka et al., 2021). The use of the RIR index to determine other biological parameters, such as blood lactate, has been researched and determined to be appropriate. The reflection of respiration has reliably been shown to indicate the shift from an aerobic to an anaerobic dominated state under high load intensity, which often occur in firefighters, due to the vigorous nature of many of the emergency situations they are faced with (Ito et al., 2020; Oka et al., 2021).

Ito et al. (2020) investigated the relationship between RIR and firefighters' activity using a Holter monitor while firefighters performed a simulation protocol. The researchers reported that the combined use of HR and RIR provided invaluable insight into the physiological stressors firefighters faced, and significantly related to the intensity of the load placed on them. In addition, HRV and RIR measurements were related to the blood lactic acid levels and the activity level of the firefighters while performing the simulated tasks (Ito et al., 2020). The use of HR and RIR, in concurrence, may reduce the incidence of overexertion in firefighters and support the improvement in their occupational safety. As many firefighters do suffer from suboptimal lung function (Navarro et al., 2019; Slattery, Johnston, Paquet, Bennett, & Crockett, 2018), the use of HRV may also prove useful in measuring the firefighters' lung function while using SCBA and other breathing apparatuses.

In a study by Oka et al. (2021) the researchers investigated the applicability of using HRV analysis to improve firefighter occupational safety, using a threshold for firefighters to stop their activity immediately and recover. The researchers used the RIR as a means to determine the physiological stress of the firefighting activities. The study found that RIR parameters predicted increased perceived physiological stress and may provide valuable insight into the recovery of firefighters after strenuous emergency duties. The use of HRV to determine RIR shows additional usefulness and versatility in measuring and/or determining physiological stress that firefighters routinely face. Higher RIR may indicate the onset of anaerobiosis, which is indicative of high physiological strain (Oka et al., 2021; Vlasenko, 2020). Earlier onset of anaerobiosis will cause the earlier onset of fatigue, severely limiting occupational performance.

## Physiological Demands and Energy Expenditure

Robertson et al. (2017) investigated the use of HRV technologies to assess the physiological demands and nutritional practices of Canadian Fire Rangers during fire deployments over a 16-hour wake period. To monitor HRV, the researchers used a BioHarness3 HRV monitor, an iPod Touch to monitor food logs, and an ActiSleep monitor to track the sleeping patterns of firefighters. The study divided fires into three classes, initial attack (most stressful and intense, short duration), project fire (prolonged, moderately-intensity) and fire base (firefighters are not on fire deployment). The results indicated that initial attack fires resulted in the highest physiological stress, and time spent in physiological recovery was lowest in this group. This provided information on the reduced parasympathetic reactivation between short and intense firefighting events and moderate-intensity prolonged firefighting events. In addition, HRV could estimate energy expenditure, which can be used by fire services to monitor the energy requirements of firefighters to ensure peak performance on duty, especially vigorous-intensity emergency duties (Robertson et al., 2017). The use of the portable monitors to track physical demands of emergency duties, and the energy expenditure of that duty, may provide additional benefits for efficient recovery in firefighters and ensure adequate nutrient intake post emergency. This may be especially useful in observing overall workload throughout the shift week.

## Recovery and Heart Rate Variability

Recovery is an often-overlooked aspect in firefighters' ability to cope with the stressors of the job. Due to the strenuous nature of firefighting many firefighters routinely exceed 90% of the age predicted HR maximum (Johnson et al., 2020; Nazari, MacDermid, Sinden, & Overend, 2018; Smith, DeBlois, et al., 2016; Smith, Haller, Benedict, & Moore-merrell, 2015). Along with the vigorous nature of their occupation, firefighters contend with hazardous chemicals and fumes, extreme temperatures, and traumatic incidents (Smith et al., 2013; Smith, DeBlois, et al., 2016; Soteriades, Smith, Tsismenakis, Baur, & Kales, 2011). This places significant physical and psychological strain on firefighters throughout a shift. Monitoring firefighters that are experiencing exorbitant amounts of physical and psychological stress may provide useful information in ensuring adequate recovery.

Ebersole, Cornell, Flees, Shemelya, & Noel (2020) investigated the contribution of the autonomic nervous system to recovery in a sample of 37 male firefighters. The researchers used a Polar V800 watch and H7 monitor to collect heart rate and R-R interval data in firefighters. The HRV standard software (version 3.0; Kubios, Kuopio, Finland) was used to analyze the HRV data, specifically the RMSSD. The study reported that recovery was related to the intensity of the activity performed by the firefighters and HRV, where HRV was reduced after maximal physical exertion. Recovery was significantly lower after the 10-minute recovery period after maximal effort activities. These results may aid in prescribing adequate recovery after monitoring heart rate responses and HRV during strenuous emergency situations. Monitoring HRV will allow for adequate autonomic recovery after maximal effort activities, such as fire suppression. Biéchy et al. (2021) used HRV as a tool to measure the benefit to cardiovascular recovery using deep breathing and mental imagery in firefighters after physical stress was induced using the cooper run test. The study found that HRV could be used to accurately monitor recovery, and that deep beathing and mental imagery assisted recovery. The study highlighted the versatility of using HRV in determining the usefulness in using various recovery measures in firefighters.

Schlicht et al. (2018) investigated the effect of wrist cooling on recovery in firefighters, using HRV (Polar H7 heart rate monitor) as the recovery indicator. Although the study did not find a significance using HRV as an indicator of recovery, it did share a similar result of non-significance with rating of fatigue. This may allude to fatigue and HRV being closely related in relation to high temperature exposures. The study suggests that HRV may also be used as a long-term monitoring system, post fire suppression, to monitor firefighters' physiological recovery. However, more research needs to be conducted on this.

## Heat Stress and Heart Rate Variability

Heat stress is an external stress which places significant stress unto firefighters (Larsen et al., 2015; Vincent et al., 2017). Although different monitors can be used to assess heat strain on firefighters, there are specific measures of HRV that can be used to measure changes in baroceptor activity, which would suggest that HRV would provide insight into vascular activity in firefighters while performing firefighter suppression duties (Larsen et al., 2015; Malik et al., 1996; Vincent et al., 2017). Therefore, HRV provides information on vascular responses firefighters may be experiencing in these strenuous situations. Andersen et al. (2017) assessed whether firefighting activities were associated with cardiovascular effects in young trainee firefighters exposed to live fires and particulate matter (PM) while wearing appropriate Personal Protective Equipment (PPE). Cardiovascular effects were measured using reactive hyperemia index (RHI) and HRV, using the portable EndoPAT2000. The study did not find any significance between the microvascular function and HRV during any fire extinguish protocols. However, fire extinction was associated with a decrease in RHI and HRV. Specifically, a decrease in time domain HRV measures (SDNN, pNN50 and RMSSD), and associated with reduced HF power, increased LF power and increased LF/HF ratio toward sympathetic dominance. The fire exposure also increased the firefighters body temperature; however, this may be due to the increased workload, rather than heat-induced. This decrease in HRV may be related, in particular, to the increased physical exertion and physical stress associated with fire suppression in firefighters. The close relationship between HRV, particularly the LF/HF ratio, may provide valuable insight into vascular function of firefighters during fire suppression, especially when under heat stress. As established, the frequency domains are closely related to physiological phenomenon, particularly baroreceptor function (Acharya et al., 2006; Shaffer & Ginsberg, 2017).

Specific HRV measures may be applied to firefighters fulfilling different duties who may experience different physiological or psychological stressors. This may provide valuable feedback when firefighters are performing fire suppression for extended periods of time and the risk of heat exhaustion is increased.

## Psychological Stress and Heart Rate Variability

As previously discussed, firefighting is a psychologically demanding occupation where firefighters are routinely exposed to life threatening situations. This requires firefighters to make spontaneous life or death decisions, perform emergency recusation, and are regularly the first responders on site to attend to vehicle collisions and other traumatic events. Research has indicated that these high stress situations are related to the development and progression of cardiovascular conditions (Carpenter et al., 2015; Gaughan et al., 2014; Smith, DeBlois, et al., 2016). These stressors that cause increased psychological load may cause increased sympathetic activation, as firefighters are in a constant state of anxiety or fear. Eventually, these stressors cause long term psychological conditions such as post-traumatic stress disorders, depression, and mental burnout (Liao et al., 2014; Shin et al., 2016; Yook, 2019). The increased sympathetic stimulation manifests as a decrease in HRV and may indicate firefighters that are experiencing severe psychological load and may need professional therapy to remain psychologically fit for active duty.

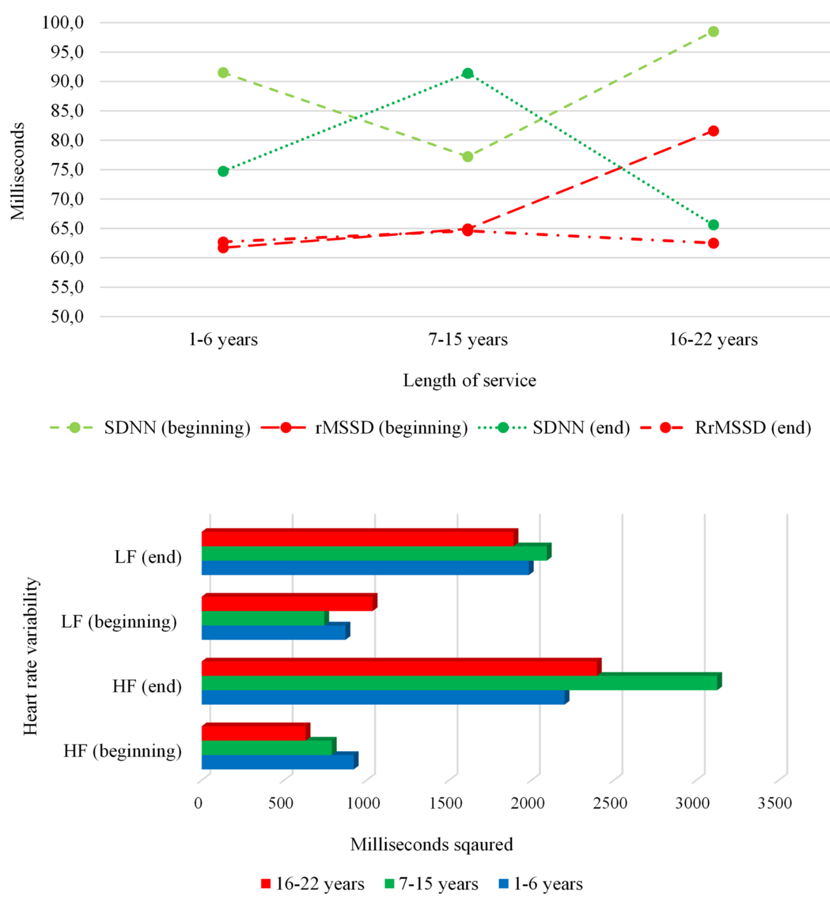
Pluntke et al. (2019) investigated the relationship between physical and psychological stress in seven firefighters using HRV. In the study, the researchers used a Polar H7 heart rate monitor and the Elite-HRV app to visually monitor, in real-time, the data streaming. The study reported that HRV was very accurate and reliable in identifying stress inducing factors and would be particularly useful in high stress occupations such as fire suppression, and particularly useful in detecting physical and mental stress. The researchers developed a model to accurately detect and classify physical and mental stress using HRV analysis in real-time. This was developed using a low cost unintrusive technology that did not hinder firefighter activity/mobility during the simulation course (Pluntke et al., 2019). However, another study conducted on similar variables contradicted these results, where the study reported that occupational stress was not significantly related to HRV in firefighters (Yook, 2019).

Age may be a compounding factor in this, nonetheless, firefighters with more years of experience have higher prevalence's of cardiovascular health risks, mental illnesses, and poor work ability (Airila, Hakanen, Punakallio, Lusa, & Luukkonen, 2012; Bucala & Sweet, 2019; Firoozeh, Saremi, Kavousi, & Maleki, 2017; Negm et al., 2017; Ras, Mosie, Strauss, & Leach, 2021; Saremi, fallah, Laal, Noorizade, & Rahimi, 2019). Vlasenko (2020) investigated the relationship between complex visual-motor reactions, HRV and length of service in firefighters exposed to varying workloads. The researchers used the Kredo diagnostic complex to monitor HRV. The study noted that HRV parameters were significantly different at the beginning of the work shift compared to the end of the shift. At the end of the shift, an increase in vagal effects was noted in all the service length groups. However, firefighters with 7-18 years of service experienced the most significant alterations in HRV measures (Figure 10). This suggested that all firefighters are at risk for altered HRV, regardless of age or experience levels. Firefighters may benefit from HRV monitoring that are routinely exposed to high workloads, are aged (40 years and older) and have spent an extended period as firefighters. Coincidentally, these are the demographic characteristics of firefighters that most often have underlying cardiovascular and musculoskeletal health concerns (Frost et al., 2015; Ras & Leach, 2021; Smith et al., 2013, 2019; Smith, DeBlois, et al., 2016; Soteriades, Smith, et al., 2011).

Marcel-Millet et al. (2021) investigated the psychophysiological responses of firefighters to day and night shifts using HRV. The researchers used the Hexoskin® suit to monitor HRV while performing an intermittent fitness test. Thereafter, firefighters completed the same simulated rescue intervention under three different conditions; firstly, during the day, in the morning, with a sound alarm signal (DaySA); secondly, during the night with a sound alarm signal (NightSA); and thirdly, during the night with a vibrating alarm signal (NightVA). The study by Marcel-Millet et al. (2021) reported all the HRV indices were lower in the NightSA condition in comparison to the DaySA condition. Heart rate reactivity was lower in the DaySA condition in comparison to the NightSA condition and was also lower in the NightVA condition in comparison to the NightSA condition. Additionally, they found that firefighters had a higher stress response to alarm signals during night-time simulation performance, compared to during the day. Parasympathetic reactivation after the simulation was more impaired in the night in comparison to the day. From the results of the study, night shift or 24-hour shifts may pose increased stress on firefighters and firefighters may benefit from these extended working periods or shift work. The study indicated that during night-time the risk for impaired autonomic control may be significantly increased. Night-time monitoring of HRV may prove useful to discern firefighters who are stressed, fatigued or sleepy or sluggish, which may negatively impact performance.

Susana Rodrigues, Paiva, Dias, & Cunha (2018), investigated HRV during a conventional shift week. Heart rate variability was measured using a VitalJacket® and data was collected onto a smartphone using a software application designed for the VitalJacket®. The study used the AVNN heart beats and the LF/HF ratio. The results showed that fires were the most common emergency, however, accidents were the more stressful situation, causing abnormalities in HRV. Fire services often divide the core duties of firefighters, where many firefighters would attend to accident scenes the majority of their monthly

*Figure 12. Heart rate variability and length of service*

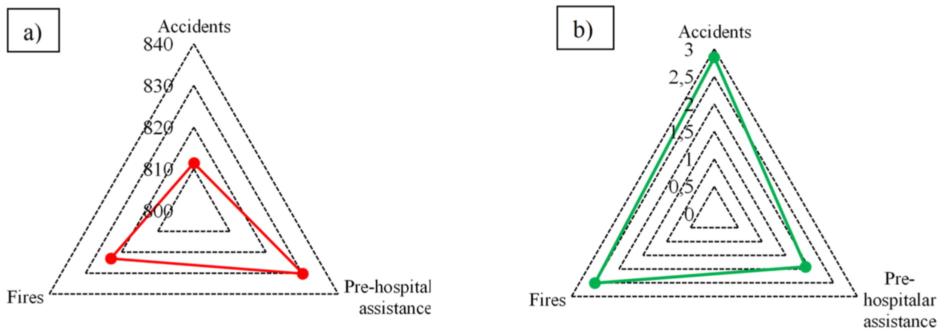



shifts (Rodrigues, et al. 2018). This would cause significant psychological strain and may account for the high prevalence of mental illness in firefighters. The use of HRV to monitor workloads in firefighters, especially during pre and post shift provides valuable information in monitoring the physiological strain firefighters experience during that particular shift. This may allow firefighters to start using flexible shifts, where firefighters that were physically overloaded on a particular shift may benefit from having a longer break between subsequent shifts.

## Cognitive Performance and Heart Rate Variability

Cognitive performance is essential for acceptable occupational performance and decision making. Mental fatigue or reduced cognitive performance may prove detrimental for firefighter decision making, particularly when placed in stressful situations. Susana Rodrigues, Paiva, Dias, Pimentel, et al. (2018) investigated the applicability of using HRV to monitor the influence of stress on cognitive performance in firefighters using the VitalJacket® connected to a smartphone application. They used the Trier Social

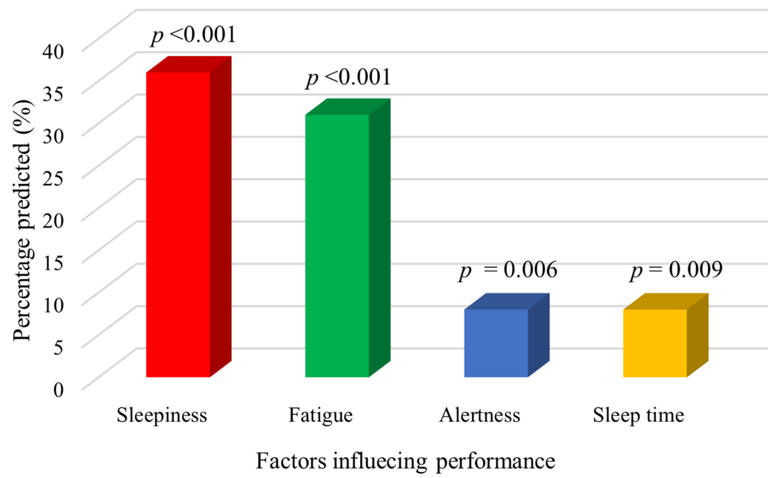
*Figure 13. The difference in heart rate variability between emergency duties. a) represents AVNN in milliseconds and b) represents LF/HF ratio*




Stress Test and the 2-Choice Reaction Time Task to assess the relationship between stress, cognitive performance, and HRV. The results indicated that stress induced tasks resulted in a decrease in HRV (AVNN, SDNN and LF/HF) and was related to a decrease in cognitive performance in firefighters. Heart rate variability may provide a valuable intermediate measure to discern firefighters at risk for stress induced cognitive impairment while on duty. Another study by Susana Rodrigues, Dias, et al. (2018) investigated the relationship between stress on a typical work shift and HRV in firefighters. Similar to the previous study, the authors used the VitalJacket® to record HRV data. The researchers used AVNN, SDNN RMSSD, pNN50 and LF/HF to retrieve HRV data. The study reported that stress was significantly related to all HRV indices, and that stress significantly increased throughout firefighters shifts. Often, firefighters work double shifts, and following the general trend of the study by Rodrigues et al. would indicate that the double shifts would cause significant psychophysiological stress in firefighters (Chappel, Aisbett, Vincent, & Ridgers, 2016; Jang, Jeong, Ahn, & Choi, 2020).

Similarly, Jeklin et al. (2021) investigated the relationship between HRV and indices of fatigue, total sleep time, and reaction time in ten firefighters. The researchers used a Polar H7 heart rate monitor and a smartphone application (Elite HRV®) to monitor HRV. The computer software program Kubios HRV 2.2 was used to analyze the HRV data. Reaction time was measured using three tasks, i.e., simple reaction time (SRT), choice reaction time (CRT), and discrimination reaction time (DRT), and administered using E-prime software Version 3.0 on an ASUS tablet. Sleep was objectively measured using a triaxial actigraph/accelerometer, and levels of fatigue, alertness, and sleepiness were measured subjectively using visual analogue scales (VAS). The study reported that there was no significant relationship between reaction time and HRV, however, HRV had a significant association between sleepiness, feelings of fatigue alertness and total sleep time. The study noted that HRV was a significant predictor of sleepiness (36%), fatigue (31%), alertness (8%) and sleep time (8%). No significant association was found between HRV and cognitive performance. Previous studies on HRV and reaction time indicated that reduced HRV decreased reaction time. However, in the study by Jeklin et al., there were no such relationships present. This may be due to the small sample size, and large-scale studies may provide different results.

*Figure 14. Prediction of factors influencing performance in firefighters*



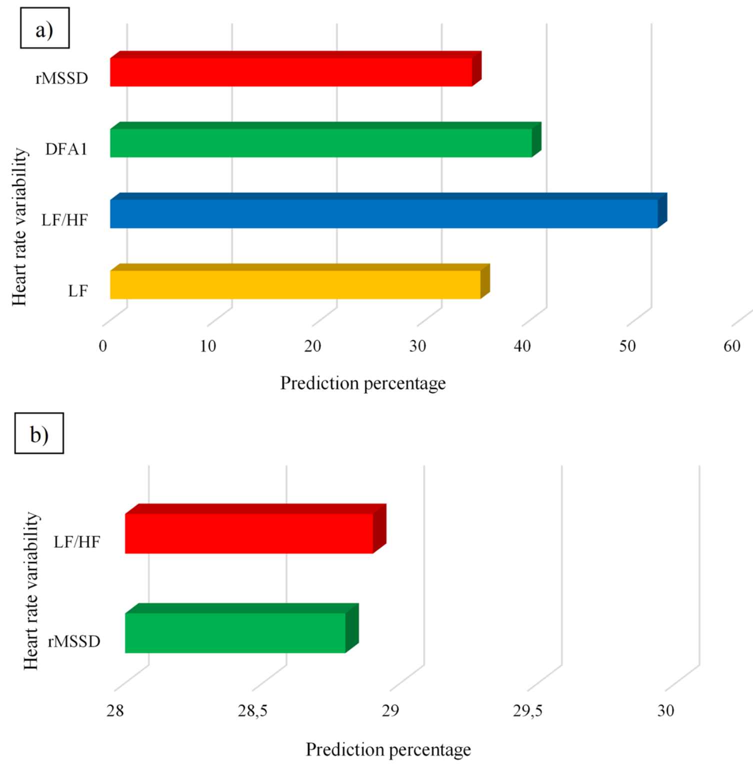

## Risk Taking Behavior and Heart Rate Variability

Risk taking behavior is an important facet of firefighters that are routinely exposed to dangerous situations. Firefighters are at a higher risk for injury, or worse, in the instance that poor decisions were made while in these dangerous or life threatening situations Prell et al. (2020) investigated the relationship between HRV, risk taking behavior and resilience in firefighters. The Polar RS800CX (Polar Electro Oy, Kempele, Finland) heart rate monitor was used to record HRV, and to assess risk taking, resilience, and subjective stress, the risk-taking scale, the Resilience Scale and the multi-dimensional NASA-Task Load Index (NASA-TLX) were used, respectively. The study found that increased stress negatively affected heart rate variability, and that risk taking behavior increased as HRV decreased, indicating sympathetic dominance, and resilience was positively associated with an increase in HRV. These results indicated that firefighters that are under more stress, and have a low HRV, are more likely to make poor decisions on duty, which may cause harm to themselves or civilians. Although having a high HRV may indicate good cardiovascular and physical health, it also indicates good mental resilience in firefighters (Prell et al., 2020). In Figure 13a, LF/HF ratio had the highest prediction value of risk-taking behavior. This is expected as a ratio toward high frequency dominance indicates firefighters are more stressed and can account for the increased risky behavior in emergency situations. Healthier psychological coping mechanisms during stressful situations, and better decision making may reduce serious injuries in firefighters, as well as increase the work efficiency of firefighters. Monitoring HRV on duty, prior and during emergency situations, become increasingly important when ensuring good decision making by firefighters, especially when lives may be at risk.

## Resilience and Heart Rate Variability

Firefighters are routinely exposed to traumatic events on duty which negatively affect their mental health. The ability of firefighters to cope with these traumatic events is known as resilience. Firefighters with higher resilience have better coping mechanisms, assisting in reducing the incidence of post-traumatic stress disorders, depression, and mental burnout. If firefighters develop their resilience, their HRV will be higher, and as a result, their decision making may improve in high-risk situations while on duty. Although resilience is a very important aspect of long-term mental health in firefighters, the ability of firefighters to adapt mentally to varying stress inducing situations may prove invaluable.

*Figure 15. Predicting risk-taking behavior using heart rate variability*




Schwerdtfeger & Dick (2019) investigated the psychophysiological concomitants of resilience, particularly related to HRV in every-day life in firefighters, who are routinely exposed to stressful work environments. The researchers measured psychological and contextual variables in daily life using the smartphone application movisensXS (movisens, Karlsruhe, Germany), resilience was assessed using the resilience scale, RS-25, and HRV was measured using a portable ECG that recorded continuously throughout a 24-hour work shift. Heart rate variability was analyzed using RMSSD, SDNN, LF and HF. The study notes that stressful incidents predicted reductions in both RMSSD and HF-HRV. Firefighters that had higher levels of resilience had lower negative emotions during varying stressful situations. Stressful situations were also related to reduced RMSSD, indicating that firefighters experienced vagal withdrawal and autonomic dysregulation during stressful situations (Schwerdtfeger & Dick, 2019). Firefighters that had the ability to rapidly withdraw vagal effect was a positive and protective adaptive response to the stressors placed upon them, possibly protecting their physical health in strenuous and stressful situations (Schwerdtfeger & Dick, 2019). A study reported that HRV was significantly associated with resilience in firefighters, particularly LF/HF ratio and rMSSD (Prell et al., 2020)(Figure 13b). Although having a high HRV may indicate good cardiovascular and physical health, it also indicates good mental resilience in firefighters, to allow better coping during stressful situations, and better decision making. Monitoring HRV on duty, prior and during emergency situations become increasingly important when ensuring good decision making by firefighters when in life threatening emergency situations.

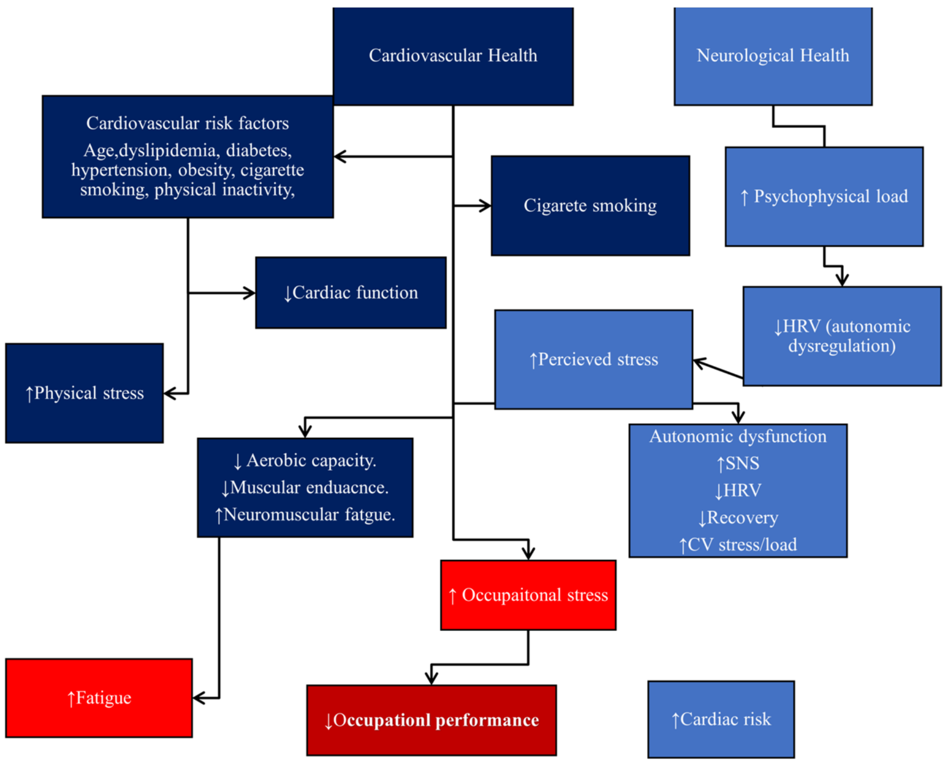
Although resilience is an important aspect in firefighters coping strategies to the strenuous conditions that they routinely face, measuring this stress while firefighters are on-duty may be an important in determining those firefighters with high perceived stress based on their movements and HRV measures while on duty. Meina et al. (2020) examined the relationship between HRV and accelerometery to determine the perceived stress levels during a 24-hour work shift in 43 firefighters. The researchers used a researcher generated questionnaire, specifically designed to assess firefighters perceived stress and HRV was monitored using Equivital™ EQ-02 Life Monitor sensor belts and calculated using time domain measures, such as SDNN and rMSSD among others. The study reported that HRV was significantly related to perceived stress and motion in firefighters. The higher movements while on shift were generally related to lower HRV.

The use of HRV in firefighters, while on duty, provides a valuable psychological screening tool, where stressed induced mental fatigue may be pre-emptively noticed, and safety precautions made. In addition, the use of HRV may be used as a real time psychological and physiological monitoring system in firefighters to discriminate symptoms of chronic and acute stress in firefighters (Meina et al., 2020). Firefighters with low HRV may be at higher risk for risky behavior in emergency situations, have increased fatigue and sleepiness and reduced reaction time (Hom et al., 2016; Jeklin et al., 2021; Meina et al., 2020; Prell et al., 2020; Schwerdtfeger & Dick, 2019; Vincent et al., 2017). Future research should be conducted on establishing clear guidelines and cut-off values to indicate mental fitness for duty using this new developing technology.

## Theoretical Underpinnings Explaining the Relationship Between Coronary Artery Disease Risk Factors and Heart Rate Variability in Firefighters

Figure 16 highlights the relationship between cardiovascular, psychological health and HRV in firefighters, and is based on the previous literature discussed in the chapter. Individually, all the factors that negatively affect cardiovascular health and also affect HRV in firefighters (Mehta, 2015; Schuster et al., 2016; Sessa et al., 2018; Tomes et al., 2020). This is due to the increased physiological stress with increased number of risk factors, and the increased inflammatory responses associated with these risk factors. The combination of deteriorating cardiovascular health and reduced HRV may indicate firefighters that are not ready for active duty and may have high risk cardiovascular abnormalities present (S. Al-Zaiti et al., 2015; S. S. Al-Zaiti & Carey, 2015; Soteriades, Targino, et al., 2011). The increased cardiovascular strain and sympathetic nervous system stimulation significantly reduces cardiorespiratory capacity and muscular endurance, potentially leading to premature fatigue while on duty. Needless to say, this poses a significant risk for firefighters themselves, but also the civilians they have sworn to protect. The psychological stress and its relation to physiological health is often overlooked in relation to its influence on fatigue, occupational performance, and cardiac risk in firefighters. In the diagram, we can see the effect that increased psychological load has on HRV, which stimulates the body's fight or flight response, and increasing SNS activation. The increasing SNS stimulation, and reduced HRV, augments the cardiovascular load for the duration of fire suppression and other emergency duties and, in turn, adversely effects their cardiovascular recovery post fire suppression (S. Al-Zaiti et al., 2015; Ebersole et al., 2020; Lyytikäinen et al., 2017; Qiu et al., 2017). The subtle physiological changes, although small, significantly increase firefighters' risk for cardiac events while on duty. Heart rate variability may also be used as a means to monitor chronic fatigue and psychophysiological burnout in firefighters. Chronic fatigue and psychophysiological stress would manifest as low HRV in the absence of any pathological conditions present. The use of HRV to monitor fatigue and psychophysiological stress may be most appropriate in middle-aged firefighters, where chronic fatigue and burnout seem to be most prominent (Vaulerin, d'Arripe-Longueville, Emile, & Colson, 2016).

*Figure 16. Flow diagram illustrating the possible relationship between CAD and HRV in firefighters*




## Physiological Factors Affecting Heart Rate Variability and Occupational Performance

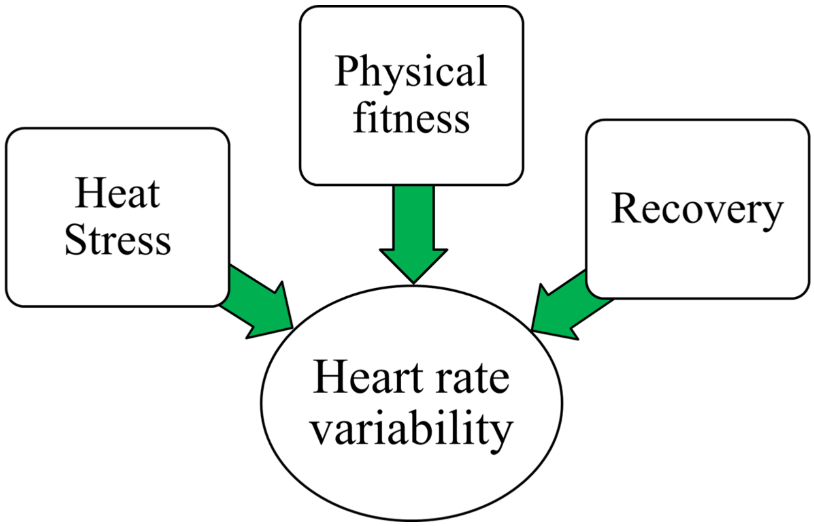
As previously mentioned, physical fitness is an important factor that affects HRV in firefighters, either positively or negatively. Improved physical fitness will reduce the cardiovascular and physical stress experienced by firefighters during vigorous intensity activities (Marcel-Millet et al., 2020; Porto et al., 2019; Yook, 2019). Heat stress is an external factor that augments the physiological load experienced by firefighters, causing a decrease in HRV that remains depressed for an extended period of time post activity (Schlicht et al., 2018; Smith, Horn, Woods, Ploutz-Snyder, & Fernhall, 2016; Vincent et al., 2017). It was reported that increased physical fitness was related to better thermal regulation when exposed to heat stress (Havenith & van Middendorp, 1990). The improved physical fitness may reduce the negative heat stress that firefighters experience. This is related to improved vascular functioning and improved thermoregulatory abilities (Larsen et al., 2015; Schlicht et al., 2018; Vincent et al., 2017). Physical activity led to increased heat production as a by-product of energy metabolism (Havenith & van Middendorp, 1990; Larsen et al., 2015). For any given load, fitter firefighters will cope much better and have lower energy requirements, resulting in lower heat production compared to unfit firefighters. The lower internal heat produced by fitter firefighters will lessen the physiological strain during fire suppression duties. To the same extent, heat stress experienced by unfit firefighters will be augmented by the increased metabolic heat production in combination with the external heat stress (Havenith & van Middendorp, 1990; Larsen et al., 2015). Physical fitness also has a direct relationship to recovery in firefighters. Fitter firefighters' recovery is faster after all stressors that are placed upon them (Ebersole et al., 2020; Lyytikäinen et al., 2017). Improved recovery enhanced vagal reactivation, autonomic regulation, and thermoregulatory recovery post fire suppression (Marcel-Millet et al., 2020, 2018). Improved recovery after emergency duties may well allow better performance on concurrent strenuous emergency situations. With the use of HRV, heat stress, physical health and recovery can easily be monitored while firefighters are on duty. Resting HRV will be much higher in fitter firefighters, lower in unfit firefighters, and could be used as an early screening system for those firefighters, specifically. The physiological stress of heat on firefighters may be monitored while firefighters are inundated by fire suppression duties, and recovery post fire suppression, can be monitored when firefighters have completed their duties. Poorer recovery, increased HRV depression due to heat stress and reduced physical fitness manifesting as depressed HRV can be used as an early warning system to indicate firefighters at risk for injury while on duty.

Depressed HRV is related to reduced decision-making ability in firefighters (Clifford et al., 2019; Prell et al., 2020; Schwerdtfeger & Dick, 2019). In addition, when HRV was depressed, firefighters would have riskier behavior on duty (Prell et al., 2020). This could be partially due to the increased fatigue caused by reduced HRV as a result of the increased cardiovascular strain (Marcel-Millet et al., 2020; Pluntke et al., 2019; Shin et al., 2016). Moreover, increased fatigue has been shown to reduce decision making ability (Dennison, Mullineaux, Yates, & Abel, 2012; Jeklin et al., 2021; Prell et al., 2020). Not only does higher fatigue cause poorer decision-making abilities in firefighters, but may also cause reduced physical performance while engaging in vigorous intensity duties. Premature fatigue is particularly detrimental to performance of their duties and may increase the damage to property and risk of injury and loss of life of civilians. Due to increased fatigue, performance of their duties may be significantly and negatively affected (Dennison et al., 2012; Nazari et al., 2018). Depressed HRV may adversely affect muscular force production and cardiorespiratory capacity, reducing occupational performance on duty (Dennison et al., 2012; Porto et al., 2019; Schmit & DeBeliso, 2019; Siddall, Stevenson, Turner, & Bilzon, 2018). The increased time taken to execute their duties may significantly increase the spread of fires and damage to property, and the risk of severe injury or death of citizens. From the literature, monitoring HRV may assist in reducing the possibility of firefighters at risk for increased risk-taking behavior, fatigue, and suboptimal occupational performance.

## SOLUTIONS AND RECOMMENDATIONS

Though HRV is a relatively new technology, it has many applications and the research interest and practicality of its use in firefighters has grown substantially. It is recommended that health policy makers and the health care industry advance the case for and adopt the use of HRV technology, such as ECG

*Figure 17. Physiological factor impacting heart rate variability and occupational performance in firefighters*




smartwatches and chest straps to regularly monitor the cardiovascular health in firefighters that may be at high cardiovascular, physical, and psychological risk. Initially, those firefighters at the highest risk of suboptimal occupational performance should be monitored, and thereafter, the mobile technology should be made more freely available to all firefighters. Because of the advancements of technology and the relatively low cost of monitoring HRV in firefighters, should, in theory, be easily implemented, particularly in the younger firefighter generation. In addition, this will assist in the early detection of firefighters at risk for suboptimal occupational performance, reducing the likelihood of damage to property and civilian casualties. Moreover, this will assist in lowering the long-term costs associated with injuries, missed workdays, and medical treatment associated with the occupation, and in the long term, reduce the incidence of early retirement and on-duty fatalities in firefighters.

## FUTURE RESEARCH AND INNOVATION

Future research should investigate on a longitudinal level, the use of HRV to screen the cardiovascular health of firefighters, as a means to predict physical fitness and musculoskeletal health in firefighters, as a relatively cost-effective assessment tool in firefighters. In addition, research should investigate the applicability of using this technological tool in firefighter psychophysiological stress monitoring and fitness for duty. More research should be conducted on non-invasive applications on using these mobile devices on and with firefighters, which is comfortable and does not infringe on work performance. A study conducted by (Dąbrowska, Bartkowiak, & Kotas, 2021) investigated the use of a warning system installed into smart protective clothing developed for firefighters. Although the results are promising, the research is still in its infancy, and future research should investigate the applicability of implementing mobile and wearable technology, which monitors firefighters' vital signs, in real time, which would, in theory, reduce duty related fatalities.

## Strengths and Practical Applications of Mobile Technology in Firefighters

This chapter illustrates the usefulness of technology in firefighters, especially for monitoring physical and psychological load. The chapter has highlighted the possibility in monitoring increased cardiovascular load in emergency situations in firefighters. In addition, the chapter has highlighted the use of mobile technology in monitoring the physical fitness levels and the psychological load in firefighters, which negatively affect their physical health, decision making ability and likelihood of risky behavior while on duty. In addition, the progressive nature of technology and research have highlighted future uses of technology in firefighters, specifically for monitoring pulmonary function, energy consumption and recovery. In a practical sense, this allows firefighters to be monitored continuously while in emergency situations, and to use HRV as an early warning system for those firefighters at increased risk for cardiovascular or psychological health concerns. Although using technology in firefighters is still in its incipiency, it provides the basis of developing an advanced monitoring system in firefighters to ensure firefighters continue to be fit and are ready for active duty.

## CONCLUSION

Firefighters adopting to the use of technology has been a slow progression in the literature. Partly due to firefighters' attitudes toward not having aids to assist with their physiological monitoring on duty and the reluctance of older firefighters to adopt newer technology. Heart rate variability is a versatile technology with a plethora of uses, particularly in monitoring the cardiovascular strain as a result of firefighting and recovery post-fire suppression. In addition, HRV may be used as a monitoring system for firefighters that are categorized as high risk. Future research should focus on conducting longitudinal studies investigating the applicability of using this new technology on firefighters while on duty, both from a practical and a financial standpoint. Technology use in high-risk emergency occupations is the future and use of these technologies to ensure career health and wellness are inevitable.

## REFERENCES

Acharya, U. R., Joseph, K. P., Kannathal, N., Lim, C. M., & Suri, J. S. (2006). Heart rate variability: A review. *Medical & Biological Engineering & Computing*, *44*(12), 1031–1051. doi:10.100711517-006-0119-0 PMID:17111118

Airila, A., Hakanen, J., Punakallio, A., Lusa, S., & Luukkonen, R. (2012). Is work engagement related to work ability beyond working conditions and lifestyle factors? *International Archives of Occupational and Environmental Health*, *85*(8), 915–925. doi:10.100700420-012-0732-1 PMID:22270385

Al-Zaiti, S., Rittenberger, J. C., Reis, S. E., & Hostler, D. (2015). Electrocardiographic Responses during Fire Suppression and Recovery among Experienced Firefighters. *Journal of Occupational and Environmental Medicine*, *57*(9), 938–942. doi:10.1097/JOM.0000000000000507 PMID:26340281

Al-Zaiti, S. S., & Carey, M. G. (2015). The prevalence of clinical and electrocardiographic risk factors of cardiovascular death among on-duty professional firefighters. *The Journal of Cardiovascular Nursing*, *30*(5), 440–446. doi:10.1097/JCN.0000000000000165 PMID:24874885

Almeida-Santos, M. A., Barreto-Filho, J. A., Oliveira, J. L. M., Reis, F. P., da Cunha Oliveira, C. C., & Sousa, A. C. S. (2016). Aging, heart rate variability and patterns of autonomic regulation of the heart. *Archives of Gerontology and Geriatrics*, *63*, 1–8. doi:10.1016/j.archger.2015.11.011 PMID:26791165

Andersen, M. H. G., Saber, A. T., Pedersen, P. B., Loft, S., Hansen, Å. M., Koponen, I. K., Møller, P. (2017). Cardiovascular health effects following exposure of human volunteers during fire extinction exercises. *Environmental Health: A Global Access Science Source, 16*(1), 1–9. doi:10.1186/s12940-017-0303-8

Baur, D. M., Christophi, C. A., Tsismenakis, A. J., Cook, E. F., & Kales, S. N. (2011). *Cardiorespiratory Fitness Predicts Cardiovascular Risk Profiles in Career Firefighters. 53*(10), 1155–1160. doi:10.1097/JOM.0b013e31822c9e47

Baur, D. M., Christophi, C. A., Cook, E. F., & Kales, S. N. (2012). Age-related decline in cardiorespiratory fitness among career firefighters: Modification by physical activity and adiposity. *Journal of Obesity*, *2012*, 1–6. Advance online publication. doi:10.1155/2012/710903 PMID:22666557

Baur, D M, Leiba, A., Christophi, C. A., & Kales, S. N. (2012). Low fitness is associated with exercise abnormalities among asymptomatic firefighters. Occupational Medicine. doi:10.1093/occmed/kqs112

Biéchy, J. P., Charissou, C., Gobert, S., Verdier, J. C., Castel-Lacanal, E., Amarantini, D., & Fautrelle, L. (2021). The combination of deep breathing and mental imagery promotes cardiovascular recovery in firefighters. *Ergonomics*, *64*(10), 1231–1242. doi:10.1080/00140139.2021.1916606 PMID:33899680

Billman, G. E., Huikuri, H., Sacha, J., & Trimmel, K. (2015). An introduction to heart rate variability: Methodological considerations and clinical applications. *Frontiers in Physiology*, *6*(February), 2013–2015. doi:10.3389/fphys.2015.00055 PMID:25762937

Bonnell, E., Huggins, C., Huggins, C., McCaffrey, T., Palermo, C., & Bonham, M. (2017). Influences on Dietary Choices during Day versus Night Shift in Shift Workers: A Mixed Methods Study. *Nutrients*, *9*(3), 193. doi:10.3390/nu9030193 PMID:28245625

Bucala, M., & Sweet, E. (2019). Obesity in the fire service: An inside look at the perceptions of firefighters towards obesity and other health issues. Research Square., doi:10.21203/rs.2.15518/v1

Bugajska, J., Zużewicz, K., Szmauz-Dybko, M., & Konarska, M. (2007). Cardiovascular stress, energy expenditure and subjective perceived ratings of fire fighters during typical fire suppression and rescue tasks. *International Journal of Occupational Safety and Ergonomics*, *13*(3), 323–331. doi:10.1080/10803548.2007.11076730 PMID:17888240

Caminal, P., Sola, F., Gomis, P., Guasch, E., Perera, A., Soriano, N., & Mont, L. (2018). Validity of the Polar V800 monitor for measuring heart rate variability in mountain running route conditions. *European Journal of Applied Physiology*, *118*(3), 669–677. doi:10.100700421-018-3808-0 PMID:29356949

Carey, M. G., Al-Zaiti, S. S., Dean, G. E., Sessanna, L., & Finnell, D. S. (2011). Sleep problems, depression, substance use, social bonding, and quality of life in professional firefighters. *Journal of Occupational and Environmental Medicine*, *53*(8), 928–933. doi:10.1097/JOM.0b013e318225898f PMID:21785370

Carlén, A., Nylander, E., Åström Aneq, M., & Gustafsson, M. (2019). ST/HR variables in firefighter exercise ECG – relation to ischemic heart disease. *Physiological Reports*, *7*(2), 1–10. doi:10.14814/phy2.13968 PMID:30688031

Carpenter, G. S. J., Carpenter, T. P., Kimbrel, N. A., Flynn, E. J., Pennington, M. L., Cammarata, C., Zimering, R. T., Kamholz, B. W., & Gulliver, S. B. (2015). Social support, stress, and suicidal ideation in professional firefighters. *American Journal of Health Behavior*, *39*(2), 191–196. doi:10.5993/AJHB.39.2.5 PMID:25564831

Chandel, R. S., Sharma, S., Kaur, S., Singh, S., & Kumar, R. (2021). Smart watches: A review of evolution in bio-medical sector. *Materials Today: Proceedings*.

Chappel, S. E., Aisbett, B., Vincent, G. E., & Ridgers, N. D. (2016). Firefighters' Physical Activity across Multiple Shifts of Planned Burn Work. *International Journal of Environmental Research and Public Health*, *13*(10), 973. Advance online publication. doi:10.3390/ijerph13100973 PMID:27706057

Choi, B., Ko, S., & Kojaku, S. (2017). Resting heart rate, heart rate reserve, and metabolic syndrome in professional firefighters: A cross-sectional study. *American Journal of Industrial Medicine*, *60*(10), 900–910. doi:10.1002/ajim.22752 PMID:28869309

Chuang, C., Chung, W., Shu, C., & Chen, M. (2007). Pain Assessment in Musculoskeletal Pain Patients by Heart Rate Variability. Journal of Musculoskeletal Pain. doi:10.1300/J094v15n04

Cilhoroz, B., Zaleski, A., Taylor, B., Fernhall, B., Chen, M., Thompson, P., & Pescatello, L. (2021). The ambulatory blood pressure and heart rate variability responses following sudden vigorous physical exertion among firefighters with hypertension [Hipertansiyonlu itfaiyeciler arasında ani yü ksek şiddetli fiziksel efor sonrası ambulatuvar kan basıncı]. *Turkish Journal of Sports Medicine*, *56*(3), 98–105. doi:10.47447/tjsm.0492

Clifford, R. M. S., Jung, S., Hoerrnann, S., Billinqhurst, M., & Lindeman, R. W. (2019). Creating a stressful decision making environment for aerial firefighter training in virtual reality. *26th IEEE Conference on Virtual Reality and 3D User Interfaces, VR 2019 - Proceedings*, 181–189. 10.1109/VR.2019.8797889

Cullen, S., O'Loughlin, G., McGoldrick, A., Smyth, B., May, G., & Warrington, G. D. (2015). Physiological Demands of Flat Horse Racing Jockeys. *Journal of Strength and Conditioning Research*, *29*(11), 3060–3066. doi:10.1519/JSC.0000000000000977 PMID:25932980

Dąbrowska, A., Bartkowiak, G., & Kotas, R. (2021). Evaluation of Functionality of Warning System in Smart Protective Clothing for Firefighters. *Sensors (Basel)*, *21*(5), 1767. Advance online publication. doi:10.339021051767 PMID:33806399

Dennison, K. J., Mullineaux, D. R., Yates, J. W., & Abel, M. G. (2012). The Effect of Fatigue and Training Status on Firefighter Performance. *Journal of Strength and Conditioning Research*, *26*(4), 1101–1109. doi:10.1519/JSC.0b013e31822dd027 PMID:22446677

Dobson, M., Choi, B., Schnall, P. L., Wigger, E., Garcia-Rivas, J., Israel, L., & Baker, D. B. (2013). Exploring Occupational and Health Behavioral Causes of Firefighter Obesity: A Qualitative Study. *American Journal of Industrial Medicine*, *56*(7), 776–790. doi:10.1002/ajim.22151 PMID:23335437

Donovan, G. (2009).. . *Validity and Reliability of Short-Term Heart-Rate Variability from the Polar*, *S810*(January). Advance online publication. doi:10.1249/MSS.0b013e318184a4b1

Ebersole, K. T., Cornell, D. J., Flees, R. J., Shemelya, C. M., & Noel, S. E. (2020). Contribution of the Autonomic Nervous System to Recovery in Firefighters. *Journal of Athletic Training*, *55*(9), 1001–1008. doi:10.4085/1062-6050-0426.19 PMID:32841323

Farioli, A., Yang, J., Teehan, D., Baur, D. M., Smith, D. L., & Kales, S. N. (2014). Duty-related risk of sudden cardiac death among young US firefighters. *Occupational Medicine*, *64*(6), 428–435. doi:10.1093/occmed/kqu102 PMID:25104277

Feairheller, D. L. (2015). Blood pressure and heart rate responses in volunteer firefighters while wearing personal protective equipment. *Blood Pressure Monitoring*, *20*(4), 194–198. doi:10.1097/MBP.0000000000000120 PMID:25856421

Firoozeh, M., Saremi, M., Kavousi, A., & Maleki, A. (2017). Demographic and occupational determinants of the work ability of firemen. *Journal of Occupational Health*, *59*(1), 81–87. doi:10.1539/joh.15-0296-FS PMID:27916763

Frost, D. M., Beach, T. A. C., Crosby, I., & McGill, S. M. (2015). Firefighter injuries are not just a fireground problem. *Work (Reading, Mass.)*, *52*(4), 835–842. doi:10.3233/WOR-152111 PMID:26409354

Gaughan, D. M., Siegel, P. D., Hughes, M. D., Chang, C. Y., Law, B. F., Campbell, C. R., Richards, J. C., Kales, S. F., Chertok, M., Kobzik, L., Nguyen, P., O'Donnell, C. R., Kiefer, M., Wagner, G. R., & Christiani, D. C. (2014). Arterial stiffness, oxidative stress, and smoke exposure in wildland firefighters. *American Journal of Industrial Medicine*, *57*(7), 748–756. doi:10.1002/ajim.22331 PMID:24909863

Gendron, P., Lajoie, C., Laurencelle, L., & Trudeau, F. (2018). Cardiovascular Disease Risk Factors in Québec Male Firefighters. *Journal of Occupational and Environmental Medicine*, *60*(6), e300–e306. doi:10.1097/JOM.0000000000001309 PMID:29461386

Havenith, G., & van Middendorp, H. (1990). The relative influence of physical fitness, acclimatization state, anthropometric measures and gender on individual reactions to heat stress. *European Journal of Applied Physiology and Occupational Physiology*, *61*(5), 419–427. doi:10.1007/BF00236062 PMID:2079061

Heesch, M. W. S., & Slivka, D. R. (2015). Running Performance, Pace Strategy, and Thermoregulation Differ Between a Treadmill and Indoor Track. *Journal of Strength and Conditioning Research*, *29*(2), 330–335. doi:10.1519/JSC.0000000000000662 PMID:25162647

Henriksen, A., Haugen Mikalsen, M., Woldaregay, A. Z., Muzny, M., Hartvigsen, G., Hopstock, L. A., & Grimsgaard, S. (2018). Using Fitness Trackers and Smartwatches to Measure Physical Activity in Research: Analysis of Consumer Wrist-Worn Wearables. *Journal of Medical Internet Research*, *20*(3), e110. doi:10.2196/jmir.9157 PMID:29567635

Hernández-Vicente, A., Hernando, D., Marín-Puyalto, J., Vicente-Rodríguez, G., Garatachea, N., Pueyo, E., & Bailón, R. (2021). Validity of the Polar H7 Heart Rate Sensor for Heart Rate Variability Analysis during Exercise in Different Age, Body Composition and Fitness Level Groups. *Sensors (Basel)*, *21*(3), 902. Advance online publication. doi:10.339021030902 PMID:33572800

Hernando, D., Roca, S., Sancho, J., Alesanco, Á., & Bailón, R. (2018). Validation of the Apple Watch for Heart Rate Variability Measurements during Relax and Mental Stress in Healthy Subjects. *Sensors (Basel)*, *18*(8), 2619. Advance online publication. doi:10.339018082619 PMID:30103376

Hinde, K., White, G., & Armstrong, N. (2021). Wearable Devices Suitable for Monitoring Twenty Four Hour Heart Rate Variability in Military Populations. *Sensors (Basel)*, *21*(4), 1061. Advance online publication. doi:10.339021041061 PMID:33557190

Hom, M. A., Stanley, I. H., Rogers, M. L., Tzoneva, M., Bernert, R. A., & Joiner, T. E. (2016). The association between sleep disturbances and depression among firefighters: Emotion dysregulation as an explanatory factor. *Journal of Clinical Sleep Medicine*, *12*(2), 235–245. doi:10.5664/jcsm.5492 PMID:26350604

Isakadze, N., & Martin, S. S. (2020). How useful is the smartwatch ECG? *Trends in Cardiovascular Medicine*, *30*(7), 442–448. doi:10.1016/j.tcm.2019.10.010 PMID:31706789

Ito, Y., Oka, Y., & Kuriyama, Y. (2020). Applicability of the Reflection Index of Respiration Based on Heart Rate Variability Analysis to Firefighting Activity. *Fire Science & Technology*, *39*(1), 1–15. doi:10.3210/fst.39.1

Jahnke, S. A., Poston, W. S. C., Jitnarin, N., & Haddock, C. K. (2012). Health Concerns of the U.S. Fire Service: Perspectives from the Firehouse. *American Journal of Health Promotion*, *27*(2), 111–118. doi:10.4278/ajhp.110311-QUAL-109 PMID:23113781

Jang, T. W., Jeong, K. S., Ahn, Y. S., & Choi, K. S. (2020). The relationship between the pattern of shift work and sleep disturbances in Korean firefighters. *International Archives of Occupational and Environmental Health*, *93*(3), 391–398. doi:10.100700420-019-01496-3 PMID:31768636

Jeklin, A. T., Perrotta, A. S., Davies, H. W., Bredin, S. S. D., Paul, D. A., & Warburton, D. E. R. (2021). The association between heart rate variability, reaction time, and indicators of workplace fatigue in wildland firefighters. *International Archives of Occupational and Environmental Health*, *94*(5), 823–831. Advance online publication. doi:10.100700420-020-01641-3 PMID:33426591

Johnson, Q. R., Goatcher, J. D., Diehl, C., Lockie, R. G., Orr, R. M., Alvar, B., ... Dawes, J. J. (2020). Heart rate responses during simulated fire ground scenarios among full-time firefighters. *International Journal of Exercise Science*, *13*(2), 374–382. PMID:32148623

Kuorinka, I., & Korhonen, O. (1981). Firefighters' reaction to alarm, an ECG and heart rate study. *Journal of Occupational Medicine. Official Publication of the Industrial Medical Association*, *23*(11), 762–766. doi:10.1097/00043764-198111000-00010 PMID:7320775

Larsen, B., Snow, R., & Aisbett, B. (2015). Effect of heat on firefighters' work performance and physiology. *Journal of Thermal Biology*, *53*, 1–8. doi:10.1016/j.jtherbio.2015.07.008 PMID:26590449

Lavie, C. J., Arena, R., Swift, D. L., Johannsen, N. M., Sui, X., Lee, D. C., Earnest, C. P., Church, T. S., O'Keefe, J. H., Milani, R. V., & Blair, S. N. (2015). Exercise and the cardiovascular system: Clinical science and cardiovascular outcomes. *Circulation Research*, *117*(2), 207–219. doi:10.1161/CIRCRESAHA.117.305205 PMID:26139859

Levels, K., de Koning, J. J., Foster, C., & Daanen, H. A. M. (2012). The effect of skin temperature on performance during a 7.5-km cycling time trial. *European Journal of Applied Physiology*, *112*(9), 3387–3395. doi:10.100700421-012-2316-x PMID:22270485

Liao, L.-M., Al-Zaiti, S. S., & Carey, M. G. (2014). Depression and heart rate variability in firefighters. *SAGE Open Medicine*, *2*. doi:10.1177/2050312114545530 PMID:26770735

Lyytikäinen, K., Toivonen, L., Hynynen, E., Lindholm, H., & Kyröläinen, H. (2017). Recovery of rescuers from a 24-h shift and its association with aerobic fitness. *International Journal of Occupational Medicine and Environmental Health*, *30*(3), 433–444. doi:10.13075/ijomeh.1896.00720 PMID:28481376

Malik, M., Bigger, J. T., Camm, A. J., Kleiger, R. E., Malliani, A., Moss, A. J., & Schwartz, P. J. (1996). Heart rate variability: Standards of measurement, physiological interpretation, and clinical use. *European Heart Journal*, *17*(3), 354–381. doi:10.1093/oxfordjournals.eurheartj.a014868 PMID:8737210

Marcel-Millet, P., Groslambert, A., Gimenez, P., Grosprêtre, S., & Ravier, G. (2021). Psychophysiological responses of firefighters to day and night rescue interventions. *Applied Ergonomics*, *95*(April), 103457. Advance online publication. doi:10.1016/j.apergo.2021.103457 PMID:33984583

Marcel-Millet, P., Ravier, G., Esco, M. R., & Groslambert, A. (2020). Does firefighters' physical fitness influence their cardiac parasympathetic reactivation? Analysis with post-exercise heart rate variability and ultra-short-term measures. *International Journal of Occupational Safety and Ergonomics*, 1–9. doi:10.1080/10803548.2020.1738689 PMID:32586212

Marcel-Millet, P., Ravier, G., Grospretre, S., Gimenez, P., Freidig, S., & Groslambert, A. (2018). Physiological responses and parasympathetic reactivation in rescue interventions: The effect of the breathing apparatus. *Scandinavian Journal of Medicine & Science in Sports*, *28*(12), 2710–2722. doi:10.1111ms.13291 PMID:30171784

Marciniak, R. A., Wahl, C. A., & Ebersole, K. T. (2021). Autonomic Nervous System Response to Far-Infrared Sauna Exposure in Firefighters. *Annals of Work Exposures and Health*. Advance online publication. doi:10.1093/annweh/wxab088 PMID:34632485

Mehta, R. K. (2015). Impacts of obesity and stress on neuromuscular fatigue development and associated heart rate variability. *International Journal of Obesity*, *39*(2), 208–213. doi:10.1038/ijo.2014.127 PMID:25042859

Meina, M., Ratajczak, E., Sadowska, M., Rykaczewski, K., Dreszer, J., Bałaj, B., Biedugnis, S., Węgrzyński, W., & Krasuski, A. (2020). Heart rate variability and accelerometry as classification tools for monitoring perceived stress levels—A pilot study on firefighters. *Sensors (Switzerland)*, *20*(10), 1–21. doi:10.339020102834 PMID:32429383

Morresi, N., Casaccia, S., Sorcinelli, M., Arnesano, M., & Revel, G. M. (2020). Analysing performances of heart rate variability measurement through a smartwatch. *2020 IEEE International Symposium on Medical Measurements and Applications (MeMeA)*, 1–6. 10.1109/MeMeA49120.2020.9137211

Navarro, K. M., Kleinman, M. T., Mackay, C. E., Reinhardt, T. E., Balmes, J. R., Broyles, G. A., Ottmar, R. D., Naher, L. P., & Domitrovich, J. W. (2019). Wildland firefighter smoke exposure and risk of lung cancer and cardiovascular disease mortality. *Environmental Research*, *173*(March), 462–468. doi:10.1016/j.envres.2019.03.060 PMID:30981117

Nazari, G., MacDermid, J. C., Sinden, K. E., & Overend, T. J. (2018). The Relationship between Physical Fitness and Simulated Firefighting Task Performance. *Rehabilitation Research and Practice, 2018*(2007), 1–7. doi:10.1155/2018/3234176

Negm, A., MacDermid, J., Sinden, K., D'Amico, R., Lomotan, M., & MacIntyre, N. J. (2017). Prevalence and distribution of musculoskeletal disorders in firefighters are influenced by age and length of service. *Journal of Military, Veteran and Family Health*, *3*(2), 33–41. doi:10.3138/jmvfh.2017-0002

Oka, Y., Sawaguchi, Y., Kuriyama, Y., & Ito, Y. (2021). Proposal for alert threshold for "stop activity" to improve firefighters' occupational safety based on heart rate variability analysis. *Safety Science*, *144*, 105449. doi:10.1016/j.ssci.2021.105449

Pillutla, P., Li, D., Ahmadi, N., & Budoff, M. J. (2012). Comparison of Coronary Calcium in Firefighters With Abnormal Stress Test Findings and in Asymptomatic Nonfirefighters With Abnormal Stress Test Findings. *The American Journal of Cardiology*. doi:10.1016/j.amjcard.2011.09.044

Plews, D. J., Scott, B., Altini, M., Wood, M., Kilding, A. E., & Laursen, P. B. (2017). Comparison of Heart-Rate-Variability Recording With Smartphone Photoplethysmography, Polar H7 Chest Strap, and Electrocardiography. *International Journal of Sports Physiology and Performance*, *12*(10), 1324–1328. doi:10.1123/ijspp.2016-0668 PMID:28290720

Pluntke, U., Gerke, S., Sridhar, A., Weiss, J., & Michel, B. (2019). Evaluation and Classification of Physical and Psychological Stress in Firefighters using Heart Rate Variability. *2019 41st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*, 2207–2212. doi:10.1109/EMBC.2019.8856596

Porto, L. G. G., Schmidt, A. C. B., de Souza, J. M., Nogueira, R. M., Fontana, K. E., Molina, G. E., Korre, M., Smith, D. L., Junqueira, L. F., & Kales, S. N. (2019). Firefighters' basal cardiac autonomic function and its associations with cardiorespiratory fitness. *Work (Reading, Mass.)*, *62*(3), 485–495. doi:10.3233/WOR-192883 PMID:30909264

Prell, R., Opatz, O., Merati, G., Gesche, B., Gunga, H. C., & Maggioni, M. A. (2020). Heart Rate Variability, Risk-Taking Behavior and Resilience in Firefighters During a Simulated Extinguish-Fire Task. *Frontiers in Physiology*, *11*(July), 1–11. doi:10.3389/fphys.2020.00482 PMID:32754042

Qiu, S., Cai, X., Sun, Z., Li, L., Zuegel, M., Steinacker, J. M., & Schumann, U. (2017). *Heart Rate Recovery and Risk of Cardiovascular Events and All-Cause*. doi:10.1161/JAHA.117.005505

Ras, J., & Leach, L. (2021). Prevalence of coronary artery disease risk factors in firefighters in the city of Cape Town fire and rescue service – A descriptive study. *Journal of Public Health Research, 10*(1). doi:10.4081/jphr.2021.2000

Ras, J., Mosie, D., Strauss, M., & Leach, L. (2021). Knowledge and attitude toward health and CVD risk factors among firefighters in Cape Town, South Africa. *Journal of Public Health Research*. Advance online publication. doi:10.4081/jphr.2021.2307 PMID:34351095

Robertson, A. H., Larivière, C., Leduc, C. R., McGillis, Z., Eger, T., Godwin, A., Larivière, M., & Dorman, S. C. (2017). Novel tools in determining the physiological demands and nutritional practices of Ontario firerangers during fire deployments. *PLoS One*, *12*(1), 40–50. doi:10.1371/journal.pone.0169390 PMID:28107380

Rodrigues, S., Dias, D., Paiva, J. S., & Cunha, J. P. S. (2018). Psychophysiological Stress Assessment among On-Duty Firefighters. *Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBS,* 4335–4338. doi:10.1109/EMBC.2018.8513250

Rodrigues, S., Dias, D., Paiva, J. S., & Cunha, J. P. S. (2018). Psychophysiological Stress Assessment Among On-Duty Firefighters. *2018 40th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*, 4335–4338. doi:10.1109/EMBC.2018.8513250

Rodrigues, S., Paiva, J. S., Dias, D., & Cunha, J. P. S. (2018). Stress among on-duty firefighters: An ambulatory assessment study. *PeerJ*, *6*, e5967. doi:10.7717/peerj.5967 PMID:30581658

Rodrigues, S., Paiva, J. S., Dias, D., Pimentel, G., Kaiseler, M., & Cunha, J. P. S. (2018). Wearable Biomonitoring Platform for the Assessment of Stress and its Impact on Cognitive Performance of Firefighters: An Experimental Study. *Clinical Practice and Epidemiology in Mental Health*, *14*(1), 250–262. doi:10.2174/1745017901814010250 PMID:30972123

Saremi, M., Fallah, R., Laal, F., Noorizade, N., & Rahimi, E. (2019). Assessment of mental workload, work ability and musculoskeletal disorders of firefighters. Journal of Community Health Research. doi:10.18502/jchr.v8i3.1562

Savall, A., Charles, R., Bertholon, A., Gramont, B., Trombert, B., Barthélémy, J. C., & Roche, F. (2020). Volunteer and career French firefighters: Cardiovascular risk factors and cardiovascular risk assessment. *European Journal of Preventive Cardiology*, *27*(1), 107–109. doi:10.1177/2047487319827463 PMID:30722684

Schlicht, E., Caruso, R., Denby, K., Matias, A., Dudar, M., & Ives, S. J. (2018). Effects of Wrist Cooling on Recovery From Exercise-Induced Heat Stress With Firefighting Personal Protective Equipment. *Journal of Occupational and Environmental Medicine*, *60*(11), 1049–00. doi:10.1097/JOM.0000000000001436 PMID:30188495

Schmit, M., & DeBeliso, M. (2019). The Relationship between Firefighters' Physical Performance Aspects and Simulated Firefighting Demands. *Turkish Journal of Kinesiology*, *5*(2), 63–75. doi:10.31459/turkjkin.560623

Schuster, A. K., Fischer, J. E., Thayer, J. F., Mauss, D., & Jarczok, M. N. (2016). Decreased heart rate variability correlates to increased cardiovascular risk. *International Journal of Cardiology*, *203*, 728–730. doi:10.1016/j.ijcard.2015.11.027 PMID:26587729

Schwerdtfeger, A. R., & Dick, K. (2019). Episodes of momentary resilience in daily life are associated with HRV reductions to stressful operations in firefighters: An ambulatory assessment approach using bayesian multilevel modeling. *The Journal of Positive Psychology*, *14*(5), 593–602. doi:10.1080/17439760.2018.1497689

Sessa, F., Anna, V., Messina, G., Cibelli, G., Monda, V., Marsala, G., Ruberto, M., Biondi, A., Cascio, O., Bertozzi, G., Pisanelli, D., Maglietta, F., Messina, A., Mollica, M. P., & Salerno, M. (2018). Heart rate variability as predictive factor for sudden cardiac death. *Aging (Albany NY)*, *10*(2), 166–177. doi:10.18632/aging.101386 PMID:29476045

Shaffer, F., & Ginsberg, J. P. (2017). An Overview of Heart Rate Variability Metrics and Norms. *Frontiers in Public Health*, *5*, 258. doi:10.3389/fpubh.2017.00258 PMID:29034226

Shaffer, F., Ginsberg, J. P., & Shaffer, F. (2017). An Overview of Heart Rate variability Metrics and Norms. Frontiers in Public Health. doi:10.3389/fpubh.2017.00258

Shin, J. H., Lee, J. Y., Yang, S. H., Lee, M. Y., & Chung, I. S. (2016). Factors related to heart rate variability among firefighters. *Annals of Occupational and Environmental Medicine*, *28*(1), 1–9. doi:10.118640557-016-0111-6 PMID:27298728

Siddall, A. G., Stevenson, R. D. M., Turner, P. J. F., & Bilzon, J. L. J. (2018). Physical and Physiological Performance Determinants of a Firefighting Simulation Test. *Journal of Occupational and Environmental Medicine*, *60*(7), 637–643. doi:10.1097/JOM.0000000000001313 PMID:29485491

Slattery, F., Johnston, K., Paquet, C., Bennett, H., & Crockett, A. (2018). The long-term rate of change in lung function in urban professional firefighters: A systematic review. *BMC Pulmonary Medicine*, *18*(1), 149. doi:10.118612890-018-0711-8 PMID:30189854

Smith, D. L., Barr, D. A., & Kales, S. N. (2013). Extreme sacrifice: Sudden cardiac death in the US Fire Service. *Extreme Physiology & Medicine*, *2*(1), 1–9. doi:10.1186/2046-7648-2-6 PMID:23849605

Smith, D. L., DeBlois, J. P., Kales, S. N., & Horn, G. P. (2016). Cardiovascular strain of firefighting and the risk of sudden cardiac events. *Exercise and Sport Sciences Reviews*, *44*(3), 90–97. doi:10.1249/JES.0000000000000081 PMID:27111479

Smith, D. L., Haller, J. M., Benedict, R., & Moore-merrell, L. (2015). *Cardiac Strain Associated with High-rise Firefighting*. doi:10.1080/15459624.2014.970272

Smith, D. L., Haller, J. M., Korre, M., Sampani, K., Porto, L. G. G., Fehling, P. C., Christophi, C. A., & Kales, S. N. (2019). The Relation of Emergency Duties to Cardiac Death Among US Firefighters. *The American Journal of Cardiology*, *123*(5), 736–741. doi:10.1016/j.amjcard.2018.11.049 PMID:30567633

Smith, D. L., Horn, G. P., Woods, J., Ploutz-Snyder, R., & Fernhall, B. (2016). Effect of Aspirin Supplementation on Hemostatic Responses in Firefighters Aged 40 to 60 Years. *The American Journal of Cardiology*, *118*(2), 275–280. doi:10.1016/j.amjcard.2016.04.032 PMID:27241836

Soteriades, E. S., Smith, D. L., Tsismenakis, A. J., Baur, D. M., & Kales, S. N. (2011). (in Review). Cardiovascular disease in US firefighters: A systematic review. *Cardiology*, *19*(4), 202–215. doi:10.1097/CRD.0b013e318215c105 PMID:21646874

Soteriades, E. S., Targino, M. C., Talias, M. A., Hauser, R., Kawachi, I., Christiani, D. C., & Kales, S. N. (2011). Obesity and Risk of LVH and ECG Abnormalities in US Firefighters. *Journal of Occupational and Environmental Medicine*, *53*(8), 867–871. doi:10.1097/JOM.0b013e318221c6fe PMID:21775903

Spaccarotella, C. A. M., Polimeni, A., Migliarino, S., Principe, E., Curcio, A., Mongiardo, A., Sorrentino, S., De Rosa, S., & Indolfi, C. (2020). Multichannel Electrocardiograms Obtained by a Smartwatch for the Diagnosis of ST-Segment Changes. *JAMA Cardiology*, *5*(10), 1176–1180. doi:10.1001/jamacardio.2020.3994 PMID:32865545

Togo, F., & Takahashi, M. (2009). Heart rate variability in occupational health - A systematic review. *Industrial Health*, *47*(6), 589–602. doi:10.2486/indhealth.47.589 PMID:19996534

Tomes, C., Schram, B., & Orr, R. (2020). Relationships Between Heart Rate Variability, Occupational Performance, and Fitness for Tactical Personnel: A Systematic Review. *Frontiers in Public Health*, *8*(November), 583336. Advance online publication. doi:10.3389/fpubh.2020.583336 PMID:33240835

Vaulerin, J., d'Arripe-Longueville, F., Emile, M., & Colson, S. S. (2016). Physical exercise and burnout facets predict injuries in a population-based sample of French career firefighters. *Applied Ergonomics*, *54*, 131–135. doi:10.1016/j.apergo.2015.12.007 PMID:26851472

Vincent, G. E., Aisbett, B., Larsen, B., Ridgers, N. D., Snow, R., & Ferguson, S. A. (2017). The Impact of Heat Exposure and Sleep Restriction on Firefighters' Work Performance and Physiology during Simulated Wildfire Suppression. *International Journal of Environmental Research and Public Health*, *14*(2), 180. Advance online publication. doi:10.3390/ijerph14020180 PMID:28208688

Vlasenko, N. Yu. (2020). Peculiarities of Complex Visual–Motor Reaction and Heart Rate Variability Influenced by Working Load in Rescue Firefighters. *Human Physiology*, *46*(5), 522–530. doi:10.1134/S0362119720040143

Vyas, K., & Mcgregor, C. (2018). The use of heart rate for the assessment of firefighter resilience: A literature review. *2018 IEEE Life Sciences Conference*. *LSC*, *259–262*. Advance online publication. doi:10.1109/LSC.2018.8572095

Wallén, M. B., Hasson, D., Theorell, T., Canlon, B., & Osika, W. (2012). Possibilities and limitations of the polar RS800 in measuring heart rate variability at rest. *European Journal of Applied Physiology*, *112*(3), 1153–1165. doi:10.100700421-011-2079-9 PMID:21766225

Wulsin, L. R., Horn, P. S., Perry, J. L., Massaro, J. M., & D'Agostino, R. B. (2015). Autonomic imbalance as a predictor of metabolic risks, cardiovascular disease, diabetes, and mortality. *The Journal of Clinical Endocrinology and Metabolism*, *100*(6), 2443–2448. doi:10.1210/jc.2015-1748 PMID:26047073

Yook, Y. S. (2019). Firefighters' occupational stress and its correlations with cardiorespiratory fitness, arterial stiffness, heart rate variability, and sleep quality. *PLoS One*, *14*(12), 1–9. doi:10.1371/journal.pone.0226739 PMID:31869395

Yu, C. C. W., Au, C. T., Lee, F. Y. F., So, R. C. H., Wong, J. P. S., Mak, G. Y. K., Chien, E. P., & McManus, A. M. (2015). Association between leisure time physical activity, cardiopulmonary fitness, cardiovascular risk factors, and cardiovascular workload at work in firefighters. *Safety and Health at Work*, *6*(3), 192–199. doi:10.1016/j.shaw.2015.02.004 PMID:26929827

Zimerman, A., Sheridan, B., Cooke, S., & Jena, A. B. (2020). Trends in New Diagnoses of Atrial Fibrillation after Release of an ECG-Capable Smartwatch. *Circulation*, *814–816*(8), 814–816. Advance online publication. doi:10.1161/CIRCULATIONAHA.119.045562 PMID:32833515

## KEY TERMS AND DEFINITIONS

**Cognitive Performance:** Involves the mental ability to think critically, logically, make the correct inferences and respond swiftly and appropriately to any situation one faces.

**Decision Making:** The ability to make the correct decision or appropriate course of action among several alternative option, particularly while in uncertain situations, while under external pressure.

**Heart Rate Variability:** Is the variation in the time between each heartbeat, measures in milliseconds (ms).

**Occupational Performance:** Is the ability to perceive, desire, recall, plan and carry out roles, routines, tasks, and sub-tasks for the purpose of self-maintenance, productivity, leisure and rest in response to demands of the internal and/or external environment.

**Physical Fitness:** The ability to perform muscular work satisfactorily and include cardiovascular endurance, body composition, muscular strength, muscular endurance, and flexibility.

**Physical Stress:** A feeling of physical tension originating from a strenuous situation or task that places strain unto an individual's body as one attempts to overcome the strenuous challenge or physical demand.

**Psychological Stress:** A feeling of mental tension or strain originating from a strenuous, dangerous, or hazardous situation, between the person and the environment, that causes increased feelings of anxiety, worry, depression, anger, irritability, restlessness, and bad decision making.

**Recovery:** The ability of one's bodily processes to achieve a state of resting homeostasis swiftly and timeously after intense mental and physical exertion.

**Resilience:** The psychological ability to cope with a crisis mentally or emotionally and/or the ability to return to pre-crisis state promptly.

**Risk Taking Behavior:** When one consciously or non-consciously makes decision or takes action with a perceived uncertainty about its outcome, and/or about its possible benefits or costs for the physical, economic or psycho-social well-being of oneself or others.

# Chapter 9
# Advances in Pediatric Research Using Non-Invasive Technology-Showing Precursors of Cardiovascular Disease Occurring Later in Life

**Tammy Charlene Hartel**
https://orcid.org/0000-0003-2154-5379
*University of the Western Cape, South Africa*

**Juley De Smidt**
*University of the Western Cape, South Africa*

**Andre Oelofse**
*University of the Western Cape, South Africa*

## ABSTRACT

*There is an increasing prevalence of cardiovascular risk factors in children, specifically in low socio-economic regions where children are exposed to several factors as early as the fetal stage, increasing their risk of developing cardiovascular disease (CVD) later in life. However, atherosclerosis develops silently from early childhood, long before the manifestation of cardiovascular risk factors. The aim of the chapter is to provide insights on the advances in pediatric research using non-invasive ultrasound technology for the detection of subclinical atherosclerosis in children and to explore the acceptance and distribution of ultrasound technology. The use of ultrasound technology is increasing in developing countries, and many universities are offering training courses for health professionals. Therefore, the adoption of low-cost, portable ultrasound machines, training of medical staff, together with teleradiology can drastically improve healthcare access, cardiovascular risk identification in pediatrics, and prevent the development of CVD in high-risk populations.*

DOI: 10.4018/978-1-6684-3996-8.ch009

## INTRODUCTION

Atherosclerotic cardiovascular disease (ASCVD), a collective term for disorders of the heart and blood vessels, and the prevalence of its risk factors remains a major global health problem and leading cause of global morbidity and mortality (Arnett et al. 2019). Cardiovascular disease risk factors include physical inactivity, tobacco use and several metabolic and vascular abnormalities, known as cardiometabolic risk factors (Cannon 2007). These include dyslipidemia, defined as low High-density lipoprotein cholesterol (HDL-cholesterol), high Low-density lipoprotein (LDL-cholesterol) or elevated triglycerides, central obesity, insulin resistance or high fasting blood glucose concentrations (Cannon 2007). In recent decades, overweight and obesity has substantially increased in children and adolescents in many regions and countries (Walton and Acuin 2016). Low and middle-income countries have also experienced a rapid increase in overweight and obesity in children and adolescents (Letswalo et al. 2021). In children, the atherosclerotic process develops silently from early childhood into adolescence before any clinical manifestations of cardiovascular disease risk factors (Ras et al. 2013; Thijssen et al. 2019).

Vascular ultrasound utilizes various modalities to study blood vessels and blood flow (Myers and Clough 2004). Both structural and functional changes of the blood vessel can be monitored in pediatrics and detected by ultrasound technology. Thickening of the intima and media, the two most inner layers of the blood vessel wall, is considered the earliest anatomic change in the development of atherosclerosis. On the other hand, physiological changes such as endothelial dysfunction precedes structural vascular alterations (Myers and Clough 2004; Thijssen et al. 2019). Therefore, the aim of this chapter discusses the advances in pediatric research using non-invasive ultrasound technology for the detection of subclinical atherosclerosis in children, and how ultrasound technology and its use has advanced since inception. Furthermore, the authors focus on the similarities and differences between B-mode ultrasonography and Doppler ultrasonography, and simultaneous acquisition of these two modes. The chapter will highlight how both ultrasound technology modes was used in pediatric research, its adoption from a technology acceptance model, and how it has advanced since its inception. Further benefited by guidelines crafted as early as 1992, recently refined and renewed, promotes the efficacy of ultrasound techniques (Celermajer et al. 1992; Harris et al. 2010; Thijssen et al. 2019; Touboul et al. 2012). Additionally, how ultrasound techniques to measure intima media thickening and flow mediated dilation of blood vessels have advanced with recent recommended guidelines and potential reference guides for professionals relying on data from ultrasound technology. Lastly, how ultrasound training can be improved for the modern workforce.

## BACKGROUND

### Prevalence of Cardiovascular Disease Risk Factors in Adults

In the United states, hypertension is accountable for most deaths by ASCVD compared to other modifiable risk factors (Arnett et al. 2019). High blood pressure, also known as hypertension, is defined as a systolic blood pressure (SBP) and diastolic blood pressure (DBP) of $\geq$ 130mmHg and $\geq$ 80mmHg, respectively (Arnett et al. 2019). Dyslipidemia is defined as an abnormal level of circulating cholesterol such as HDL-cholesterol, LDL cholesterol and triglycerides in the bloodstream (Oldewage, Egal, and Grobler 2017). It is well known that obesity is the root cause of several diseases including diabetes, cardiovascular diseases and stroke. Obesity is classified as a Body Mass Index (BMI) $\geq$ 30 kg/m$^2$ and overweight is classified as a BMI between 25 and 29.9 kg/m$^2$ in adults (Arnett et al. 2019). Obesity is also associated with many cardiometabolic disorders such as high blood pressure, dyslipidemia, impaired glucose metabolism as well as insulin resistance.

Equally important, the measurement of waist circumference to determine abdominal obesity (also known as central obesity) is recommended over body mass index (BMI) as it is highly associated with cardiometabolic risk and ASCVD risk (Cannon 2007). However, there are several indicators used to estimate body fat including BMI, waist-to-hip ratio, bioimpedance (measuring the human body's response to an electrical current), waist circumference and dual-energy X-ray absorptiometry (also known as DXA), of which BMI, waist-to-hip circumference and waist circumference are the most common measurements used in clinical practice to measure cardiovascular risk (Arnett et al. 2019). Increased waist circumference is defined as a waist girth ≥ 88cm ≥ (35 inches) in women and ≥ 102 cm (≥ 40 inches) in men (Arnett et al. 2019). On the other hand, diabetes mellitus type 2 is a metabolic disorder that is characterized by hyperglycemia as a result of insulin resistance (Arnett et al. 2019) . The development of type 2 diabetes is highly influenced by body weight, amount of physical activity and most importantly, dietary pattern (Arnett et al. 2019). According to the American Heart Association (AHA), about 12% of adults in the United States are diabetic, of whom majority (90-95%) have type 2 diabetes; and a third (approximately 80 million) of adults are prediabetic (Arnett et al. 2019).The latest AHA guidelines emphasizes the importance of prevention strategies to minimize the risk of developing ASCVD by lifestyle optimization such as improvements in dietary intake, increased physical activity and avoiding tobacco smoke and second -hand smoke exposure (Arnett et al. 2019).

## Cardiovascular Disease Risk Factors in Children and Adolescents

Cardiovascular disease risk factors such as obesity, dyslipidemia, hypertension, vascular dysfunction and insulin resistance is highly prevalent in children and adolescents in developing countries such as Ecuador, Iranian, Kuwait, Mexico, as well as European developed countries (Oldewage et al. 2017). For example, in South Africa, the prevalence of being overweight is 16.5% in girls and 11.5% in boys, as well as an obesity prevalence of 7.1% in girls and 4.7% in boys aged 2-14 years old (Oldewage et al. 2017). The criteria for dyslipidemia in paediatrics is an elevated triglyceride concentration of ≥150 mg/dL (milligrams per decilitre), HDL-cholesterol concentration of ≤ 40 mg/dL, and a fasting blood glucose concentration of ≥ 100 mg/dL for elevated blood glucose (Rodrigues et al., 2013; Angoorani et al., 2018). Furthermore, a systematic review and meta-analysis reported an overall global hypertension prevalence of 4% in children ≤19 years old (Song et al. 2019). The global prevalence of hypertension also increased over the past few decades from 1.26% in 1990 to 6.02% in 2014 and the prevalence substantially increased in children who were overweight and obese, compared to children with normal weight (Song et al. 2019).

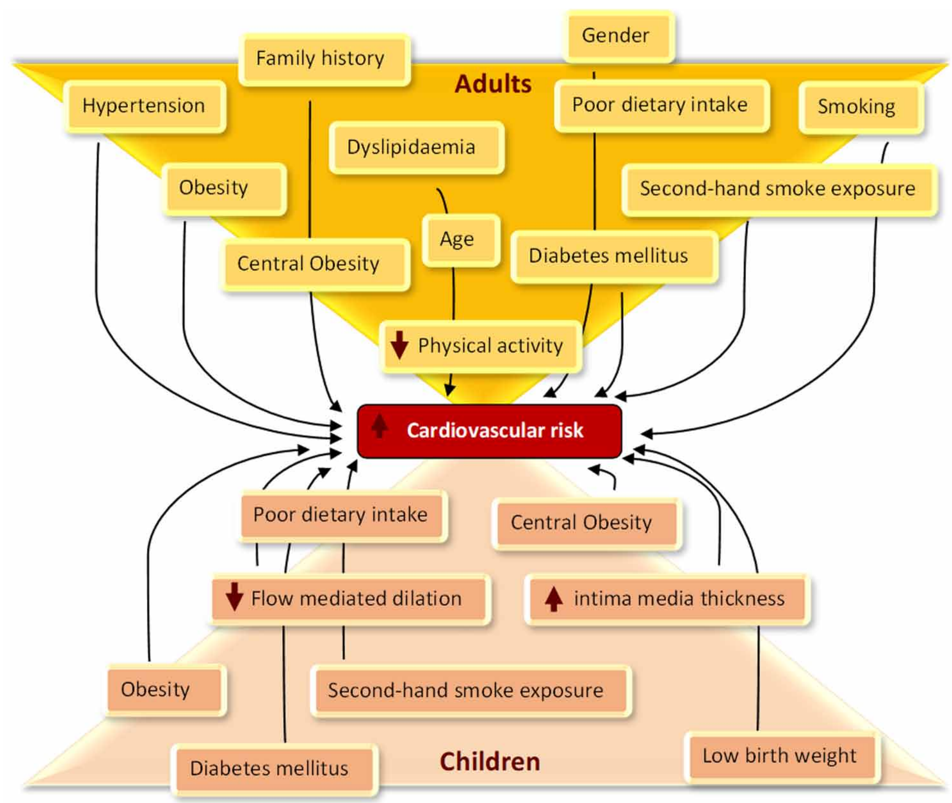
In addition, current research indicates that children in low socioeconomic regions are exposed to several factors as early as the fetal stage and, therefore, have an increased risk of developing non-communicable diseases (NCDs) later in life (Allen, Cobiac, and Townsend 2017; Oldewage et al. 2017). For example, children are exposed to several factors during their childhood such as low birth weight, poverty, malnutrition, poor dietary intake, lack of physical activity and exposure to second-hand smoke, that may be augmenting the progressive increase in prevalence of NCDs in developing countries and are often prevalent as a collective in these low socioeconomic regions (Allen et al. 2017; Oldewage et al. 2017; Viikari et al. 2014). Low birth weight is defined as a birth weight below 2500 grams whereas

*Figure 1. Smoking and alcohol consumption during pregnancy (©2022, Shutterstock. License purchased)*

normal birth weight is between 2500-4200 grams (Schlaudecker et al. 2017). Children born with a high birth weight have a higher risk of developing obesity later in life (Rayfield et al. 2016). However, studies have shown that children born with a low birth weight are also predisposed to obesity (Rayfield et al. 2016). To emphasize, studies have reported overweight/obesity, prehypertension, hypertension as well as increased intima media thickness in children in developing countries including South Africa, which predisposes them to CVD and diabetes later in life (Letswalo et al. 2021; Oldewage et al. 2017; De Smidt et al. 2019; Viikari et al. 2014).

Furthermore, children with a low socioeconomic status also tend to have an increased carotid intima media thickness (cIMT) (Epure et al. 2020). A recent systematic review and meta analyses revealed that children who were born small for gestational age had a significantly increased cIMT compared to children born normal for gestational age, as seen in 16 studies on 2 570 children (Epure et al. 2020). Majority of the studies measured the far wall of both left and right common carotid arteries. Therefore, the mean difference in cIMT was significantly higher in children born small compared to children born appropriate for their gestational age. Also, it is important to note that "low birth weight" is not synonymous with small for gestational age as only a third of low birth weight babies are born small for their gestational age (Schlaudecker et al. 2017). Small for gestational age and prematurity was significantly associated with higher cIMT (Epure et al. 2020). The significance was stronger when restricted to studies of high-quality methodology. Furthermore, three studies reported that children exposed to maternal smoking during pregnancy had an increased cIMT, but these results were not significant and the studies were not rated high quality (Epure et al. 2020). Epure et al (2020) emphasized that exposure to adverse events in the first 1000 days of life such as poor fetal growth may account for changes in the blood vessel wall and result in increased cIMT in infants, children and adults (Epure et al. 2020). Interestingly, endothelial dysfunction was also found to be strongly associated with low birth weight but not with cardiovascular risk factors in 9-10-year old children in Britain (Leeson et al. 1997). The study reported a strong positive relationship between flow mediated dilation % and birth weight, which remained significant after the adjustment for body composition, cardiovascular risk factors, ethnicity and social class (Leeson et al. 1997). Therefore, ultrasound technology and the recent advances in that technology, forms a critical role in detecting signs of vascular diseases as early as infancy. This is important as risk factors at the fetal stage, and in childhood has shown to manifest into adulthood leading to significant cardiovascular disease later in life (Figure 2).

*Figure 2. Cardiovascular disease risk factors in children and adults*



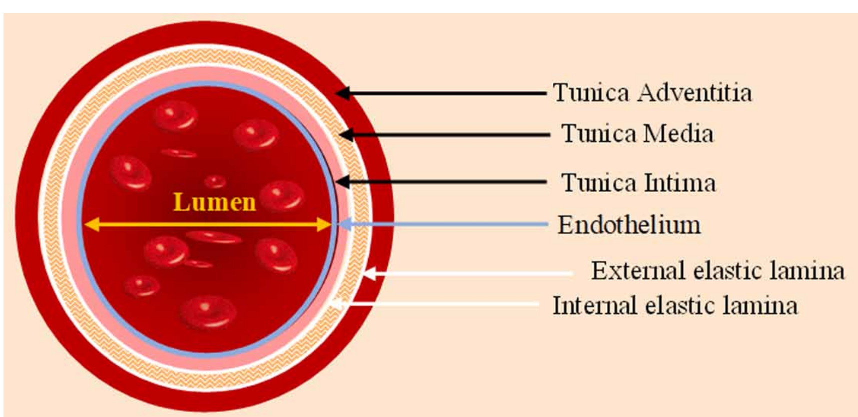

## The Blood Vessel Wall

A typical blood vessel wall is composed of three distinct layers: the tunica interna (also called the tunica intima), tunica media, and the tunica adventitia as shown in Figure 3 (Slyper 2004). The intima is the innermost wall, lining the lumen of the blood vessel with a single layer of endothelial cells called the endothelium. The endothelium releases a range of factors which play an essential role in maintaining vascular health, by regulating inflammation, cell adhesion, blood coagulation, vascular tone and growth (Kozakova and Palombo 2016). The tunica media is the middle muscular layer composed of muscle cells as well as elastic fibers, specifically in elastic arteries. The tunica media is located between the tunica intima and tunica adventitia layer and is separated by an internal and an external elastic lamina.

Due to the smooth muscle tissue in the tunica media, the arteries can regulate their diameter as blood pressure or blood volume changes. This is achieved by contraction of the smooth muscle. By decreasing the diameter of the blood vessel, the lumen becomes smaller, resulting in vasoconstriction. In contrast, when the smooth muscles relax, it results in an increase in diameter, making the lumen size larger and therefore, results in vasodilation. Lastly, the tunica adventitia is the outermost layer of the vascular wall and adjacent to the surrounding tissue. Atherosclerosis typically affects elastic arteries such as the aortic artery, carotid artery, iliac arteries, as well as muscular arteries including the coronary arteries and iliac arteries (Slyper 2004). Muscular arteries are known as medium-sized arteries or distribution arteries as they typically distribute blood to the rest of the body, whereas elastic arteries are typically large arteries that carry large volumes of blood (Martini and Nath n.d.).

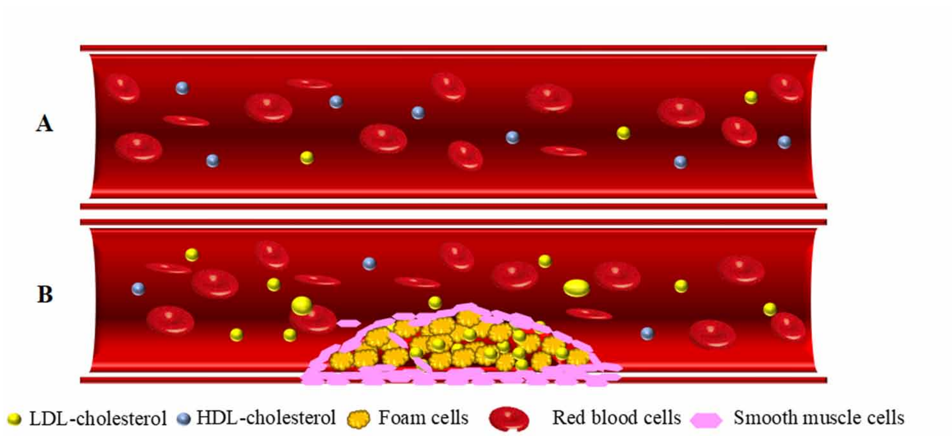
The first sign of a disturbance in vascular function is dysfunction of the endothelium which, over time, will lead to structural abnormalities such as the thickening of the intima and media layers and result in the development of plaque in the arteries (Slyper 2004). The build-up of lipids in the tunica media is associated with injury to the endothelium layer which is believed to be the initial event in the development of atherosclerosis (Kattoor et al. 2017). Atherosclerosis is a chronic inflammatory disease where thickening, hardening or narrowing of the arteries is caused by an accumulation of lipids and inflammatory cells in and on the arterial wall of medium and large arteries, resulting in atherosclerotic plaque formation (Kattoor et al. 2017; Skilton et al. 2019). The atherosclerotic plaque may reduce blood flow or completely block blood flow through an artery, leading to a heart attack or stroke. The pathophysiological mechanism involves the activation of inflammatory pathways, release of cytokines (growth factors) and oxidative stress (Kattoor et al. 2017). Oxidative stress is an imbalance in reactive oxygen species (ROS) which play a vital role in cell growth, apoptosis (programmed cell death), inflammatory responses, oxidation of LDL-cholesterol and changes in vascular tone (Kattoor et al. 2017). An increase in ROS production in the blood vessel wall is present in most CVD risk factors and therefore, there is some state of oxidative stress in risk factors such as smoking, diabetes, hypertension and dyslipidemia (Kattoor et al. 2017). In addition, oxidative stress also decreases Nitric Oxide (NO) synthesis, a vasodilator of the artery (Toda and Ayajiki, 2010; Bosco and Diaz, 2012).

*Figure 3. A cross-section of a blood vessel illustrating three concentric layers of the arterial wall*



The pathophysiologic process of atherosclerosis begins in early life stages, but symptoms or cardiovascular complications such as a myocardial infarction or stroke only present in adulthood (Järvisalo et al. 2001; Skilton et al. 2019). In addition, atherosclerosis tends to develop in patients with abnormal lipid profiles, a disorder known as dyslipidemia, specifically chronically elevated cholesterol (Martini and Nath n.d.). Elevated cholesterol levels, specifically LDL-cholesterol or hypertension for a long period of time can be dangerous as it can cause injury to the endothelium. The lipids eventually accumulate inside the blood vessel at the site of injury and become oxidized, signaling the body's immune system. The body produces an inflammatory response by sending monocytes that travel in the bloodstream to the site of injury, differentiate into macrophages and will attempt to remove the cholesterol from the bloodstream through a process called phagocytosis ("eating"). Instead, the monocytes become filled with lipids (now known as foam cells) and attach themselves to the endothelial lining of the blood vessels, releasing growth factors called cytokines. This vicious cycle will continue as surrounding monocytes will invade the area, moving through the endothelium, while lipids will continue to accumulate due to the cells attempt to phagocytize the lipids (Martini and Nath n.d.).

*Figure 4. A: Healthy arterial wall, B: Narrowed artery with atherosclerotic plaque formation*




Cytokines as well as ROS will stimulate division (also known as proliferation) of smooth muscle cells near the tunica intima, to migrate from the tunica media to the atherosclerotic plaque to deposit calcium. This will lead to the thickening and hardening of the vascular wall (due to the calcium deposits), and eventually the development of an atherosclerotic plaque.

## MAIN FOCUS OF THE CHAPTER

### Vascular Markers of Cardiovascular Risk Identification

Carotid intima media thickness has been reported by studies to be a predictor of CVD (Leary and Polak 2002). The assessment of preclinical atherosclerosis by measuring the arterial wall intima media thickness of the carotid artery using high-resolution B mode ultrasound, in addition to the identification of traditional risk factors, may identify patients at high risk of developing CVD (Leary and Polak 2002). The concept of risk assessment was first proposed by the Framingham Heart study (Leary and Polak 2002). Traditional risk factor measurements included in risk profiles were blood pressure, HDL-cholesterol, LDL-cholesterol, cigarette smoking and diabetes (Leary and Polak 2002). The far wall of the common carotid artery has now become a common area of study to measure atherosclerotic progression (Leary and Polak 2002). Leary and Polak (2002) provided a few advantages of focusing on this specific area such as the common carotid artery (CCA) being easier to visualize compared to the internal carotid artery (ICA), was easy to reproduce images and eliminated variability between ultra-sonographers and reduced reader bias by using automated edge detection software. However, there were a few disadvantages such as focal atherosclerosis being more common in the ICA and correlated more strongly with coronary artery disease risk factors and myocardial infarctions. Despite the disadvantages of using the CCA, the disadvantages of using ICA far outweighs the CCA. For example, the ICA is more difficult to visualize, a greater chance of human error or missing data, and greater variability among users (Leary and Polak 2002). Therefore, the CCA still remains a preferred site to study subclinical CVD risk and disease progression.

In the cardiovascular system, nicotine from cigarette smoking has been shown to increase atherosclerotic plaque formation which leads to atherogenic and ischemic changes eventually leading to an increased hypertension and cardiovascular morbidity. In addition to nicotine, alcohol has also demonstrated consistent changes in blood vessels such as endothelial dysfunction and stiffening, like that of nicotine (Toda and Ayajiki, 2010; Rodríguez- Rodríguez *et al.*, 2018; De Smidt *et al.*, 2019).

## Historical Perspectives on the Invention of the Ultrasound Machine

Ultrasonography is an imaging modality that is clinically accepted and can be easily learned by different medical personnel for rapid diagnosis and treatment in different settings (Stewart et al. 2020). The invention of the ultrasound machine and the development of modern ultrasound technology would not be possible without the many great scientists who contributed valuable knowledge during the $19^{th}$ and $20^{th}$ century (Donald 2013). These included Thomas Young who described the concept of “phase shifting” in 1801 that contributed to the evolution of 3-dimensional (3D) imaging and Christian Doppler who first proposed the “Doppler effect” to explain “the colour of double stars” in 1842 (Donald 2013; Thrush and Hartshorne 2005, p. 24). In ultrasound, the doppler effect is used to measure blood flow in arteries (Thrush and Hartshorne 2005). Furthermore, Pierre Curie described the concept of electric charge in 1880 which is now used to generate ultrasonic waves; and many more scientists made major contributions to the evulsion of ultrasound technology, as cited in Donald (2013). Thanks to these scientists, modern ultrasound technology can now view 4D images as seen in figure 5.

Equally important, Ian Donald, together with Tom Brown (an engineer), developed the world’s first ultrasound scanning machine in 1958 called the Diasonograph that was able to produce 2-dimensional (2D) images (Donald 2013). Their paper on this new technology was published in the Lancet which explained the scanning techniques on pregnant women as well as the fetus, gynecological tumors, and the safety, strengths and limitations, and future directions of this technique (Donald 2013). The Diasonograph was 8 feet (2.44 meters) in height and occupied a large amount of space. The gantry, a bridge-like supporting structure which housed the ultrasound probe had to be physically moved to alter the scanning plane, unlike the probes of the modern era which requires minimal effort to move (Donald 2013).

*Figure 5. A modern 4D ultrasound scan of a fetus in the womb (©2022, Shutterstock. License purchased)*

Interestingly, in those days, many people referred to the Diasonograph as the "Dinosaurograph", due to its extremely large size (Donald 2013). After 1958, the ultrasound evolution began.

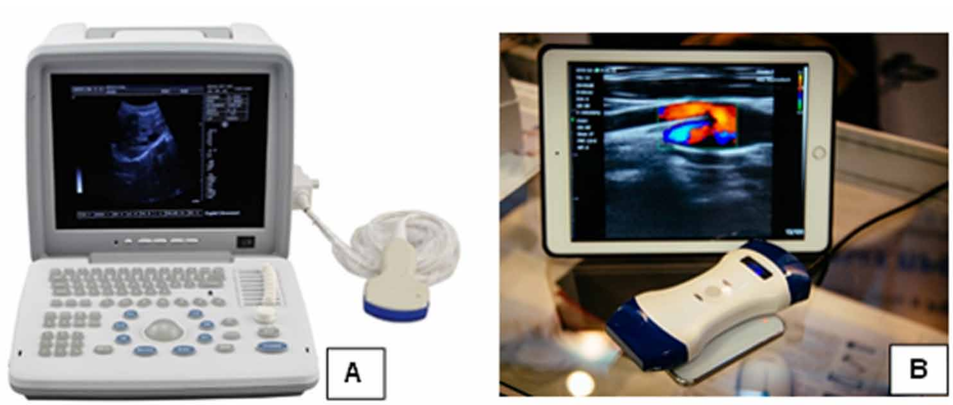
The profession of a diagnostic ultra-sonographer, a health care professional who performs diagnostic ultrasound procedures and interprets images, was founded in 1970 and the main responsibility of the sonographer was exclusively technical, whereas patient diagnosis was limited (Hall et al. 1999). Therefore, both sonographers and physicians had to be experienced, educated and well trained. However, over time, many physicians relied on the highly interpretive skills of the sonographer to identify anatomical abnormalities in the images. Between 1970 and 1980, it was often assumed that physicians could easily acquire the skills of an ultra-sonographer during their studies, but there was a lack of training in the duration of their studies, and less time to acquire these skills, which lead to the expansion of the talented and experienced ultra-sonographer (Hall et al. 1999). In 1999, the profession termed "ultrasound practitioner" was proposed as the demand for ultrasound services increased (Hall et al. 1999).

In the past 50 years of ultrasound use, it has become the most utilized method for imaging in clinical practice (Sporea 2019). Since its inception, it is evident that ultrasound use is growing in many countries as well as in low resource settings as it is relatively cheap and portable (Stewart et al. 2020). Figure 6 demonstrates a portable ultrasound machine (A) and a modern handheld ultrasound machine connected to a regular tablet/ iPad. These portable ultrasound devices are now handheld, very light, reliable, relatively low-cost compared to Computed Tomography (CT) imaging tool and Magnetic Resonance Imaging (MRI), can be used by a minimally-trained single operator and produce high quality images

(Britton et al. 2019; Sporea 2019; Stewart et al. 2020). Globally, ultrasound technology is primarily used for health screening and for obstetrical use. However, it is also used for other applications such as cardiology, infectious disease, trauma, gynecologic and also abdominal conditions (Stewart et al. 2020).

## Basic Principles of Vascular Ultrasound

*Figure 6. A: Portable Ultrasound machine, B: Handheld ultrasound machine connected to an iPad (©2022, Shutterstock. License purchased)*




Ultrasound utilizes various modes to study the internal human body including the vascular system such as blood vessels and blood flow. Modern ultrasound systems as seen in figure 7, are now able to perform simultaneous acquisition of different modes such as B mode and pulsed Doppler. The various modes which ultrasound uses include B mode ultrasound, Doppler and M-mode. B-mode ultrasound produces 2D greyscale images. As the transducer allows a beam to penetrate through the human tissue, the depth, brightness and direction of each echo creates a real-time, two-dimensional greyscale image (Myers and Clough 2004).

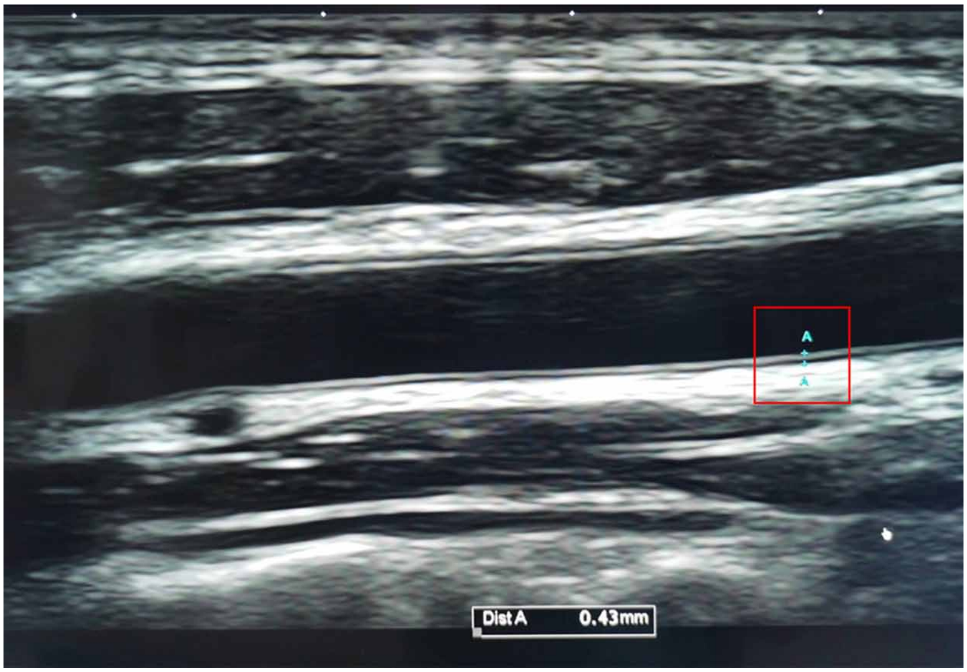
There are three types of Doppler ultrasound: Color doppler, Power Doppler and Spectral Doppler. Color doppler, as stated in its name, produces an array of colors to show the direction of speed of blood flow through a vessel. Power Doppler is more sensitive than color doppler and can show a more detailed view of blood flow, specifically in cases when blood flow is minimal. However, it does not provide sense of direction in terms of blood flow for radiologists. Spectral doppler on the other hand, displays a graphical presentation of blood flow measurements such as the distance that blood flows per unit of time as well as the ability to produce sounds with every heartbeat. B-mode ultrasound produces an image showing the arterial wall as a pattern correlating with the anatomical layers of the vascular wall (Touboul et al. 2012). Lastly, M-mode produces a narrow stationary beam that creates a one-dimensional (1D) display of the anatomical structures over a period of time (Giudice et al. 2018).

*Figure 7. An ultrasound system (©2022, Shutterstock. License purchased)*

## Intima-Media Thickness

Measurements of the intima-media thickness of the carotid artery was first proposed and validated by Paolo Pignoli in 1986 (Pignoli et al. 1986). Pignoli (1986) conducted in vitro and in vivo research and first reported that B mode imaging using ultrasound technology was a useful approach in measuring the intima media thickness in human arteries. Intima media thickness is a combined measurement of the tunica intima and tunica media of the vascular wall and is measured using high-resolution ultrasound as shown in figure 8 (Kozakova and Palombo, 2016). In ultrasound, the intima media thickness is identified as a double-line pattern displayed by echography in a longitudinal image on both the arterial walls of the common carotid artery (CCA) as shown in figure 8 (Touboul et al. 2012).

*Figure 8. Ultrasound greyscale image of the carotid artery showing a normal Intima media thickness (0.43mm) identified as a double-line pattern (©2022, Shutterstock. License purchased)*




According to Kozakova et al (2016), a high precision of intima media thickness measurements is required as the classification of normal and increased intima media thickness differs by less than 1mm. For example, there is less than 1 milimeter (mm) difference between the 25$^{th}$ percentile and 75$^{th}$ percentile, of which the 75$^{th}$ percentile is often used as a cut off for increased thickening (Kozakova and Palombo 2016; Sharma, Blaha, and Blumenthal 2009). A cIMT value greater than the 75$^{th}$ percentile is regarded as high values, and values below the 25$^{th}$ percentile is considered low, whereas values that fall between the range of the 25$^{th}$ and 75$^{th}$ percentile is considered normal (Sharma et al. 2009).

Carotid plaque on the other hand, is defined by the Manheim consensus as a focal carotid arterial wall thickening greater than 1.5mm (Sharma et al. 2009; Touboul et al. 2012). However, higher precision can be achieved through utilization of automated edge-detection algorithms or radiofrequency echo-tracking technology to allow automatic measurements of the intima media thickness (Kozakova and Palombo 2016). Ultrasound methodology literature is not well reported when using B-mode imaging. However, a standardized protocol is normally used such as the Manheim Carotid Intima Media Thickness and Plaque Consensus, an international protocol (Touboul et al. 2012). Several guidelines support the use of cIMT measurements in clinical practice such as the "ACC/American Heart Association (AHA) guidelines on the detection of cardiovascular risk", "American Society of Echocardiography and Society of Athero-sclerosis Imaging and Prevention", "ESH/ESC European practice guidelines", as well as the "National Cholesterol Education program". Since the year 2000, guidelines on B-mode imaging suggest that this technique is safe, inexpensive and non-invasive to determine subclinical atherosclerosis (Touboul et al. 2012). When measuring cIMT, the patient is placed in supine position on a bed with their head resting comfortably. The head of the patient is hyperextended and rotated in the opposite direction of the probe.

## Flow Mediated Dilation

Flow mediated dilation is a high-resolution, non-invasive ultrasound technique that measures endothelial function (Moens et al. 2005). In 1992, David Celermajer developed this non-invasive ultrasound method as a means to study early vascular physiological changes in systemic arteries. He used high resolution ultrasound to study changes in blood vessel diameter in response to increased blood flow (Celermajer et al. 1992). Celermajer was the first to prove that dysfunction of the endothelium was prevalent in children as young as eight years old who had risk factors of vascular disease, but no anatomical abnormalities in their blood vessel wall. An important consequence of endothelial dysfunction was the inability to release NO from the endothelium, known as the endothelium-derived relaxing factor (EDRF) at the time (Celermajer et al. 1992).

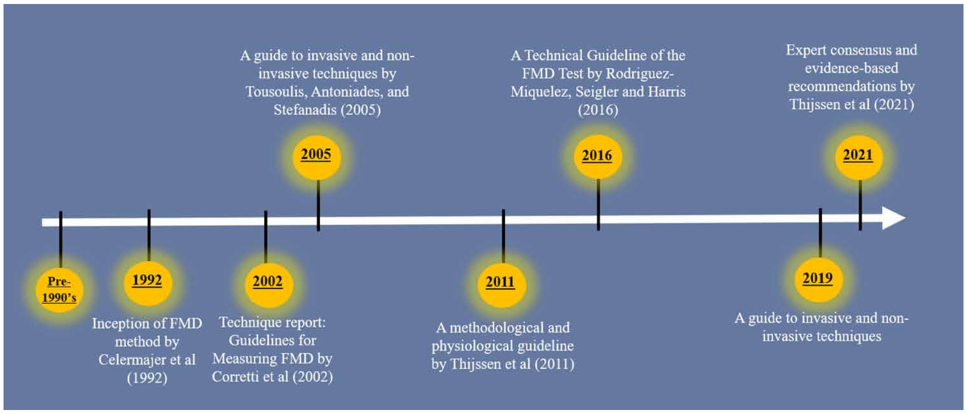
Thereafter, research studies began to test this technique and found that it could be a reliable method in identifying patients at risk for atherosclerotic disease by studying their endothelial function. Repeated measurements of flow mediated dilation (FMD) of the brachial artery was reported to be reliable with a coefficient of variation of approximately 3-4%. In statistics, a coefficient of variation below 5% is considered reliable. This method was reliable for short two-hour intervals as well as long term intervals such as three weeks. This means that measurements repeated every two hours or even three weeks, would only vary between 3-4%. Therefore, flow mediated dilation was proven to have many advantages such as being reliable, safe and a faster method than invasive methods (Tousoulis, Antoniades, and Stefanadis 2005).

Due to the many advantages of the FMD method, researchers began to utilize this method on pediatric cohorts as it was non-invasive, and therefore safe. Tousoulis, Antoniades, and Stefanadis (2005) reported that their study results were closely associated with endothelial function of the coronary arteries. Several studies concluded that the measurement of FMD may be an important prognostic tool in predicting and preventing CVD in high-risk populations (Moens et al. 2005; Tousoulis et al. 2005). However, at the time, the FMD method had poor resolution, seemed highly operator dependent and required a well-trained operator as well as excellent co-operation from the patient (Tousoulis et al. 2005). Therefore, guidelines were developed over the past two decades (figure 9) to attempt to improve this method as it was put to the test in research studies. Therefore, the development of standard guidelines using the correct methods is crucial in promoting the use of these methods in future for the successful diffusion of ultrasound technology across various stakeholders and organizations in high-risk populations.

## Basic Principles of Measuring Flow Mediated Dilation

Normal endothelial cells in the blood vessels promote vasodilation and therefore prevent atherosclerosis by inhibiting platelet aggregation, white blood cell adhesion and proliferation of smooth muscle cells (Moens et al. 2005). When the vasodilation response (which is endothelium dependent) is dysfunctional, it promotes platelet aggregation, white blood cell adhesion and proliferation of smooth muscle cells. When a patient presents with endothelium dysfunction, it means that there is a decreased bioavailability of production of NO (Moens et al. 2005). Nitric oxide has been suggested to be the main mediator of endothelial function (Harris et al., 2010). Nitric oxide is a vasodilator which inhibits platelet aggregation and adhesion and therefore atherosclerosis (Toda and Ayajiki, 2010; Bosco and Diaz, 2012). This means that NO plays a vital role during the process of relaxation of the blood vessel wall. Reduced NO bioavailability results in derangements in vasodilatory response of the vessel wall and has therefore become synonymous with a condition described as "endothelial dysfunction" (Harris et al., 2010; Bel-

*Figure 9. Historical timeline of the development of Flow-mediated dilation (FMD) technique guidelines since its inception*




lamkonda et al., 2017). Endothelial dysfunction plays a key role in the development and progression of atherosclerosis (Moens et al. 2005). According to Harris et al. 2010, endothelial dysfunction is the primary etiology and earliest identifiable event in the process of atherosclerosis, and if measured correctly using FMD, can represent a functional biological assay of endothelium derived NO availability.

Therefore, identifying subclinical atherosclerosis is important at a young age to prevent CVD later in life. Subclinical atherosclerosis can be assessed using non-invasive procedures to assess endothelial dysfunction such as FMD in the brachial artery and changes in arterial wall can be assessed by measuring aortic and carotid intima medial thickness (Harris et al., 2010; Hong, 2010; Giudice et al., 2018). Studies have considered that atherosclerosis begins in childhood and develops in the distal aorta and coronary arteries and, therefore, may also be a viable site to evaluate blood vessel changes in adolescents in comparison to the carotid artery (Hong, 2010; Giudice et al., 2018).

## Flow Mediated Dilation Technique

Flow mediated dilation is measured on the Brachial artery to assess endothelium-dependent vasodilation by measuring blood flow velocity and arterial diameter using Doppler and B-mode ultrasonography, respectively. Duplex mode is used as this allows simultaneous acquisition of B -mode ultrasound and Doppler ultrasound to determine vessel diameter and blood velocity, respectively. The flow mediated dilation technique is comprised of measurements at three different periods: The baseline testing period, cuff occlusion period and post-occlusion period.

In the baseline testing period, the ultra-sonographer establishes that the patient is in resting state based on their blood pressure, blood velocity and arterial diameter. Thereafter, the baseline measurements are taken such as the baseline arterial diameter. It is recommended to use more than 10 cardiac cycles when calculating baseline diameter. The diameter is measured from intima to intima to provide an actual representation of the vessel lumen. In addition, the baseline velocity is measured at rest and averaged over a 10-20 second period.

During the cuff occlusion period, there will be a five-minute vascular occlusion period with a supra-systolic cuffing period of 200mmHg to 250mmHg to prevent non-endothelium-dependent vasodilators being involved in the vasodilatory response. The pediatric cuff is positioned distal to the ultrasound probe and inflated ≥25 to 50 mm Hg above the systolic arterial pressure for five minutes to induce a reactive hyperemia stimulus that is NO dependent and predominantly endothelium mediated.

Lastly, during the post-occlusion period, it is recommended that post cuff measurements be imitated ≥10 seconds before the cuff release. Although peak velocity occurs approximately at 15 seconds and peak vasodilation occurs at approximately 45-80 seconds after cuff release, peak diameter should be determined on the individual. Blood velocity and arterial diameter should be measured for ≥ two minutes after cuff release to obtain the reactive hyperemia measurements. The baseline diameters, absolute change in diameter, and shear rate are documented in addition to FMD percentage. The average arterial diameter assessed over ≥10 cardiac cycles during end diastole is used as the baseline diameter. Figure 10 below presents the equation used to calculate the FMD in percentage.

*Figure 10. FMD% is calculated using the following equation*

$$\text{FMD}\ (\%) = \frac{\text{peak diameter} - \text{baseline diameter}}{\text{baseline diameter}} \text{ x } 100$$

## Clinical Role of Ultrasound in Pediatric Cardiovascular Risk Assessment

Slyper (2004) reviewed the potential clinical role of ultrasound in pediatric health risk assessment. The author mentioned the two major advances in pediatric cardiovascular research which is the ability to measure endothelial function using flow mediated dilation and detecting anatomical signs of atherosclerosis using high resolution ultrasound (Slyper 2004). These are considered major advances as they are now non-invasive and conveniently performed on the brachial artery for endothelial function and on the common carotid artery to measure flow mediated dilation and intima media thickness, respectively. Slyper (2004) recommended the use of ultrasound technology to evaluate brachial artery flow mediated dilation and carotid intima media thickness for cardiovascular risk assessment in high-risk pediatric patients such as children with a family history of hypercholesteremia, coronary artery disease, dyslipidemia and type 1 diabetes mellitus.

To illustrate, the Early Vascular Ageing (EVA) study conducted a community-based health screening in the general population of Austria and Italy, focusing on the detection of vascular risk factors and metabolic abnormalities on approximately 16-year-old adolescents in schools (Kiechl et al. 2022). The large-scale health screening revealed a high diagnostic yield and identified new medical conditions in 45,5% of the 2 088 adolescents, of which elevated blood pressure, hypertension, hypercholesteremia, hypertriglyceridemia, hyperuricemia, metabolic syndrome and subclinical hypothyroidism were the most prevalent (Kiechl et al. 2022). In addition, another school-based screening for hypertension and obesity was performed on children aged 8-18 years old in Houston, Texas (Sorof et al. 2004). The study reported a prevalence of hypertension (83%) and overweight (45%) in 97 children (Sorof et al. 2004). The study also obtained B mode ultrasound images and performed an echocardiography to compare abnormalities in surrogate markers for cardiovascular disease between children referred to a paediatric clinic due to hypertension and children who participated in the school-based screening. The study found that children who were referred to the pediatric clinic had a significantly higher carotid intima media thickening, but this did not persist after controlling for BMI (Sorof et al. 2004). This means that children who are hypertensive or obese, may present with more severe abnormalities in terms of surrogate markers such as carotid intima media thickness and left ventricular hypertrophy. Left ventricular hypertrophy (LVH) is when the heart's pumping chamber on the left has thickened and may not be functioning efficiently. The prevalence of LVH is a predictor and independent risk factor of cardiovascular diseases such as coronary heart disease, heart failure or even stroke. To emphasize, another study reported that cIMT was higher in children and adolescents classified as metabolically healthy overweight and metabolically healthy obese. Metabolically healthy children referred to those with no metabolic disorders. The odds of having a higher cIMT were 2.29 and 3.91 for metabolically healthy overweight and healthy obese children, compared to metabolically healthy normal weight children (Zhao et al. 2019). Furthermore, metabolically unhealthy overweight and unhealthy obese children were 3.49 and 6.96 times more likely to have a higher cIMT, respectively (Zhao et al. 2019). Similar patterns were reported in developing countries such as South Africa, where more than half (52%) of 248 adolescents had at least one CVD risk factor such as hypertension or overweight/obesity or both (Letswalo et al. 2021). Therefore, weight control in childhood and adolescence remains an important preventative measure despite children's metabolic status or even socioeconomic status.

Therefore, a simple health screening approach can identify unknown risk factors that require further interventions such as guideline-recommended lifestyle changes or pharmacological treatment, thereby preventing the development of cardiovascular disease later in life. The screening used in the study by Kiechl and colleagues (2022) took approximately 15-20 minutes (maximum 3 minutes), did not require special or high-cost devices, nor require special skills or qualifications. The exception in terms of special devices may be a scale and sphygmomanometer to measure weight and blood pressure, respectively. Therefore, regular health screening works well in a school setting and can be performed by a school doctor or even nurse. A recent systematic review found that ultrasound providers in research studies in low and middle-income countries were mainly physicians, but also midwives, residents, ultrasound technicians and community health workers (Stewart et al. 2020).

## Ultrasound Technology Acceptance and Distribution

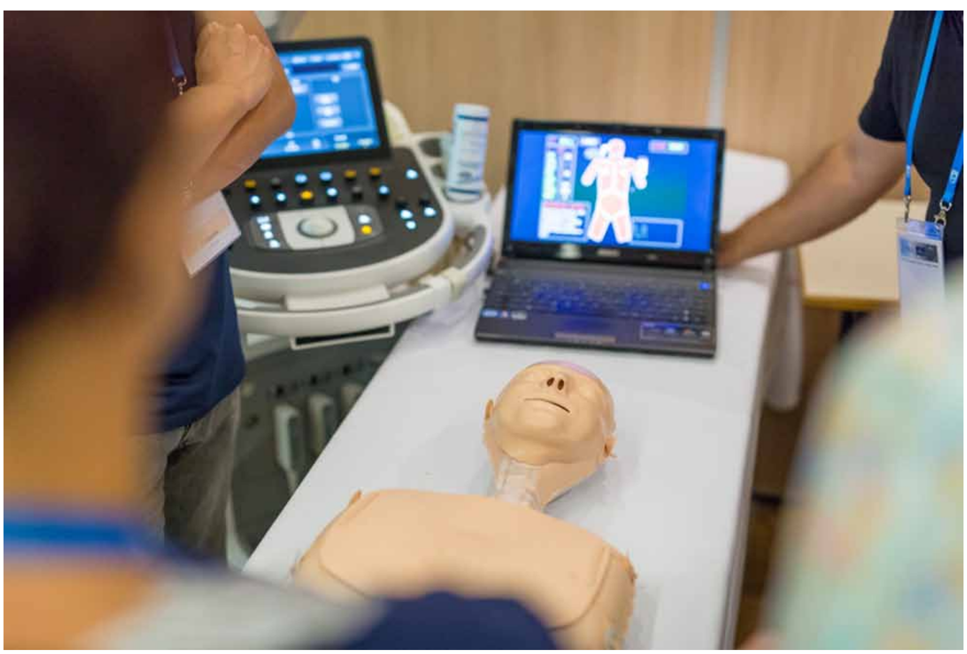
The theoretical framework of this chapter is based on the Technology Acceptance Model (TAM), a predictive tool for testing users' acceptance of new technologies such as ultrasound technology in industries such as health care (Koksalmis 2019). In addition to the TAM, the theoretical framework consists of the Diffusion of Technology theory to investigate factors that may hinder or facilitate the use of ultrasound technology for cardiovascular health screening during regular child health check-ups (Bolick and Bolick 2017). A literature search was conducted to investigate the use of ultrasound in developing countries and to determine which factors may hinder or facilitate the adoption of ultrasound in low-socioeconomic regions. The authors also consulted experts in the fields of ultrasound, vascular imaging and fetal origins of cardiometabolic disease.

A recent systematic review studied trends in the use of ultrasound in low and middle-income countries between 2010-2018 and reported an increase in the utilization of ultrasound in research studies in these countries (Stewart et al. 2020). Ultrasound use has geographically expanded by 20% in the last decade, with the highest number of ultrasound studies in India (20%), followed by Egypt, Nigeria and Pakistan with 9.8%, 8.8% and 7.3%, respectively (Stewart et al. 2020). In addition, the number of countries using ultrasound has increased from 50% in 2010 to 62% in 2018 (Stewart et al. 2020). Stewart et al (2020) reported that 25% of ultrasound studies focused on cardiology and 14% on obstetrics and gynaecology, whereas only 5.8% of ultrasound studies worldwide focused on paediatrics (Stewart et al. 2020). However, evidence suggests that more than 70% of studies in middle-income countries performed ultrasound imaging in tertiary health care centers, emphasizing a lack of access to ultrasound and healthcare in general in low-income countries, specifically low socioeconomic regions (Stewart et al. 2020).

For emphasize, a study conducted in a rural sub-Saharan African setting in Uganda explored the perspectives of healthcare providers on Doppler ultrasound (Ali et al. 2021). The study identified a shortage of trained staff in ultrasound, a lack of equipment, frequent electricity cuts and long travelling distances to and from hospitals as the main factors hindering the implementation of Doppler ultrasound (Ali et al. 2021). Healthcare providers in mid-western Uganda were unfamiliar with using Doppler ultrasound, and to use it as a diagnostic tool and to guide clinical decisions.

Sporea (2019) stated that many countries aim to introduce ultrasonography as a core module in specialist fields such as emergency medicine, rheumatology, endocrinology and gastroenterology or hepatology, which includes theoretical and practical training of ultrasound on simulators or humans as illustrated in figure 11. Therefore, the next initiative should be to offer basic to advanced ultrasound training to general practitioners, specifically on portable ultrasound machines which can be used in their clinical practices. There is evidence that these types of training is being offered at medical universities in countries such as Romania, United States and Germany, for example (Sporea 2019). In Cape Town, South Africa, universities also offer annual ultrasound courses including vascular ultrasound for health professionals including doctors who seek training to learn how to use ultrasound technology or improve their ultrasound skills with hands on training.

*Figure 11. Ultrasound training on a training simulator (©2022, Shutterstock. License purchased)*



Teleradiology, a tool that has substantially advanced in high income settings and a sustainable solution during the Covid-19 pandemic, is a branch of telemedicine that uses telecommunication to transfer medical images from a distance; thereby providing healthcare from a distance (Qurat et al. 2020). Teleradiology or specifically "Tele-ultrasound" allows the opportunity for an experienced ultra-sonographer to view and interpret ultrasound images without being physically on-site (Britton et al. 2019; Stanton and Mwanri 2014). This tool is particularly important in developing countries as it can address barriers such as lack of basic infrastructure like unstable electrical power, slow internet connectivity or lack of access to basic healthcare (Qurat et al. 2020). This may improve ultrasound access and encourage the adoption and distribution of ultrasound technology in low-income settings. An advantage of this process is that it is convenient as it can be done in real-time, or in a synchronous or asynchronous way in which images and data are stored and transmitted at a later stage for interpretation (Britton et al. 2019). Therefore, the tele-ultrasound provides doctors and other health care providers the opportunity to learn the necessary skills to perform ultrasound exams, whilst working remotely with ultra-sonographers to successfully diagnose high risk patients. A recent systematic review investigated the use of tele-ultrasound in low-resource settings and reported that studies conducted in low-resource settings informed the conclusion that training, regardless of the length of training, provided high quality images by non-experts, sufficient for remote interpretation (Britton et al. 2019). Therefore, utilizing non-experts to perform ultrasound exams may provide more resources, staff, save time and provide a platform to perhaps focus on regular health monitoring in pediatric patients in low socioeconomic regions.

## SOLUTIONS AND RECOMMENDATIONS

It is recommended that health policy makers and the health care industry advance the case for and adopt the use of ultrasound technology such as portable ultrasound machines to regularly monitor cardiovascular health in children, as many studies have reported increased intima media thickness and vascular dysfunction in children (Letswalo et al. 2021; De Smidt et al. 2019). The adoption of ultrasound technology, and more so portable ultrasound machines, should be more widely available and used, specifically in children from low socioeconomic regions which may be at high risk. This will assist in the early detection of cardiovascular risk, thereby preventing the development of adult diseases through early intervention such as changes in dietary intake and increased physical activity. If successful, early detection and prevention in children will reduce the prevalence of NCDs, a major public health problem in most developing countries, as preventative measures can be put in place to aid this population. Additionally, lowering long term cost on countries health expenditures, and improving the overall health through early and more widely adoption and use of ultrasound technologies.

## FUTURE RESEARCH DIRECTIONS

There is growing evidence that ultrasound technology is particularly valuable in pediatric research. With recent developments in standard guidelines and the increase in research using ultrasound to detect early cardiovascular risk, the health industry might be more accepting in technology use on a regular basis. Especially more research on factors that influence the efficacy of portable ultrasound technologies. More evidence from future research in this regard, as well as with advances in this field will be made when clinical pediatricians collaborate with pediatric researchers and ultra-sonographers and adopt these techniques in their clinical work. As a result, health professionals will be able to acquire the necessary skills and training to utilize this technology in the modern workforce, as flow mediated dilation, specifically, is difficult to measure, requiring a skilled and well-trained clinician. In addition, long term studies in advanced imaging techniques used for the detection of subclinical atherosclerosis in children seems promising as a screening method and in the prevention of diseases and needs further research. Furthermore, future research directions could also focus on inter-disciplinary approaches that could involve and help inform policy makers, civic government, Non-Governmental Organizations (NGO's), and businesses who could work towards as well as monitor and evaluate free services for pregnant mothers and young children. Future research focus could also look at how evidence from ultrasound technology, collated in one area or tracked to a community, could be supported through community gardens, and fitness programs.

## CONCLUSION

Therefore, the literature provides evidence that ultrasound technology is evolving and increasingly utilized in developing countries. Connectivity in a global context has significantly improved during the pandemic and therefore has made training and the use of tele-ultrasound more feasible in resource-limited settings. With recent advances in ultrasound technology, available ultrasound courses offered to all health professionals in developing countries, together with the use of tele-ultrasound may pave the way forward in overcoming barriers in low-resource settings, reduce cardiovascular risk by identifying and diagnosing pediatric patients at risk and therefore preventing disease occurring later in life. By identifying children at risk for cardiometabolic diseases, appropriate interventions can be implemented, thereby reducing both prevalence of cardiovascular diseases in the long term, as well as hospitalization and morbidity.

## REFERENCES

Ali, S., Kabajaasi, O., Kawooya, M. G., Byamugisha, J., Zakus, D., Papageorghiou, A. T., Grobusch, K. K., & Rijken, M. J. (2021). Antenatal Doppler Ultrasound Implementation in a Rural Sub - Saharan African Setting : Exploring the Perspectives of Women and Healthcare Providers. *Reproductive Health*, *18*(1), 1–12. doi:10.118612978-021-01233-5 PMID:34620186

Allen, L., Cobiac, L., & Townsend, N. (2017). Quantifying the Global Distribution of Premature Mortality from Non-Communicable Diseases. *Journal of Public Health (United Kingdom)*, *39*(4), 698–703. doi:10.1093/pubmed/fdx008 PMID:28184435

Arnett, D. K., Blumenthal, R. S., Albert, M. A., Buroker, A. B., Goldberger, Z. D., Hahn, E. J., Himmelfarb, C. D., Khera, A., Lloyd-Jones, D., McEvoy, J. W., Michos, E. D., Miedema, M. D., Muñoz, D., Smith, S. C., Virani, S. S., Williams, K. A., Yeboah, J., & Ziaeian, B. (2019). 2019 ACC/AHA Guideline on the Primary Prevention of Cardiovascular Disease. A Report of the American College of Cardiology/ American Heart Association Task Force on Clinical Practice Guidelines.

Britton, N., Miller, M. A., Safadi, S., Siegel, A., Levine, A. R., & Mccurdy, M. T. (2019). Tele-Ultrasound in Resource-Limited Settings. *Systematic Reviews*, *7*(September), 244. Advance online publication. doi:10.3389/fpubh.2019.00244 PMID:31552212

Cannon, C. P. (2007). Cardiovascular Disease and Modifiable Cardiometabolic Risk Factors. *Clinical Cornerstone*, *8*(3), 11–28. doi:10.1016/S1098-3597(07)80025-1 PMID:18452839

Celermajer, D. S., Sorensen, K. E., Gooch, V. M., Spiegelhalter, D. J., Miller, O. I., Sullivan, I. D., Lloyd, J. K., & Deanfield, J. E. (1992). Non-Invasive Detection of Endothelial Dysfunction in Children and Adults at Risk of Atherosclerosis. *Lancet*, *340*(8828), 1111–1115. doi:10.1016/0140-6736(92)93147-F PMID:1359209

De Smidt, J., Odendaal, H. J., Nel, D. G., Nolan, H., Du Plessis, C., Brink, L. T., & Oelofse, A. (2019). In Utero Teratogen Exposure and Cardiometabolic Risk in 5-Year-Old Children : A Prospective Pediatric Study. *The Journal of Maternal-Fetal & Neonatal Medicine*, *0*(0), 1–10. doi:10.1080/14767058.2019.1692337 PMID:31762362

Donald, I. (2013). *History A Short History of Sonography in Obstetrics and Gynaecology*. Academic Press.

Epure, A. M., Rios-Leyvraz, M., Anker, D., Di Bernardo, S., da Costa, B. R., Chiolero, A., & Sekarski, N. (2020). Risk Factors during First 1,000 Days of Life for Carotid Intima-Media Thickness in Infants, Children, and Adolescents: A Systematic Review with Meta-Analyses. *PLoS Medicine*, *17*(11), 1–29. doi:10.1371/journal.pmed.1003414 PMID:33226997

Giudice, Dilillo, Tromba, La Torre, Blasi, Conti, Viola, Cucchiara, & Duse. (2018). *Aortic, Carotid Intima-Media Thickness and Flow- Mediated Dilation as Markers of Early Atherosclerosis in a Cohort of Pediatric Patients with Rheumatic Diseases*. . doi:10.1007/s10067-017-3705-7

Hall, Coffin, Cyr, Persutte, Roberts, Spitz, & Waggoner. (1999). *The Ultrasound Practitioner*. Academic Press.

Järvisalo, Jartti, Näntö-Salonen, Irjala, Rönnemaa, Hartiala, Celermajer, & Raitakari. (2001). *Increased Aortic Intima-Media Thickness*. Academic Press.

Kattoor, A. J., Naga Venkata, K. P., Palagiri, D., & Mehta, J. L. (2017). Oxidative Stress in Atherosclerosis. *Current Atherosclerosis Reports*, *19*(11), 42. Advance online publication. doi:10.100711883-017-0678-6 PMID:28921056

Kiechl, S. J., Staudt, A., Stock, K., Gande, N., Bernar, B., Hochmayr, C., Winder, B., Geiger, R., Griesmacher, A., Egger, A. E., Pechlaner, R., Kiechl, S., Knoflach, M., & Kiechl-Kohlendorfer, U. (2022). Diagnostic Yield of a Systematic Vascular Health Screening Approach in Adolescents at Schools. *Diagnostic Yield of a Systematic Vascular Health Screening Approach in Adolescents at Schools.*, *70*(1), 70–76. doi:10.1016/j.jadohealth.2021.10.019 PMID:34930573

Koksalmis. (2019). *Drivers to Adopting B-Flow Ultrasonography : Contextualizing the Integrated Technology Acceptance Model*. Academic Press.

Kozakova, M., & Palombo, C. (2016). *Vascular Ultrasound and Cardiovascular Risk Assessment*. Academic Press.

Leary & Polak. (2002). *Intima-Media Thickness : A Tool for Atherosclerosis Imaging and Event Prediction.* Academic Press.

Letswalo, Schmid, Brix, Matjuda, Klosz, Obernhumer, Gaisl, Fredriksen, Engwa, & Sewani. (2021). *Cardiometabolic Risk Factors and Early Indicators of Vascular Dysfunction : A Sectional Cohort Study in South African Adolescents*. . doi:10.1136/bmjopen-2020-042955

Martini & Nath. (n.d.). *Fundamentals of Anatomy and Physiology*. Academic Press.

Moens, A. L., Goovaerts, I., Claeys, M. J., & Vrints, C. J. (2005). Flow-Mediated Vasodilation: A Diagnostic Instrument, or an Experimental Tool? *Chest*, *127*(6), 2254–2263. doi:10.1378/chest.127.6.2254 PMID:15947345

Myers, K., & Clough, A. (2004). *Making Sense of Vascular Ultrsound: A Hands-on Guide*. doi:10.1201/b13409

Oldewage, T., Egal, A., & Grobler, C. (2017). *Anthropometry as cardiovascular risk factors and their association with dietary intakes in children from rural*. Academic Press.

Pignoli, P., Tremoli, E., Poli, A., Oreste, P., & Paoletti, R. (1986). Intimal plus Medial Thickness of the Arterial Wall. *Direct Measurement with Ultrasound Imaging A.*, *74*(6), 1399–1406. PMID:3536154

Ras, R. T., Streppel, M. T., Draijer, R., & Zock, P. L. (2013). Flow-Mediated Dilation and Cardiovascular Risk Prediction : A Systematic Review with Meta-Analysis. *International Journal of Cardiology*, *168*(1), 344–351. doi:10.1016/j.ijcard.2012.09.047 PMID:23041097

Rayfield, S., Plugge, E., Rayfield, S., & Plügge, E. (2016). *Systematic Review and Meta-Analysis of the Association between Maternal Sm*. doi:10.1136/jech-2016-207376

Schlaudecker, E. P., Munoz, F. M., Bardají, A., Boghossian, N. S., Khalil, A., Mousa, H., Nesin, M., Nisar, M. I., Pool, V., Spiegel, H. M. L., Tapia, M. D., Kochhar, S., & Black, S. (2017). Small for Gestational Age: Case Definition & Guidelines for Data Collection, Analysis, and Presentation of Maternal Immunisation Safety Data. *Vaccine*, *35*(48), 6518–6528. doi:10.1016/j.vaccine.2017.01.040 PMID:29150057

Sharma, K., Blaha, M. J., Blumenthal, R. S., & Musunuru, K. (2009). Clinical and Research Applications of Carotid Intima-Media Thickness. *AJC*, *103*(9), 1316–1320. doi:10.1016/j.amjcard.2009.01.020 PMID:19406278

Skilton, M. R., Celermajer, D. S., Cosmi, E., Crispi, F., Gidding, S. S., Raitakari, O. T., & Urbina, E. M. (2019). Natural History of Atherosclerosis and Abdominal Aortic Intima-Media Thickness: Rationale, Evidence, and Best Practice for Detection of Atherosclerosis in the Young. *Journal of Clinical Medicine*, *8*(8), 1201. doi:10.3390/jcm8081201 PMID:31408952

Slyper, A. H. (2004). *Clinical Review 168 What Vascular Ultrasound Testing Has Revealed about Pediatric Atherogenesis, and a Potential Clinical Role for Ultrasound in Pediatric Risk Assessment.* Academic Press. . doi:10.1210/jc.2003-030644

Song, P., Zhang, Y., Yu, J., Zha, M., Zhu, Y., Rahimi, K., & Rudan, I. (2019). Global Prevalence of Hypertension in Children: A Systematic Review and Meta-Analysis. *JAMA Pediatrics*, *173*(12), 1154–1163. doi:10.1001/jamapediatrics.2019.3310 PMID:31589252

Sorof, J. M., Turner, J., Martin, D. S., Garcia, K., & Garami, Z. (2004). *Cardiovascular Risk Factors and Sequelae in Hypertensive Children Identified by Referral Versus*. doi:10.1161/01.HYP.0000114696.96318.4e

Sporea, I. (2019). *US4all (Ultrasound for All).* . doi:10.11152/mu-2178

Stanton, K., & Mwanri, L. (2014). Global Maternal and Child Health Outcomes. *The Role of Obstetric Ultrasound Global Maternal and Child Health Outcomes : The Role of Obstetric Ultrasound in Low Resource Settings*, (May). Advance online publication. doi:10.12691/jpm-1-3-3

Stewart, K. A., Navarro, S. M., Kambala, S., Tan, G., Poondla, R., Lederman, S., Barbour, K., & Lavy, C. (2020). Trends in Ultrasound Use in Low and Middle Income Countries : A Systematic Review. *International Journal of Maternal and Child Health and AIDS*, *9*(1), 103–120. doi:10.21106/ijma.294 PMID:32123634

Thijssen, D. H. J., Bruno, R. M., Van Mil, A. C. C. M., Holder, S. M., Faita, F., Greyling, A., Zock, P. L., Taddei, S., Deanfield, J. E., Luscher, T., Green, D. J., & Ghiadoni, L. (2019). Expert Consensus and Evidence-Based Recommendations for the Assessment of Flow-Mediated Dilation in Humans. *European Heart Journal*, *40*(30), 2534–2547. doi:10.1093/eurheartj/ehz350 PMID:31211361

Thrush, A., & Hartshorne, T. (2005). *Peripheral Vascular Ultrasound. second* (D. Thom & K. McGechie, Eds.). Elsevier Ltd.

Touboul, Hennerici, Bornstein, & Csiba. (2012). *Mannheim Carotid Intima-Media Thickness and Plaque Consensus (2004 – 2006 – 2011).* . doi:10.1159/000343145

Tousoulis, Antoniades, & Stefanadis. (2005). *Evaluating endothelial function in humans : A guide to invasive and non-invasive techniques*. . doi:10.1136/hrt.2003.032847

Viikari, J. S. A., Gall, S., Venn, A., Dwyer, T., Magnussen, C. G., Huynh, Q. L., Raitakari, O. T., Kähönen, M., & Juonala, M. (2014). Exposure to Parental Smoking in Childhood or Adolescence Is Associated with Increased Carotid Intima-Media Thickness in Young Adults: Evidence from the Cardiovascular Risk in Young Finns Study and the Childhood Determinants of Adult Health Study. *European Heart Journal*, *35*(36), 2484–2491. doi:10.1093/eurheartj/ehu049 PMID:24595866

Walton, J., & Acuin, C. (2016). *Worldwide Trends in Body-Mass Index, Underweight, Overweight, and Obesity from 1975 to 2016 : A Pooled Analysis o*. Related Papers.

Zhao, M., López-Bermejo, A., Caserta, C. A., Medeiros, C. C. M., Kollias, A., Bassols, J., Romeo, E. L., Ramos, T. D. A., Stergiou, G. S., Yang, L., Xargay-Torrent, S., Amante, A., Gusmão, T. M. E., Grammatikos, E., Zhang, Y., Prats-Puig, A., de Carvalho, D. F., Yang, L., Carreras-Badosa, G., ... Ramalho, M. C. (2019). Metabolically Healthy Obesity and High Carotid Intima-Media Thickness in Children and Adolescents. *International Childhood Vascular Structure Evaluation Consortium.*, *42*(January), 119–125. doi:10.2337/dc18-1536 PMID:30420475

## KEY TERMS AND DEFINITIONS

**Atherosclerosis:** Atherosclerosis is a chronic inflammatory disease. It is a buildup of plaque in the arterial wall, leading to the narrowing or blocking of the blood vessels as a result of an accumulation of lipids in the blood vessel wall.

**Cardiovascular Diseases:** A broad term used to group disorders of the cardiovascular system such as the heart conditions and diseased blood vessels. For examples, coronary artery disease, heart failure, cardiac arrest, peripheral artery disease and stroke.

**Non-Invasive Technology:** The use of medical technology that utilizes procedures that do not physically enter the body or cause physical harm or pain to the patient.

**Ultrasonography:** A specialized field of study that uses technology to produce images of the inside of the human body.

# Chapter 10
# Digital Film-Making Response to a Hate Crime:
## Narratives of Immigrant Youth

**Regina Casale**
*Film and Educational Research Academy, USA*

**Dominic Mentor**
*Teachers College, Columbia University, USA*

## ABSTRACT

*This chapter revisits the creation and results of cultivating mobile journalism and film making skills with middle and high schoolers in Long Island. The youth digital film production effort was in response to a hate crime. An immigrant was killed by a group of young males after a suspected spree of other attacks. After the murderous incident, immigrant parents and students of the local schools feared for their lives. Working towards narrative goals, the organizers set out to teach students how to use mobile and computer technologies for filmmaking. Using themes of human rights, they also focused on responding to hate crimes and immigration issues. The chapter offers further key discoveries, lessons, and positive outcomes of the program. The programs provided academic and workforce development skills as well as using computer technology for digitizing narratives. The program also offered informal academic purposes, along with opportunities and recommendations from the findings for other digital filmmaking endeavors.*

## INTRODUCTION

This chapter will focus on the continuation of the youth driven 2011 summer media workshops, from 2014-2018, all stemming from the original design. It explores the process and highlights the lessons learned as well as offer some examples from around the world and how these video projects were used to connect young students from around the world. Since the inauguration of LIFE through My Eyes in Patchogue in 2010 there have been several success stories of students pursuing degrees in the visual

DOI: 10.4018/978-1-6684-3996-8.ch010

arts, film, and television. Alumni have taken on leadership roles as facilitators and graphic designers. Many have been encouraged to submit work to film festivals or other competitions and some have been recognized for their talents as recipients of the Marcelo Lucero Award as well by local legislators and organizations. There has been a total of 19 youth produced digital narratives and over 150 participants at five different schools in two different school districts.

The summer media workshop was implemented to cultivate mobile activism and develop mobile journalistic instincts with 1.5 generation Ecuadorian middle and high school students from Patchogue, New York. The term 1.5 generation signals the split identity of these immigrant children who arrived in the United States of America (USA) as adolescents and grew up with what has been referred to as a split identity (Rojas, 2012). Hosting and traversing the ambiguity of the country of origin and new country of residence's culture and language. To start working towards the goals of mobile activism and mobile journalism, the organizer and her partners arranged a hands-on, project based, short term engagement. The summer workshop was set up to teach students how to leverage technology for digital narratives with the theme of human rights. The goals were to enhance 21st century academic skills, promote civic engagement, encourage intercultural dialogue, and empower youth.

This chapter also focuses on the broad domains of practice, in terms of youths' digital narratives and video production that foster a host of critical thinking, hard and soft skills, agency as well as academic enthusiasm. Invoking enthusiasm was also achieved by utilizing multimodal stimulation and active engagements. The reflection on our efforts will also bring attention to how mobile telecommunication has been leveraged by formal organizations and educational institutions. While our literature review that informed this chapter has the potential to aid K-12 schools who might consider leveraging the ever-growing mobile learning and mobile telecommunication services to help their recently arrived immigrant students acculturate to a new environment. Simple information sharing with these students could aid connecting them to their home support networks or by forming new virtual and/or physical networks.

Also shared in this chapter will be key discoveries and lessons from a summer media and human rights program. The short intensive summer program provided access, use, as well as highlighting the value of computer technology for digitizing personal narratives of understanding. The program also offered informal academic purposes, along with observations, opportunities, and recommendations from the findings for other middle and high school digital video narrative and filmmaking endeavors. The program inadvertently also empowered and provided young students with new skills that they could explore for future studies, or career tracks. Whether they focus on digital autobiographies, family stories, capturing oral histories or responding to hate crimes, immigration, or protests and activism.

## BACKGROUND

The summer media and human rights workshop was in response to a hate crime in 2008 when Marcelo Lucero, an Ecuadorian immigrant was attacked and killed by a group of young males who were out "beaner hopping". A derogatory term used to describe the despicable act of group attacks on people perceived as undocumented immigrants. In 2009 the Southern Poverty Law Center released *Climate of Fear*, detailing other incidents of violence against Latino immigrants in the community over the last decade. The findings of this report triggered an investigation by the Department of Justice into the Suffolk County Police Department. Tensions at schools escalated against immigrant students. Parents and teachers concerned for the safety of their children suggested that their children never walk alone and always walk in a group, to and from school.

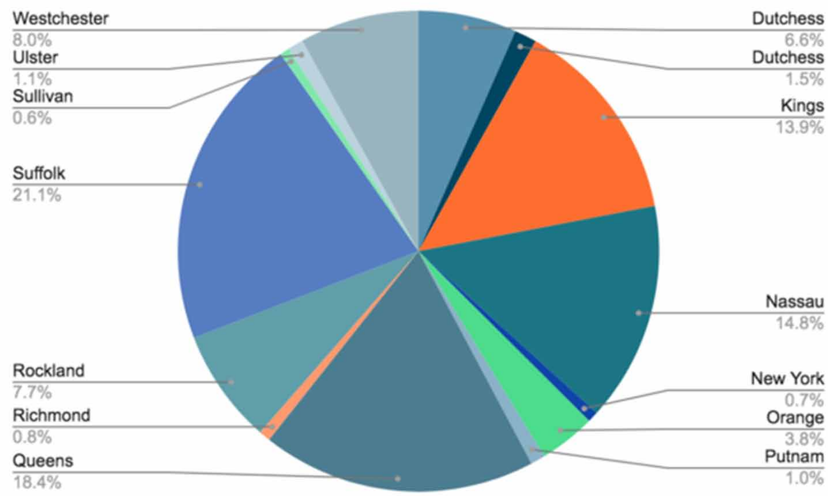
LIFE through My Eyes, a human rights media project, was a result of the tragedy. It was initially funded by the WK Kellogg Foundation through their America Healing initiative and co-sponsored by Film and Educational Research Academy (FERA) as well as the Long Island Teachers Association (LILTA) as a summer workshop for immigrant Ecuadorian youth. Apart from educating students on human rights and how bullying violates those rights, the program goals also focused on empowering youth with 21$^{st}$ century academic skills, promoting civic engagement as well as encouraging intercultural dialogue. Computer and information technology is interwoven throughout students' lives and does not run separately from their daily interactions. Be it their mobile phones, social media or other computer technology, students traverse their lives in an ever-growing computer-mediated manner that demands learning how to use and leverage the technology as producers and not just as passive consumers of media. The 21st-century academic skills they learned involved computer-mediated educational engagement and taught the students how to create digital video, giving them a chance to tell their stories, show their understanding and have their voices later shared in several venues throughout the community. The students developed job and life skills by not only practicing public speaking, but also gaining an introduction to media literacy and realizing the importance of decoding messages.

Real life connections were further enhanced through field trips addressing human rights themes that coincided with the summer workshop. Connections were made through visits to different religious and cultural institutions, luncheons with elected officials, university campus tours and participating in community-based projects. These experiences led to a specific topic on which to base their digital narratives. Students created storyboards, researched information, incorporated different camera angles, wrote voice over scripts, and learned how to take notes in an interview setting with their mobile devices. After the editing process was complete students shared their digital narratives in conjunction with the United Nations Plural + film festival screened at the public library, cultural centers, and community theaters. With their newfound sense of agency, the students gave voice to their unique perspectives, also shed light on the concept of immigration, a natural, global phenomena.

## IMMIGRATION AND SOCIAL JUSTICE CONCERNS

The decision to immigrate is more than an economic one. Immigrant families interviewed for the Longitudinal Immigrant Student Adaptation (LISA) study revealed, that 70% of them came to the US to provide better opportunities for their children and 18% emphasized the opportunity for a better education (Suarez-Orozco, Suarez-Orozco, & Todorova, 2008). According to the US Census, the overall racial and ethnic diversity of the country has increased since 2010. The third most diverse county in the US is Queens, NY whose diversity index increased in 2010 from 76.4 to 76.9 in 2020. The year 2020 also shows that Ecuadorians are the third largest Latino immigrant population in NYC, following Dominicans, and Mexicans but the largest Hispanic group in Queens, NY. (MOIA 2020). In Suffolk County the 2020 US Census reported the Hispanic or Latino population at 20.2% and the Village of Patchogue as 30.5%. The village of Patchogue is still home to the largest population of Ecuadorians on Long Island. In Patchogue, as for other schools on Long Island and across the country, immigrant communities have changed the faces of the students in the classroom.

*Figure 1. Unaccompanied Children Released to Sponsors by County - September 2021; Data source https://www.hhs.gov/programs/social-services/unaccompanied-children-released-to-sponsors-by-county-september-2021.html.*




According to Department of Homeland Security (DHS) there has been an increase in unaccompanied immigrant children (UC) apprehended at the southwest border by US Customs and Border Protections from 68,541 in 2014 to an all-time high of 112,192 in 2021. In New York the number of UC increased from 1,663 in September 2020 to 8,534 in September 2021. Based on the US Department of Health and Human Services statistics, New York State has received the fourth highest number of unaccompanied children after Texas, Florida and California which were then distributed among its different counties as described in the graph above. K-12 school employment, curricula, tools, practices, and educators are still working to reflect those changes in their classroom practices. In addition to cultural differences, educators must also be sensitive to immigration status of their students and family members.

According to the National Center for Education Statistics (NCES) nearly 80% of public school teachers are white while the majority of the student body is students of color (2018). This raises the question of cultural competency in K- 12 teaching, as in the need to have an awareness of one's own cultural identity and views about similarities and difference, and the ability to learn and build on the varying cultural and community norms of students and their families (NEA.org, 2015). In education cultural competency is being given a more critical role due to the acknowledgement that the linguistic, racial, cultural and class differences between students and teachers have been documented as playing significant roles in the achievement gap (Boykin & Noguera, 2011). Research shows tapping students' native language and culture advances their achievement while enriching classes for all students (Blankstein & Noguera, 2016).

Following the 2009 published report, *Climate of Fear,* exposing "beaner- hopping", a horrific criminal practice with violent attacks targeting Latinxs in Suffolk County, the US Department of Justice opened an investigation into the Suffolk County Police Department. The allegations against the SCPD for discriminatory policing, its anti-Latino sentiment discouraged Latino victims from filing complaints or cooperating with police and the department failed to investigate hate incidents or hate crimes involving Latino victims. The outcome was an agreed settlement between the DOJ and SCPD on areas of improvement to include; bias-free policing, hate crimes and hate incidents training and language access. As of 2017 the SCPD has still not received substantial compliance in the 29 reforms recommended by the Department of Justice (DOJ, 2018)

During the 2020 presidential campaign supporters invaded the streets of Patchogue for a rally just steps away from where others united for the annual vigil in memory of Marcelo Lucero. Under the previous administration the Latinx population has been the focus of anti-immigrant rhetoric. Especially on social media where, hate group, @FAIRimmigration hosts the largest number of Twitter followers. The media focus on a caravan of people arriving from Central America, MS13 gang violence and the debate on building the wall all fed the anti-immigrant sentiment. The latest FBI report showed a 17% increase in hate crimes in 2017 of which 59.6% of victims were targeted due to race/ethnicity/ancestry. The then President of the USA visited Long Island twice in 2018 to address the MS13 gang violence and show support of Operation Matador, a program to promote information sharing between the local police and Immigration and Customs Services (ICE). The SCPD provides school districts with school resource officers who are law enforcement officers responsible for safety and crime prevention in schools. The NYCLU has documented several cases where immigrant Latinx students had been deported after being interrogated by the school resource officer in several Long Island Schools (2018). It is clear that there is a proliferation of hate, and violence against Latinx generation.

When hope disappears, the desperation for change results in social upheaval or revolution. Educational leaders had predicted that ignoring inequality in education as well as healthcare, housing, wages, and quality of life would contribute to the downfall of the well-being and future of our nation (Blankstein & Noguera, 2016). In 2019 the inequities threaded through our institutions began to unravel and could no longer be ignored. The arrival of COVID 19 unveiled the disparities of our healthcare system especially among communities of color. Schools struggled to deliver equitable instruction to all communities and drowned in the abyss of social emotional needs of our students' families. Fear and frustration grew along with unemployment, hunger, and possible evictions. This collective anger led to civil unrest. Protests against inequities, injustices and abusive policing fed the Black Lives Matter (BLM) movement. The power of new media became more evident through the filming and sharing of the tragic death of George Floyd which led to a conviction. Moreover, it catapulted digital storytelling projects such as the Too Much Information (TMI) project aligned with BLM mission, and National University Libraries' BLM collective storytelling projects like at University of Washington Tacoma.

## Literature and Theoretical Framework of Digital Narratives

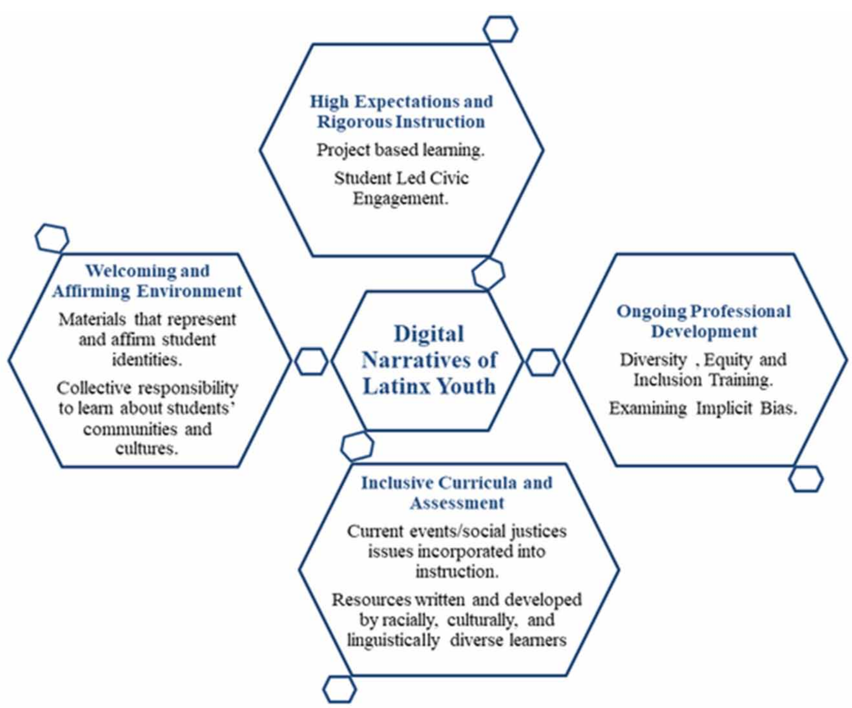
The process of creating and sharing digital narratives nurtures critical reflection and personal transformation and aids in political organizing and social activism (Brushwood Rose,2009; Gubrium and Scott, 2010; Hull and Katz, 2006; Lambert, 2013; Reed and Hill, 2010). In 2018 New York State Board of Regents directed the Office of P-12 Education and Higher Education to recruit a panel of experts to develop a framework for culturally responsive- sustaining education. The framework is grounded in four principles:

- creating a welcoming and affirming environment,
- high expectations and rigorous instruction,
- curriculum and assessment, as well as
- ongoing professional learning.

Through these pillars, the framework guides educators, and other stakeholders to create student centered learning environments that affirm cultural identities, empower students as agents of social change, and elevate marginalized voices. In 2021 the #TeachTruth movement flooded school communities across the country to encourage and defend teachers who teach about racism and resistance. On Long Island Save Our Schools anti-critical race theory (CRT) parent groups are disrupting board of education meetings against diversity, equity and inclusion policies mandated by the New York State Education Department. Their website advocates against CRT explaining to its supporters "what critical race theory is and why it's so dangerous" (saveourschools.me, 2021).

The NYSED Culturally Responsive-Sustaining (CR-S) Education Framework stems from generations of researchers advocating for asset-based pedagogies that recognize cultural difference. Traditionally, schools welcomed the cultural capital of the privileged families from dominant backgrounds as assets and ignored the value of marginalized communities. The CR-S Education framework counters dominant narratives in education, by requiring educational stakeholders to develop meaningful relationships with students and engage in their communities (NYSED, 2018). The production and implementation of digital narratives of Latinx youth directly support the four concepts of the framework as seen in figure 2.

*Figure 2. Digital Narratives impact on NYSED Culturally Responsive Sustaining Education Framework*




Culturally relevant pedagogy (CRP) is teaching that focuses on advancing student achievement, developing cultural competence and critical consciousness (Ladson-Billings, 2021). Since 1988 it has exploded globally from social studies and literacy classes to STEM and world languages. By 2012, Paris, a highly cited educational researcher based at Stanford University discussed a new vision of Culturally

Sustaining Pedagogy (CSP), which symbolizes resistance to the status quo and encourages marginalized groups to defend their linguistic and cultural sovereignty (Paris & Alim, 2017). CRP, the foundation of Culturally Sustaining Pedagogy, has been suggested by Ladson-Billings as a way to improve teacher's receptivity to our increasingly diverse student populations found in K-12 schools. She proposes that pedagogy focusing on student achievement, acceptance, and affirmation of cultural identity, as well as the development of critical consciousness, can challenge inequities in education and society (p.469). She documents how CRP provides a way for students to achieve academic success while maintaining cultural integrity. As part of the process, she proposes that students need to identify and critique social inequities which plague their communities. CRP aims to develop a learning environment in which the following are constitutive elements:

a. Students must experience academic success;
b. students must develop and/or maintain cultural competence; and
c. students must develop a critical consciousness through which they challenge the status quo of the current social order (Ladson-Billings, 1995b, p. 160).

The most current CRP has been framed within a critical race theoretical (CRT) framework and addresses issues of relevance to education through curriculum, instruction, assessment, funding, and desegregation. According to Ladson-Billings, school curriculum is a culturally specific artifact that can sometimes downplay the experiences of students of color, although extensive research shows that students' culture, language, and experiences can lead to academic success (Nieto, 2002). Many stories of youth marginalized by race and class are, however, reconstructed as acculturated (Delgado, 1989; Solorzano and Yosso, 2002) as CRT supports and encourages the retelling of stories by those people whose experiences have not been told from the perspectives of those who have lived the discrimination directly. Retelling stories is used as a tool to analyze, expose, and challenge the stories of racial privilege and racial discrimination found in the dominant discourse. It is from this tradition that many scholars have used the genres of storytelling, biography, and autobiography and other methods to challenge dominant stereotypes (Yosso, Villalpando, Delgado Bernal, Solórzano, 2001). Vasudevan (2004) has named counter-storytelling as a site of discursive possibilities for learning how youth experience, live, mediate, and embody race and other subjectivities across their everyday social practices' digital storytelling, as an educational tool, has its roots in social justice (Lambert, 2013). Studies with youth media makers reports that creating digital stories supports critiquing and rewriting dominant narratives targeting themselves and their communities and connects with issues of power, privilege, and identity (Alrutz, 2013; Rolon Dow, 2011; Weber and Mitchell, 2008).

The argument advocating for student-produced film or digital storytelling as a pedagogical tool is closely related to the role media has today in the lives of our students. In 2010, The Kaiser Family Foundation conducted a study on media use amongst Blacks, Latinos, and White youth and reported that media consumption has increased over five years from 6:21 to 7:38 hours per day. [1] Cell-phone ownership has also increased from 39% to 66%. Results also showed that the highest- level of consumption per day is found in the tweens at 11:53 and Latinos at 13:00 hours. Latinos are reported to have the highest computer use per day (1:49) but the lowest rate of access to computers at school (16%). There appears to be a contradiction between the media competency of Latino students and the lack of access to media as an educational tool in school. The students of today are the multimedia generation engaging in media encounters with smartphones, computers, Internet, cameras, Facebook, Twitter, and email. Buckingham

(2007) suggests since these new tools are new ways our youth are mediating and representing their world that schools should provide an educational space to nurture these skills and include their talents.

Several studies have documented how participatory media can be used as a tool to empower children's voices. Other examples from around the world are New York's Educational Video Center (EVC) which has offered documentary workshops to students and teachers at its own facility and at schools since 1984. Its founding executive director, Steve Goodman (2010) strongly defends the use of digital media as a legitimate and productive pedagogy, especially for impoverished districts, to foster critical media literacy and civic engagement, supporting the New York State Common Core standards. He conducted a case study in a documentary workshop, inviting a team of students to engage in a sustained video – based inquiry into a social issue within their community. The short video 'Young Gunz', highlighting gun violence in the neighborhood, allowed students to voice ideas, questions and possible solutions regarding issues that were affecting them personally or at the systemic level. EVC continues to work with the marginalized youth in NYC to document social urgent issues in their communities. Through its work with environmental issues in Harlem and the video *Breathing Easy*, it has proven how student-community partnerships can have greater impact on student media projects (2020).

Children in Immigration about Migration (CHICAM), was an action research project funded by the European Commission from 2001-2004, that involved young people in cinema clubs in Sweden, Netherlands, Germany, Italy, Greece and the UK. It was created to give children a voice and to promote intercultural communication through filmmaking (de Block, L., Buckingham, D., & Banaji, S, 2005). The various clubs were comprised of refugee and migrant students ages 10-14, one researcher and one facilitator. Not only did participants create short films but the films were then shared with their international counterparts via the Internet.

The ethnographic research project, Video Culture was conceived and first implemented in Ludwig, Germany in 1997, and explored how audiovisual media production can be used to communicate between young people in different regions. The Ludwig video culture research focused on how the form of transcultural symbolic language can overcome cultural and linguistic differences. The project included groups of young people ages 14-19, from different socioeconomic backgrounds in Germany, England, the Czech Republic, Hungary, and the United States. These students produced, exchanged, and interpreted thematically oriented videos based on work from different educational settings. Selected students had no previous media production experience and were given five days to complete a three-minute short film based on a specific theme (Niesyto, Buckingham & Fisherkeller, 2003) and inspired other programs.

Esperanza Program was created as a court diversion program for Latinx youth between 2007-2012 in a small Midwest city. It was co-sponsored by the municipal courts and a community-based organization to interrupt the school to prison pipeline. Participants referred to the program were first offenders of aggression, truancy, alcohol and drug abuse and gangs. This qualitative research case study included 33 participants to offer a voice to Latinx youth and their parents. CRT and LatCRT were used to analyze the counter stories of participants about identity, and immigration. The municipal judge coined it "success" when he did not see youth returning to his courtroom (Mancilla, 2018).

## LIFE THROUGH MY EYES

LIFE through My Eyes, is a student-led digital narrative project with a focus on human rights that was first implemented shortly after the death of Marcelo Lucero, an Ecuadorian immigrant, who was the victim of a hate crime in 2008 in Patchogue, New York.

The participating families from 2010-2014 were originally from Azuay, Ecuador, which is the largest province in Ecuador experiencing an exodus of emigrants. Today they reside in Patchogue, a suburb of Long Island located 60 miles east of New York City where the immigrant population has doubled in the last ten years. Their children, the 1.5 generation Ecuadorian youth, also called DREAMERS, were currently or previously enrolled in an ESL program. According to Immigration Policy, dreamers are young immigrants that meet the criteria for the Development, Relief, and Education for Alien Minor Act (DREAM). These individuals are under the age of 31 who have arrived in the US under 16 years of age and continuously lived 5 year or more in the US. These individuals also have not been convicted of a felony, or misdemeanor, are studying in school or college, received a GED or have served in the military. Many of these young people speak Spanish at home but English is the language of instruction at school and socializing with friends. Although some of them scored below average on the New York State ELA test, their reading and writing skills in English are stronger than in their mother tongue. Across the board, many of these young people have experienced struggles with different types of discrimination in their community and schools with limited political and social capital needed to help to address the social maladies they encounter. Mills (1959) proposed that the first step in social change is to mobilize communities with similar issues, which is one reason why the project LIFE through My Eyes was implemented.

This innovative educational project was first implemented in 2010 in the Patchogue community as an after-school program, summer program and parent workshops, and its success is attributed to its support from principals and staff, co-facilitators; Film and Educational Research Academy at Teachers College, Long Island Teachers Association, and most importantly parental support and collaboration. Over the course of three years, we nurtured the relationship with each family through dinners, graduation and confirmation parties, group excursions, soccer tournaments and LIFE through My Eyes activities. As the relationships strengthened through community building activities, we saw an increase in students' confidence as well during the filmmaking workshops. As shown in figures 7 and 8 below, students did not hesitate to approach strangers in the streets to interview or investigate concerns directly affecting their lives.

Life through My Eyes expanded after the grant period ended with W.K.Kellogg Foundation. The project was sustained for an additional year in Patchogue in collaboration with Cornell Cooperative Extension and FERA, and in 2016 it moved it moved to Longwood JHS with small grant funding opportunities from the NYSUT Retirement Council #21 and Target. As the program continued it took on new parameters. Our facilitator was no longer an adult experienced video maker, but an alumnus from our original program. She was a Latinx DREAMER from Ecuador residing in Patchogue with her family. She had a passion for filmmaking and in high school was a recipient for the Marcelo Lucero scholarship for her video, *Migration and Diversity*. After graduating high school, she began her studies in Communications and Media at the community college and later graduated from New York State University of Oswego. As a mentor she facilitated additional youth workshops in the community. Her age, passion and personal experiences made her more relatable to the students. It was important to have a Latinx hold a leadership role and for future media makers, especially of color, to see her in a position of power. Under her guidance, she set the guidelines for the workshops. She led an all-girls workshop to address body image and self-esteem producing, *We are Women* (2015). “I got to say my opinion and how I feel”, a student shared, “and I actually got to speak up”.[2] Additionally under her leadership was *Aguaponics* (2015) a video about environmental issues. During the 2016 presidential campaign and subsequent presidency, she encouraged a mixed group of Latinx to address diversity and political rhetoric with videos; *Words Matter, Speak-Up* (2016), *Fake News* (2017) and *Diversity in Fire Island* (2018). These videos can be found at the following site Fake News 2017 and Diversity in FFINS 2018.

*Figure 3. Fire Island National Seashore (FFINS) field trip (2018)*

*Figure 4. Filming for Diversity on Fire Island (2018)*

*Figure 5. Words Matter Speak Up interviews (2016)*

*Figure 6. Words Matter Speak Up editing (2016)*

*Figure 7. Child Labor On the streets of Patchogue resident is being interviewed about child labor (2014)*

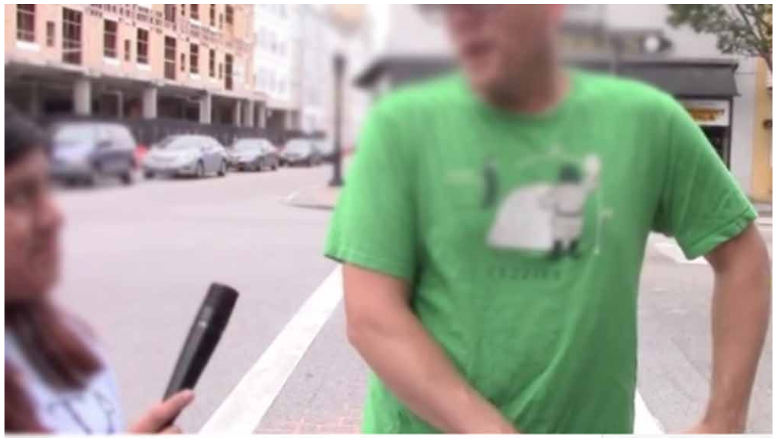


*Figure 8. Migration Interview with Legislator Calarco (2014)*


## METHODOLOGY

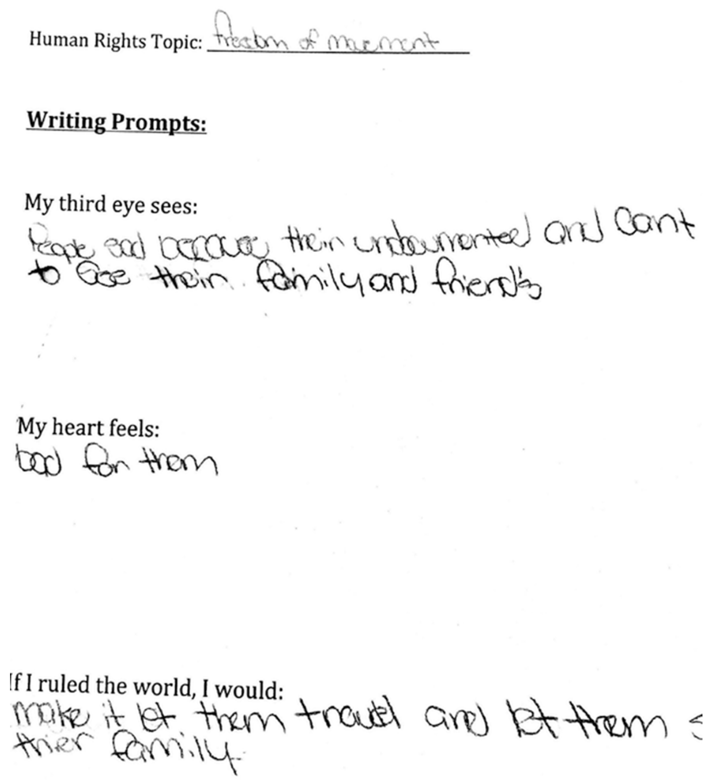
The Patchogue participants attended several filmmaking workshops held at the public library after school, on the weekends, and in the summer. The goal was to capture the collective stories of these youth on video. These digital narratives were inspired by human rights addressing religion, language, culture, family, education, and immigration. All aspects that impacted them that they did not necessarily know were rights that they had, or rights that would also apply and serve them well in the workplace. For the first few years we contracted facilitators from FERA at Teachers College and Educational Video Center (EVC). An example of the career interests and job skills cultivated through the Video Production program was that eventually we were able to recruit one of our alumni Estefania, a young filmmaker, who studies television and radio broadcasting to facilitate our workshops.

First, participants were encouraged to share topics that affected them most, either in the community, school or at home. Many of the common themes included: discrimination, racism, hunger, bullying and keeping the community clean. At the EVC workshop, students were directed to choose an article from the universal declaration of human rights and complete the writing prompts as shown in figures 9 and 10 such as: my third eye sees…my heart feels…, if I ruled the world I would….

After these activities, students were able to organize themselves into groups with common themes to write the script, and questions.

The facilitator followed similar procedures while conducting her workshops. She introduced the students to the importance of each role in filmmaking; the recorder, editor and interviewer as seen in figures 5 and 6. Once they decided on a theme, she assisted them with research, and searching for secondary images and B-roll footage.

*Figure 9. Writing prompt, freedom of movement*



Human Rights Topic: freedom of movement

**Writing Prompts:**

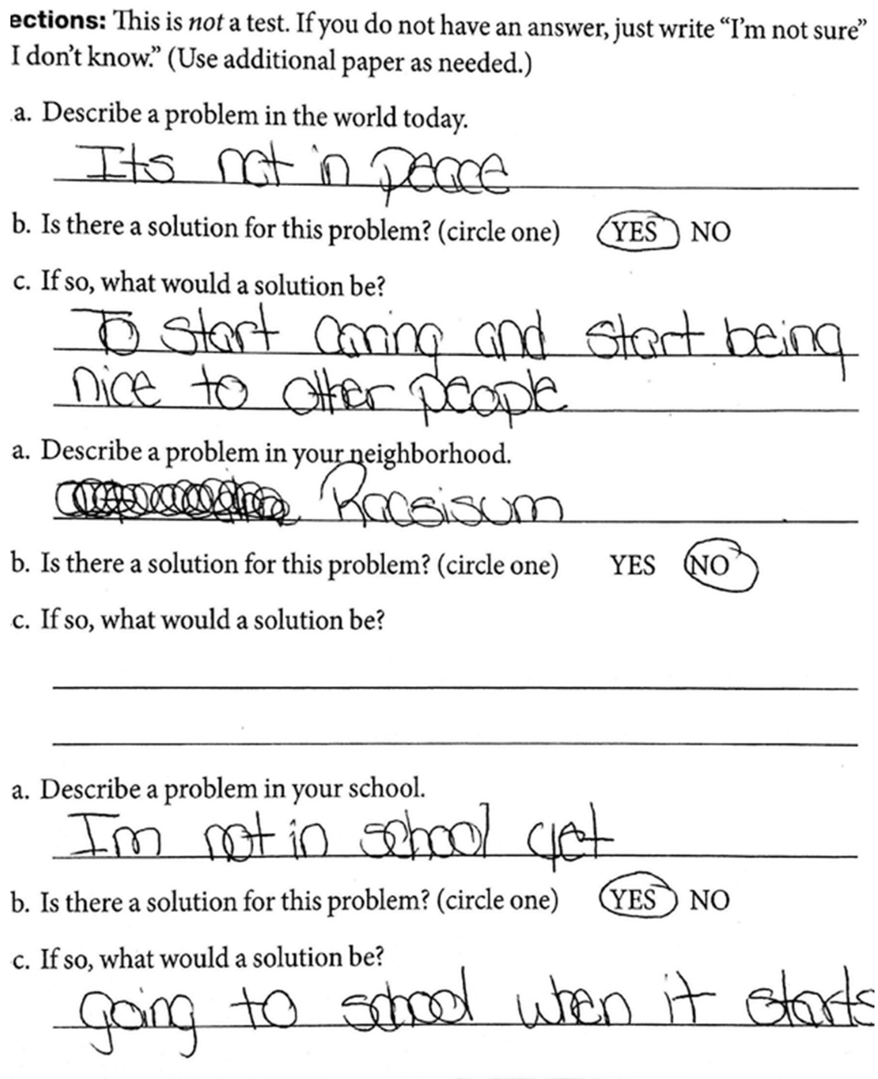
My third eye sees:
People sad because their undocumented and cant to see their family and friend's

My heart feels:
bad for them

If I ruled the world, I would:
make it let them travel and let them s
thier family.

Secondly, once the script is completed each group works on their storyboard and discusses necessary shots and photos, matches script and quotes with each image, and chooses music. Before going out on camera shooting expeditions, groups must assign the following roles: soundman, cameraman, interviewer, director, and someone to scout the scene. After each interview, students switch positions, so everyone gets an opportunity to experience each role. Third, after filming was completed groups began the editing session and again shared responsibilities. As shown in figures 11,12 and 13 editing included hard skills like video editing, adding sound or images and also took the critical thinking development further with scene selection, soundbites to include, appropriate music and font of subtitles, to mention but a few actions.

*Figure 10. Writing prompt, describing problems*



**ections:** This is *not* a test. If you do not have an answer, just write "I'm not sure" I don't know." (Use additional paper as needed.)

a. Describe a problem in the world today.

Its not in peace

b. Is there a solution for this problem? (circle one) YES NO

c. If so, what would a solution be?

To start caring and start being nice to other people

a. Describe a problem in your neighborhood.

Racisum

b. Is there a solution for this problem? (circle one) YES NO

c. If so, what would a solution be?

a. Describe a problem in your school.

Im not in school yet

b. Is there a solution for this problem? (circle one) YES NO

c. If so, what would a solution be?

going to school when it starts

Students developed individual leadership and group work skills. From the outset, we attempted not to frame our approach in formal methodology, which afforded many pros and cons. Advantages of operating from a flexible framework meant that the facilitators, support staff and students were not restricted to what they could envision or design within the framework laid out previously. Disadvantages to this flexible approach, at times, did not fit well with the formal approach or the academic modus operandi of K -12 teaching settings. Furthermore, we also needed to operate within the confines of the learning centers' digital tools, the limited after school and summer program time and their own personal audience's identified goals. In addition to requiring the students to conduct a needs assessment of their assigned themes or interests, we also asked students to get a baseline of what they currently understood from one of the UN Human Rights' themes. We also had to ascertain what digital tools we would have access to at each digital center in terms of technology (computers, mobile phones, Wi-Fi or what their knowledge or use of producing video was, as well as their computer and media literacy skills. Our informal needs assessments were conducted as part of our program, and also looked at what technology the students were currently using or had access to from a computer technology hardware and software perspective. In keeping with our learning theories that informed our methodology and the reality of time frames and time limitations, the idea was to leverage what knowledge and levels of computer proficiency they currently have, and to build on what they identified as needing to produce their digital video narrative. Ultimately, we increased their computer technological literacy and 21st century skills.

*Figure 11. Robert Branch leading editing workshop with FERA at Pat-Med HS using I-Movie (2011)*

*Figure 12. Editing workshop with EVC at South Ocean MS using I-Movie (2012)*

*Figure 13. Editing workshop at Teachers College (2013)*

*Figure 14. Field trip to Teachers College; Right to Education Tour (2013)*

Projects that continued in the years following the W.K. Kellogg funding, met with less restrictions and more flexibility. The ability to hire an alumnus and young Latinx leader was met with less resistance since fewer organizations were involved and the original organizer and facilitator of the program, had total control of the decision making. It was an advantage to move the project to the school where the project manager work, because we had more familiarity with school culture, available resources, and easy access to and more time with the students. This also saved us money and travel time.

Funding is a necessary component to the success of the project. It is imperative to pay a young leader to facilitate the workshops. In my opinion, alumni from the community, especially students of color, must be recognized for their talents and compensated for their time and effort. The students we work with are struggling financially for various reasons and why not nurture their passions and abilities. An obstacle impossible to overcome while working with funding from formal organizations is the prevention to hire undocumented youth. A disappointment with formal organizations was the lack of racial, ethnic, and socio-economic diversity while recruiting helpers. It's imperative we employ the community in which we work to be part of the change.

In 2019, COVID-19 closed the schools and changed the structure of education forever. Funding at that time was focused on synchronous and asynchronous teacher training. For personal reasons, it was difficult to organize workshops via Google classroom although it was the most needed time for students to share their voices and have their stories heard. In 2020, as schools continue to adapt to community needs there has been a push for student-focused digital storytelling. In the near future it is planned to search for new funding and continue the Life through My Eyes projects.

## CONCLUSION

Over the past few years, we have seen how social media, specifically video, has been used successfully as a tool in mobilizing communities. Examples include the following: transmitting the democratic uprising of the Arab Spring; documenting verbal abuse toward an Uber driver which led to the resignation of a NYC officer; the recorded death of Eric Gardner resulting from an illegal police chokehold in Staten Island and the recordings of a Suffolk County police officer caught stealing from undocumented immigrants during unauthorized stops as well as the recording of the murder of George Floyd in Minneapolis, Minnesota in 2020. These recorded actions have all led to a call for action once viewed by the public, having left an indelible mark on the public psyche.

The process of working up to the video production, as well as the post public presentation of the produced videos, fostered positive influence on the lives of our participants, their families, and the communities. The analogue and digital learning journey also reflected their continuous affective interactions, experiences and aided their social emotional well-being. Which in turn can have a positive effect on their personal lives as well as their academic progress and success.

Observations indicate that a collaborative project of this nature can be highly beneficial for all stakeholders as it delivers a layered work that reveals the hosting of multiple perspectives and multi-directional memory. The students' depiction of the Universal Declaration of Human Rights (UDHR) and other immigration issues posits a post-colonial tension within different contexts. The digital video production also navigates the inner thinking and at times conflicting ideas of prescribed and self-actualized identity. And does so through the promotion of agency in resisting racial policies and practices. Echoing Hall's (1972) deconstruction of race as a "floating signifier", some of the students' videos initially depicts the themes through an idealized and romanticized lens but at the same time offering multiple perspectives of a harsh politically imposed reality. The multi-dimensionality of identity and power of agency amidst a forced upon dominant culture was also explored through their production of the digital video narratives.

The video production processes were initiated in ways that increased collaborative efforts, online and offline. Using applied theoretical knowledge and experiential teaching systems, we not only strengthened the capacities of the current young literacy digital narrative programs, but also empowered the learners to draw on past experiences and individual expertise. Thus, they became active collaborative agents who had the ability to use technology to build and contribute to the film, real and online world. Youth tend to enter settings ready to learn and the program capitalized on those aspects to engage them in video production and digital narrative projects that, while they focused on themes, community needs or their group problem solving techniques, they were further motivated by intrinsic factors. The systems and instruction were designed to meet the self-identified goals and objectives of the learners, and the learners' use of the digital media tools ultimately developed them in ways that were difficult to formally assess. In general, current computer literacy, digital production and purposeful internet usage in NYC's K-12 education programs consists predominantly of desktop word processing, and unstructured Internet surfing with search engines. There were only introductory instructions on, or with digital media tools to produce the video, but students were provided space to build on the introductory foundation.

Facilitators realized there were different meta-cognitive processes at play for each student and groups of students. This was evident from the devices they used and how they employed the tools. Tools used by students showed careful consideration developed by them prior to, during and after the video production process. Teaching support staff had the opportunity to see the underlying and overarching pedagogical principles at play in incorporating digital video production in a program and as a practice in general. Shifting some of the teaching assistants' ideas, who were long-term serving teachers where passive receiving of education is the order of the day, offered some transformative learning experiences. While receiving support from the teaching assistants was challenging, it was not a deterrent to the students using the digital tools.

Success also came in the form of introducing the young learners to the numerous digital tools that went into video production tools and that was available to them. Universal user interface offered familiarity with the tools and their quick uptake of the digital tools offered a further functionality, which aided in the success of the initiatives, by anchoring the overarching goals to an objective or level of proficiency with which the learners were comfortable. Learners were reminded that success was defined by a digital narrative project that was authentic and important to them. Lessons learned lasted beyond the piloted time frame of the LIFE digital video narrative initiative. Examples of success ranged from students' own personal growth, proficiency, as well as transformative learning experience for students and for some of the full-time teachers helping as teaching assistants.

It is difficult to say which learning activities or initiatives were most appealing, as well as to have measured the students' learning enjoyment. The creation of a digital narrative and a collective space for past, present, and future films produced in the program, showed a body of work that they could be proud of, as well as showcased the skills they picked up along the way. The past and new program designs received positive reviews. These youth produced films have been screened in film festivals at universities, local theaters, libraries, cultural centers and recently in conjunction with the United Nations Plural + film festival. In 2015 and 2016 the Suffolk County Inter-Faith Anti-Bias Taskforce recognized the program, its facilitators and *Immigration and Diversity*, by means of a short film by Estefania and *Speak Up Words Matter* filmed by Longwood JHS Hispanic Heritage Learners as seen in figure 15. There were no new venues for the films besides academic presentations for American Council of Teachers of Foreign Language Cinema SIG in 2017 & 2018. Additionally, the UN Plural + Youth Video festival continued throughout the pandemic with a few changes. The categories expanded to include #SafeWorship and solidarity amid Covid 19. The festival was hosted online also due to the pandemic in 2020 and 2021.

Although many of the digital media tools still need to be integrated into their formal schooling, students now have the knowledge and skill to present any of their schoolwork or personal stories, in a well-crafted digital film manner. Parents and staff also provided positive feedback which resulted in an increase of students participating in the program over the years and an increase in the number of digital narratives produced.

*Figure 15. Words Matter Speak Up anti- discrimination film recognized at SC Interfaith Anti-bias Taskforce 2016*


In 2020 anti-Muslim hate groups declined from 84-72 while remaining groups focused on the importance of organizing at the local and state levels (SPLC, 2020). Violence continued in the new administration during the COVID-19 breakout as hate crimes against Asians rose by 76% (FBI, 2020). On May 20th, 2021 President Biden signed the anti-Asian hate crime bill in response to the increase. Empathy and desire for social change begin with an understanding of others; to listen to their stories and share one's own. In today's current climate it's most important for educators and community leaders to include the diverse perspectives our students bring to the classroom. Many of our immigrant youth are recognized as digital natives, capable of sharing narratives about how life is experienced through their eyes using computer technology. I encourage my colleagues to support the use of film as a pedagogical tool to foster cross-cultural dialogue between our educators and newcomers. I hope through the lenses of critical pedagogy and critical race theory more teachers will explore how the process of creating digital narratives nurture students' voices and increase civic engagement in a target population whose voice is limited by their immigration status.

Through our collaborative efforts, the middle and high school students emerged with a sense of innovation that catapulted them to the forefront of being able to traverse and take ownership of their physical and digital world. With the team leadership of the program organizer, the young learners increased their confidence in navigating and leveraging their new digital video production skills. The efforts by the LIFE through their eyes program, had the effect of making some of the digital learning centers more visible, not only in terms of use, but also in terms of a community presence. The digital video projects that were produced also instilled the potential for these young learners and their affiliated learning organizations to not only connect their youth with one another but also with societal issues and enhance further support for their cause of highlighting Marcelo's unfortunate death as inspiration for the empowering program. This social community digital video project, which was started for the betterment of young learners in New York City, put a strategy in motion for the Long Island Communities, New York City, and their similar organizations from around the world. Valuable lessons were learned from the implemented digital media projects and key issues were revealed that could also be applied to other digital video production centers that are pushing for more digital narrative initiatives of marginalized youth. The initial short-term implementation delivered not only lessons, but also built momentum for future projects within the program, the digital learning centers, and other non-profit organizations that focus on informal digital video production learning opportunities.

## RECOMMENDATIONS

Our immediate recommendations for a second iteration of this project encompassed the changing of digital center venues, leveraging other video production persons and organizations, as well as increasing the time frame of engagement to allow students more time to develop and hone their video narrative skills. The recommendations were multifold and interrelated with all stakeholders concerned and addressed the previous challenges faced by the students and at the learning centers. The overseeing committee also investigated how to enhance the technical and support infrastructure of the program, and either increase or reduce the involvement of the full-time teaching assistants. While the first iterations of the program were done in short pilot format bursts, the entire process could have benefited from a longer time span where students could possibly have worked on more than one digital video project over a semester. A recommendation for the program organizers was to train and empower a select group of full-time teachers as assistants and to utilize technically gifted learners to help manage the program, the center and the supportive adult group of parents and other stakeholders. Learner's social media could also have been explored to add further ownership, pride as well as to market the program objectives and their work. Utilizing the social media of the learners would offer further ownership of the projects and offer the students opportunities to revisit and hone their technical, digital video production skills, and leadership skills.

Consultants contacted could have met earlier, virtually, and longer with all the major stakeholders, ranging from the program organizers, teaching assistants as well as the learners. So that the consultants on the project could also have gained deeper insight into the students' digital literacy levels, their likes, learning styles and various other social media initiatives they embraced. This could be addressed by embedding the consultants within one or two of the projects during the semester or before the summer part of the program. They could act as passive observers and help in identifying a project management sharing tool, to provide cognitive surplus through collaborative tools and build out the infrastructure of knowledge management, and to act as a virtual hub and reference point for the digital video projects. All of which would have been beneficial to all stakeholders who were mostly full time employed with other competing demands. An online central location could also be identified for the project to be used to share resources among all involved, where everyone could document and ask questions of the program organizers and cultivate collaboration amongst themselves with virtual tools. The online tools could offer constant access and opportunity for feedback when it was convenient for all agents involved in the project rather than confining the sharing to just before the start of the summer program. All involved would then have had greater cognitive resources to share amongst themselves, cater for ongoing feedback, and everyone could have had a living document to reference during the semester running of the afterschool portion of the program. The students, who operated in teams of two or three, could also have had their own online spaces that they could have used to keep track of project progress, offered additional reflection, feedback and could have done so in that virtual space with different support staff who could have offered affirmations or ideas.

The project would not have been successful without the support of the parents. Their trust is critical for educators to successfully advocate for students. As parental approval increased so did the desire for community organizations to become more involved. From the beginning parents and students had input on how to organize the program and over the years they have taken on leadership roles. To run a successful program, it is crucial to empower parents to become community leaders and to identify globally aware, competent educators to serve as liaisons between the community and the school. The ability to receive independent funding also allows educators more freedom to implement programs through a grassroots framework.

## FUTURE DIGITAL STORYTELLING AND RESEARCH DIRECTIONS

Life through My Eyes pilot program has grown over the years to include different districts, but there is still a need to grow, teach and expose the unique advantages of interacting with as well as producing digital film and for a wide variety of audiences. There is an additional need, not just within this program, but also other youth programs of this nature to teach digital engagement and production of digital video with and via hypermedia concepts and means. Using a blended learning approach, the computer technology's hypermedia capabilities can be used to teach at all levels and can actively promote personal reflection, participation, the collation of multiple perspectives and provide opportunities to learn from other youths' previous digital film examples that could be interacted with via availability online.

The teaching of digital film via hypermedia offers collated opportunities and incorporates the use of online environments for the real-time teaching and learning of films. With the 'inter-web' paradigms shifting from end-users to active participators, the milieu of the web has increased new media use, human interaction and digital storytelling of marginalized people. The hypermedia framework is set up in such a didactic manner that teachers and students of this program and others of the same nature can be exposed to an online learning environment that is hopefully more than a repository for film clips, but rather an interactive and dynamic learning environment that offers book-marking within the film clips, space for saved reflective notes as well as asynchronous interaction with other class participants on the aforementioned points. All of which would not only activate reflection, but provide valuable tips, tricks, styles, and new ideas of how the new students in the program could approach their digital video production. Hence, instead of starting from complete scratch, they would have seen some mistakes made by others or fantastic ideas that were employed.

In creating and using an interactive hypermedia learning environment, the program staff and participants could be exposed to deal with and save for future use, discussions, theories, and concepts used by other educators, students, student analyzers, and reviewers of the previously produced digital video and its various styles, forms and/or embraced other genres in the making of their digital film.

The in-class, or rather in-person program sessions, combined with the online hypermedia video learning environment could extend review time, discussions, analysis and teaching methodologies of digital film and tools. Reflections and comments could also cover contexts, political settings, institutions, systems, and social situations. It will emphasize the comparative and divergent angles from which digital film production can be approached and offered within various learning environments from elementary through to high school.

For the program, taking movement within the context of our current digitally lived lives of online video repositories and engagement with online video via comments, community engagement and impact of different scales can be taken into consideration. The video proliferation on the web via YouTube, plus a host of other video hosting sites, the hosting of the current youth produced videos of the program could be turned into interactive engagement tools, as either part of the program or included as anchors within other educational opportunities.

The increase in youth having access to mobile devices and the permission to use these devices in class give equity to video programs to underserved communities. Capturing and editing mobile videos to further promote mobile journalism and mobile activism, as future research directions will also be explored. As shown in figures 8 and 9 student reflections on the experience prove to pursue the path of youth generated digital narratives.

## REFERENCES


Blankstein, A. M., Noguera, P., & Kelly, L. (2016). *Excellence through Equity*. ASCD.

Boykin, W. A., & Noguera, P. (2011). *Creating the opportunity to learn moving from research to practice to close the achievement gap*. ASCD.

Caro-López, H. (2010). *Ecuadorians in New York City 1990—2008.* Center for Latin American, Caribbean & Latino Studies. Retrieved from https://clacls.gc.cuny.edu/files/2013/10/Ecuadorians-in-New-York-1990-2008.pdf

Congressional Research Service. (2021, September 1). *Unaccompanied Alien Children: An Overview.* https://crsreports.congress.gov

de Block, L., Buckingham, D., & Banaji, S. (2005). *Final project report: Children in communication about migration*. London: Institute of Education, University of London.

Delgado, R. (1989). Storytelling for oppositionists and others: A plea for narrative. *Michigan Law Review*, *87*(8), 2411–2441. doi:10.2307/1289308

Department of Justice. (2018). *Sixth Report Assessing Settlement Agreement Compliance by Suffolk County Police Department.* Retrieved from https://www.justice.gov/crt/case-document/file/1054396/download

FBI. (2018, September 14). *Hate Crime*. Retrieved December 28, 2021, from https://www.fbi.gov/services/cjis/ucr/hate-crime

Fordham University of Law & Vera Institute of Justice. (2015). *Unaccompanied immigrant youth in New York: Study for identity and inclusion- a participatory research study*. Retrieved from https://www.fordham.edu/download/downloads/id/2416/unaccompanied_immigrant_youth_in_new_york_august_2015.pdf

Goodman, S. (2003). *Teaching youth media*. Teachers College Columbia University.

Goodman, S. (2010). Educating for democracy: An uncommon standard. *The New York Times,* pp. 1-6.

Goodman, S. (2020). Teaching for Environmental Justice at the Educational Video Center. *Journal of Sustainability Education*.

Ladson-Billings, G. (1995). Toward a theory of culturally relevant pedagogy. *Educational Research*, *32*(3), 465–491.

Ladson-Billings, G. (2021). Three Decades of Relative, Responsive, & Sustaining Pedagogy: What Lies Ahead? *The Educational Forum*, *85*(4), 351–354. doi:10.1080/00131725.2021.1957632

Lewis, O. (1959). *Five families: Mexican case studies in the culture of poverty*. Basic Books.

Mancilla, G. (2018). Latinx Youth Counterstories in a Court Diversion Program. *Taboo: The Journal of Culture and Education, 17*(4). Retrieved from https://digitalcommons.lsu.edu/taboo/vol17/iss4/5

National Center for Education Statistics. (2018) https://nces.ed.gov

Niesyto, B., Buckingham, D., & Fisherkeller, J. E. (2003). Video culture: Crossing borders with young people's video productions. *Television & New Media*, *4*(4), 461–482. doi:10.1177/1527476403255813

Nieto, S. (2002). *Language, culture and teaching critical perspectives for a new century*. Lawrence Erlbaum Associates, Inc.

NYC Mayor Office of Immigrant Affairs. (2020). *State of Our Immigrant City*. Retrieved from https://www1.nyc.gov/assets/immigrants/downloads/pdf/MOIA-Annual-Report-for-2020.pdf

NYCLU. (2017). *How this New York County is Helping ICE Trap Teens*. Retrieved from https://www.nyclu.org/en/news/how-ny-county-helping-ice-trap-teens

NYSED. (2018). *Culturally Responsive-Sustaining Education Framework*. http://www.nysed.gov/common/nysed/files/programs/crs/culturally-responsive-sustaining-education-framework.pdf

Paris, D. (2012). Culturally sustaining pedagogy: A needed change in stance, terminology, and practice. *Educational Researcher*, *41*(3), 93–97. doi:10.3102/0013189X12441244

Paris, D., & Alim, S. (2017). *Culturally sustaining pedagogy: Teaching and learning for justice in a changing world*. Teachers College Press.

Rojas, L. B. R. (2012, March 21). *Gen 1.5: Where an immigrant generation fits in*. Southern California Public Radio. Retrieved January 21, 2022, from https://archive.kpcc.org/blogs/multiamerican/2012/03/21/7963/what-is-a-1-5-where-an-immigrant-generation-fits-i/

Save Our Schools. (2021) *Knowledge is Power*. https://saveourschools.me/knowledge-is-power/

Solorzano, D., & Yosso, T. (2002). Critical race methodology: Counter-storytelling as an analytical framework for education research. *Qualitative Inquiry*, *8*(1), 23–44. doi:10.1177/107780040200800103

Southern Poverty Law Center. (2009). *Climate of Fear* Retrieved from https://www.splcenter.org/20090831/climate-fear-latino-immigrants-suffolk-county-ny

Southern Poverty Law Center. (2020). *The Year in Hate and Extremism*. Retrieved from https://www.splcenter.org/news/2021/02/01/year-hate-2020

Suarez-Orozco, C. S.-O., Marcelo, M., & Todorova, I. (2008). Learning a new land. The Belknap Press of Harvard University Press.

US Health and Human Services. (2021, September). https://www.hhs.gov/programs/social- services/unaccompanied-children-released-to-sponsors-by-county-september-2021.html

Vasudevan, L. (2004). *Telling different stories differently: The possibilities of (counter)storytelling with African-American adolescent boys* (Doctoral Dissertation). Retrieved from https://repository.upenn.edu/dissertations

Yosso, V., Delgado Bernal, Solorzano. (2001). *Critical Race Theory in Chicana/o Education*. Paper presented at the National Association for Chicana and Chicano Studies Annual Conference, San Jose State University.

## KEY TERMS AND DEFINITIONS

**1.5 Generation:** Term refers to foreign-born children of immigrants. Many arrive under 12 years old. Many are bilingual and bicultural and may live in hybrid household which consists of documented and undocumented family members.

**Bullying:** Aggressive behavior that seeks to harm, coerce, or intimidate another who appears vulnerable or inferior. Serious behavior in school targeted against marginalized groups.

**Counter Stories:** An opposing narrative (counter narrative) discussed in CRT in education by Ladson-Billings and Tate (1995) as a means to name one's own reality or voice. A tool to express one's lived experience contrary to the dominant narrative of the dominant culture.

**Digital Narratives:** A multi-media presentation of one's narrative or story including elements such as images, sound, text, video and/or social media.

**Hypermedia:** A system with various forms of interactive information such as text, graphics, video, audio, and data all linked together via hyperlinks.

**Latinx:** A term that neutralizes the Spanish gender of Latino or Latina which describes people of Latin American cultural or ethnic identity in the United States. Latinxs is the plural form.

**Mobile Activism:** Addressing social justice issues by using mobile technologies for documentation or mobile engagement to promote social change. Examples were found to be, and more pronounced with events such as Arab Spring, Eric Gardner killing, George Floyd murder etc.

**Youth Film Production:** Process by which video is produced by young adults. Several programs exist in schools and non-profits.

## ENDNOTES

1. Generation M2: Media in the Lives of 8-18 Year Old's Kaiser Family Foundation Study, Jan 2010
2. Student shared after film workshop addressing women's rights May 2015.

# Chapter 11
# Educational Online Video in Adaptive E-Learning

**Ikram Chelliq**
https://orcid.org/0000-0002-0998-1744
*Abdelmalek Essaâdi University, Morocco*

**Mohamed Erradi**
*Abdelmalek Essaâdi University, Morocco*

**Mohamed Khaldi**
*Abdelmalek Essaâdi University, Morocco*

## ABSTRACT

*The field of education has undergone a significant evolution in the face of technological innovation and through the use of technology that has had a significant impact on teaching and learning. The use and integration of video in adaptive e-learning has proved to be a beneficial method of delivering learning content. Educational online videos are becoming more and more successful thanks to the excellent progress in video production technology, methods, and techniques. The chapter presents a framework to develop an effective online video that facilitates learning. In this chapter, the authors present a methodology and a set of guidelines, tools, and processes for scenario setting of educational online videos. They also offer an approach to the presentation and the integration of scripted educational online video in adaptive hypermedia systems to ensure the process of scenario adaptation that will facilitate enhanced learning.*

## INTRODUCTION

Information and communication technologies (ICTs) is defined as the use of technology to enhance support and optimize the delivery of information. ICTs have greatly enhanced audiovisual engagement during the advancement of new audiovisual approaches to education. The educational video has become an effective tool for learning and engagement in education, as it combines audio and video to convey concepts often perceived by learners as abstract and complex but when done well, does so in a clear

DOI: 10.4018/978-1-6684-3996-8.ch011

and structured way. Educational videos are progressively being integrated into face-to-face or distance courses, such as online training, hybrid training, Massive Open Online Courses (MOOCS), Small Private Online Courses (SPOCS), or flipped classes for both young children and adults.

Online video can be the basis for many learning activities and can also be used as a means of learning and communicating information, to aid the transferring of knowledge, visualizing processes, or analyzing learning situations. As educational online videos have been increasingly incorporated into teaching and learning whether for young children or adults, they are being used to convey knowledge through many forms. Examples of such forms are cartoons or animated films for the youngest, real-life scenarios (for instance, videos of road situations with multiple-choice questions to learn the highway code), or recordings of courses or conferences. Educational videos are becoming increasingly popular and are being used in a variety of educational settings. On the Internet, especially on YouTube, there are thousands of educational online videos because it is fed by individual and group motivation as well as the masses and caters for individual and public interests, needs, and tastes. Although there are many contexts in which educational videos are used, creating an effective educational online video, that is, a video that teaches a concept and from which the learner retains the main message can be a difficult task. An online educational video design must ensure that both words and pictures are carefully intertwined so that the whole is greater than the sum of its parts.

This chapter presents the process of scenario setting, which is the concept of developing a pedagogical scenario for educational online video intended to be used and manipulated in a learning context to give coherence to a complex learning situation. Further, the creation of learning activities will be explored to situate the learning interactions that occur while engaging with educational videos, including subsequent assessments. To achieve the engagement objectives, it is necessary to set up an online scenario for pedagogical online videos. The chapter presents an approach and a strategy for a simulation close to the real scenario. Furthermore, this approach also offers the ability for online video to create opportunities for mediating meaning (Mentor, 2006) for online videos in a pedagogical manner. This multimedia activity, which has moved more and more online, is defined as a situation created by a teacher and proposed to the learner, which Charles Kinzer and others referred to as Anchored Instruction (Bransford et al., 2012; Glazer et al., 1999; Kinzer et al., 1994).

This chapter proposes guidelines and tools for scripting an educational online video to facilitate the creation and framing of the online video for maximum learning effectiveness. We propose a new structure for the representation and organization of an educational online video based on the cognitive and pedagogical considerations that enable educators to select or develop videos that can help teachers maximize the benefits of the usage of online videos. This structure is proposed to bridge the gap between low-level representative features and high-level semantic content in terms of object, event, and semantic relation extraction in a hypermedia learning system and to help maximize the satisfaction, understanding, speed, and learning success (performance) of each learner model.

## THE OVERVIEW OF EDUCATIONAL ONLINE VIDEO

Radio and television have employed audiovisual material for educational purposes for many years, and have been and still is a very helpful informational and educational resource in several areas of people's daily and professional lives. Additionally, educational video via television aims to improve access to highly rated pedagogical or educational practices to solve the problems related to providing more people en masse with access to education and training (McClusky, 1947; Fuchs et., 2016; Orgeron et al., 2011). This type of audiovisual resource started gaining popularity in the early 1900s to inform the audience about a specific topic (Molenda, 2008; Snelson & Perkins, 2009). For example, educational films were seen as a method for disseminating academic content within universities and schools (Fuchs, Bruch, & Annegarn-Gläß, 2016). In this case, the focus was on reproducing as closely and as objectively as possible the phenomena of the physical world. However, the pedagogy was considered paramount by film reformers if films were to contribute to educating and mobilizing young people (Fuchs et al., 2016; Fletcher, 2019). Of course, many uses of film for sharing public information, or within educational contexts, started with just audio in the form of radio.

In 1920, the British Broadcasting Corporation (BBC) began broadcasting educational radio programs for schools. The first adult education radio program broadcast by the BBC in 1924 was a presentation on insects in relation to humans (Hancock, 1964). By the 1930s, Commissioner Augustin Frigon proposed the installation of radio equipment in the Commission's schools. He was a strong believer in educational radio (Hancock, 1964; Potdevin et al., 2018). In 1960, the idea of using television in education was particularly developed for schools and for general adult education (one of the six objectives of the current BBC Royal Charter is still to "promote education and learning"). In the same year, the Commission purchased new audio-visual equipment for schools to better meet technological developments: slide projectors and fixed film projectors, episcopes, overhead projectors, 8-millimeter loop film projectors, tape recorders, electrophones, 16-millimeter film projectors, cameras, and televisions (office of School Radio and Television) (Egenfeldt, 2006; Cruse, 2006).

In the early 2000's, video compression technology and availability of videos online, addressed the need for learning with the gradual technological advancements that emerged with improvements in Information and Communication Technology (ICTs) and being made available via the world wide web. YouTube was launched and was not just for funny viral videos. It quickly became a viable resource for resource for learning, be it from video recorded courses acquiring knowledge, and learning in general. Whether it was video recorded courses posted by teachers, general public with expertise on a subject or concept, or videos recorded to help in teaching or learning concepts from formal and informal modular video lessons (Laaser, 2017). Billions of people around the world use YouTube to search for and typically learn all sorts of aspects or gain any manner of information via online video, either due to availability or as part of a thirst for knowledge that they deem necessary, as the thirst for learning, information or stimulation via video has driven high viewing numbers for the site's most popular one-off video postings, video channels and video creators. Beginning in 2008, Massive Open Online Courses, or MOOCs, and emerged or raised its profile as a popular means of open resourced online education in 2012 (McGreal, Kinuthia, Marshall, & McNamara, 2013; Pappano, 2012). MOOCs give people a chance to think about online learning in fresh ways, where people can access a wide array of learning opportunities online, through storytelling, discussion, and potential community engagement and support (Cisel et al., 2013; Saadatdoost et al., 2019). As there are storytelling variations, massive educational engagements, have also grown in variety.

There are several acronyms and variations associated with MOOCs, such as Rhizomatic Massive Open Online Courses (rMOOC) which is described as a course engagement that starts with a single root, but spreads out with sub-roots and shoots (Harris, 2016), Task-based MOOC (tMOOC), Investigation-based MOOC (iMOOC), Short Massive Open Online Courses (sMOOC), Corporate Open Online Course (COOC), Small Private Online Courses (SPOC), Small Online Open Courses (SOOC),and the list of variations continue to grow. Notedly though the educational online video is often central to many

MOOCs (Acquatella, 2016; Guo, 2017; Ghanim, 2021). Educational online video in MOOCs has been used for teaching and learning in many ways: as a guide for trainees, as support for distance or online learning, as part of content modules or as a summary. Amidst the newer MOOC interactive online formats, many countries either relaunched or continued their television broadcasts of educational lessons and some of those videos are included and used in MOOCs (Al-Nuaimi, Al-Kabi & Al-Emran, 2021; Tajik, & Vahedi, 2021).

Furthermore, during COVID-19 lockdowns and social distancing requirements when schools were closed, many countries like Albania, Lebanon, Maldives, Mexico, South Africa, Sri Lanka, Nigeria, Turkey, Zimbabwe and a host of other countries around the world either relaunched, started or continued their radio and more so their television broadcasts to offer teaching and learning engagement (Adam, Kaye, & Haßler, 2020; Alhumaid, Ali, Waheed, Zahid, & Habes, 2020, Maity, Sahu, & Sen, 2021; Misirli & Ergulec, 2021; Moghli & Shuayb, 2020; Tana, Hasa, Shengjergji, & Osmanaj, 2021). Either reverting, relaunching, or starting the primary, high school, and in some cases educational television broadcasts for higher education students, were attempts by many governments to address a concern as many educational institutions had to close due to COVID-19 restrictions. These broadcasted video lessons were also either new and live broadcasts, or previously recorded re-broadcasts of older or newer made videos on subjects for specific grade levels, but again shows the crucial importance of video in education for its cognitive and pedagogical value.

## COGNITIVE AND PEDAGOGICAL CONSIDERATIONS FOR THE SCENARIO SETTING OF EDUCATIONAL ONLINE VIDEOS

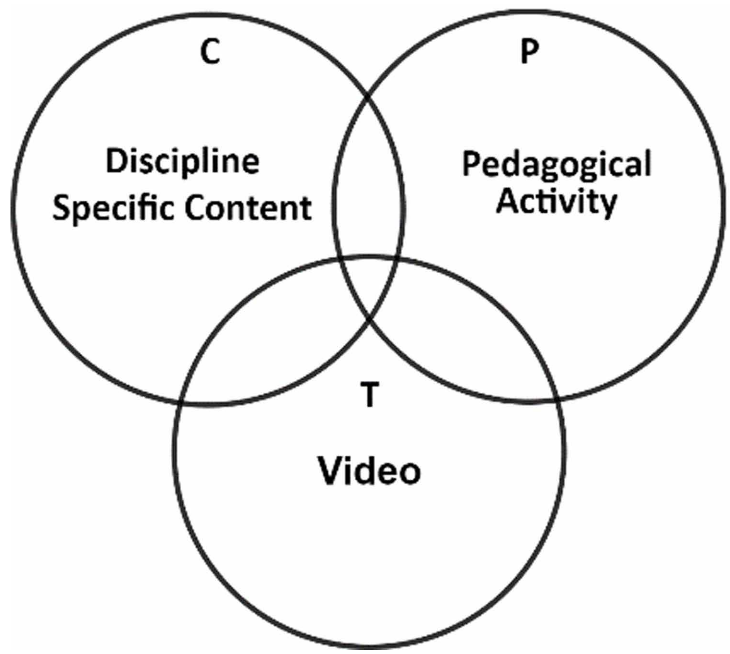
The integration of educational online videos in learning brings several benefits such as flexibility, accessibility, and interactions between various actors. Several meta-analysis research studies have shown that educational online video is a very effective teaching tool as it keeps students more connected to the material, engaged for longer, is multimodally stimulating and helps learners retain more of the learning material and information (Jena, 2020; Allen & Smith, 2012; Kay, 2012 Schmid et al., 2014; Stone, & Springer, 2019). To make this idea more explicit, we will use the Technological Pedagogical Content Knowledge (TPACK) model developed by Matthew Koehler and Punya Mishra.

The TPACK model was developed based on the Shulman (1986) Pedagogical Content Knowledge (PACK) who is a philosopher and psychologist specializing in the field of education and teacher training. This model involves the impact of disciplinary content and pedagogical knowledge on teaching practices. (Koehler & Mishra, 2008; Mishra & Koehler, 2006; Setyowibowo et al., 2017). The TPACK model adds a third component which is technology, this combination contains knowledge related at the same time to the disciplinary content (C), pedagogical knowledge (P) and technology (T).

To create and integrate an educational online video adapted to the learners' skills and needs, it is necessary to have a balanced combination of educational online video, content, and pedagogy to develop adequate strategies and context-specific representations to fit each learner. In the Technological Pedagogical Content and Knowledge (TPACK) model, knowledge is grouped into three types of knowledge: Technological Knowledge, Pedagogical Knowledge, and Disciplinary Knowledge. Based on the TPACK model and to achieve effective integration of educational online videos in distance learning, the figure below illustrates the integration of educational online video in the TPACK model:

- The disciplinary knowledge (what is taught?) corresponds to knowledge related to the content (C) and to a learning domain (Koehler & Mishra, 2008; Mishra & Koehler, 2006). This type of knowledge reflects an understanding of the nature of the knowledge to be learned or taught and its construction in different disciplinary fields, as well as the epistemological obstacles linked to their appropriation.
- The pedagogical knowledge (P) corresponds (how to teach? = Pedagogical Activity) to teaching practices and methods (Koehler & Mishra, 2008). It is an illustration of the teaching and learning process (Koehler & Mishra, 2008; Mishra & Koehler, 2006).
- Technology knowledge (T) refers (meaning what to teach?) to the knowledge about educational online videos. It reflects information about the video and skills usage.

*Figure 1. The integration of educational online video in the TPACK model (Ikram et al., 2021)*




The key takeaway from this model, as it relates to educational videos is that watching an educational online video can be both a passive and active experience. To maximize the effectiveness of educational online videos, it is important for the instructional team to consider three elements in the analysis, design, and implementation of educational online videos: cognitive load, motivation, and promotion of active learning (Brame, 2016).

These three points can help to provide a solid foundation for the scenario setting and mediating meaning within educational online videos as an effective learning object (Mentor, 2006) online video will be a productive tool for learning experience and skill. Furthermore, the three points (cognitive load, motivation, and promotion of active learning) also offer the ability for online video to create opportunities for mediating meaning (Mentor, 2006) in online videos in a pedagogical manner. Additionally, we will now cover and unpack cognitive load considerations, variations of cognitive load to consider with the motivations before, while and after using online video for education. Furthermore, we unpack how those cognitive load considerations will aid and support multimodal stimulation ranging from touch, smell, auditory and visual stimulation, as well as how all the aforementioned can impact short to long term memory and learning.

## Cognitive Load Considerations

Cognitive load is one of the main factors to consider during the pre-production of a scenario for an educational online video. It allows us to better understand how information is processed in the working memory during a learning situation.

The cognitive load theory attempts associations with the principles of instructional design based on the theory of human cognitive architecture. The instructional principles of the theory are based on assumptions of long-term memory and working memory about human cognitive architecture (Paas & Sweller, 2014). Cognitive load theory emphasizes that all new information is initially processed by working memory, which has limitations in capacity and duration, then the information is stored in unlimited long-term memory (Feldon, Callan, Juth, & Jeong, 2019).

The purpose of instruction design should be to reduce unnecessary workload memory and release learning-related processing capabilities to adapt to the limited working memory capacity (Kruger & Doherty, 2016; Vanneste et al., 2020). Cognitive load theory argues that there are three main categories that are identified for the cognitive load on working memory in each learning task. These include, Intrinsic, Extraneous, and Germane Cognitive Load (Paas & Sweller, 2014; Mutlu-Bayraktar, Cosgun, & Altan, 2019):

- **Intrinsic cognitive load:** The inherent difficulty of the material itself, which can be affected by the prior knowledge of the subject, for example, solving a complex calculus problem is considerably more difficult than calculating 2+3.
- **Extraneous cognitive load:** The load generated by the presentation of the material does not help learning, some examples of extraneous load include people talking while you're reading, working in an uncomfortable room, and listening to disorganized material that contains irrelevant information.
- **Germane cognitive load:** Elements that help information processing and promote the development of "models". As an example, creating flowcharts in presentations to explain complex concepts.

Mayer's (2001) theory of multimedia learning presents the different stages of cognitive processing of a multimedia presentation during learning (Mayer, 2001). Which also speaks to the multimodal stimulation and engagement which aids short to long term memory and learning.

1. Multimedia presentation

Multimedia presentation is defined as learning that is achieved when mental representations are constructed through pictures and words (Mayer, 2014). The theory of multimedia learning is based on cognitive load theory. The theory addresses how individuals process information and how they learn through multimedia methods (Mayer, 2014).

The cognitive theory of multimedia learning emphasizes the idea of chunking information in multimedia-rich content, arguing that auditory words and visual images work best when they are combined to communicate information (Mayer & Moreno, 1998).

Multimedia presentation is based on five principles:

a. It is better to explain things with words and pictures than just words.
b. It is better to present words and pictures simultaneously instead of separately.
c. Instead of visual text, use an auditory narration to avoid splitting learners' attention between visual and auditory information processing.
d. In general, principles A, B, and C work better when learners have limited prior knowledge of the content or limited spatial skills.
e. Provide only the most important words and images in a coherent summary.

2. Sensory memory

The storage time of sensory memory is less than one second. It derives from our five senses: sight, hearing, touch, smell, and taste. The memories are stored only if the senses are stimulated. The sensory data is then reprocessed and associated with a memory, which may be stored in the short-term memory (Mayer & Chandler, 2001). Sensory memories associated with each sense include:

- **Iconic memory:** A large amount of memory is stored here, but it is lost within less than a second. The brighter the image, the longer it remains in your iconic memory (Quilty-Dunn, 2019).
- **Echoic memory:** Echoic memories are associated with sound and hearing. Once a sound enters your ear, your temporal lobe processes it (Winkler et al., 1993). People who have difficulty speaking may store echoic memories for shorter periods of time, as research shows that echoic memory is essential to learning a language (Spector & Alsemari, 2018).
- **Haptic memory:** A haptic memory refers to the sense of touch and can be related to sensations like pressure, pain, itching, or something that feels good. It allows you to identify what you are touching (Sciutti et al., 2019).
- **Olfactory memory:** Olfactory memory helps you identify tastes since molecules from the food you eat go into your nose once you inhale them. Once you smell a smell, it will quickly spread to the part of your brain that is involved in creating long-term memories (White et al., 2015).
- **Gustatory memory:** Gustatory memory is closely related to olfactory memory. It helps you recognize foods through five basic flavors that your tongue detects through its gustatory receptor cells: Salty, Sweet, Bitter, Umami, and Sour. Casillas, Morán, & Meza-Kubo, 2017; Ranasinghe, Karunanayaka, Cheok, Fernando, Nii, & Gopalakrishnakone, 2011).

3. Working memory

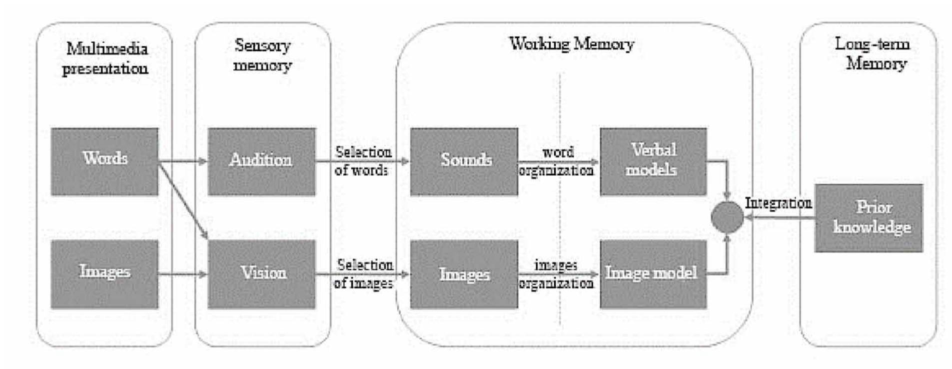
As part of working memory, learners choose images and words that are relevant to their learning. They are all processed and organized into models to help readers understand and remember information.

4. Long-term memory

As the name implies, long-term memory refers to the ability to store information for a long period of time shown in figure 2. This type of memory is stable and can last a very long time. According to Mayer, the cognitive theory of multimedia learning is a theory describing how users learn from words and images (2001). This theory is based on the idea that people have different ways of treating visual and auditory information (dual-channel hypothesis), each can process a short amount of information at a time (limited capacity hypothesis), and that successful learning involves engaging the appropriate cognitive processing during learning (active processing hypothesis).

The scenario stage of an educational online video is essential to facilitate the production of the online video. Thus, the pedagogical team should take into consideration the design and interactivity of the educational online video to facilitate the mediating setting stage.

*Figure 2. Cognitive theory of multimedia learning according to Mayer (2014)*




Based on Mayer's theory of cognitive learning, four practices are proposed for the design of effective educational online videos are presented in Table 3: Indication, Segmentation, Pruning, and Paired Modalities (Mayer, 2014; Brame, 2016).

## The Motivation

Motivation is a very important aspect when using online video for educational benefit. It is necessary to include learning activities that help promote motivation and active participation of the learners.

- **Duration:** According to the results of recent studies (Davis, 2018; Nordmann, 2020), students can stay attentive for up to six minutes, regardless of the length of the online video. This can be addressed by incorporating pauses in the online video for learners to answer questions and resume reading after formulating the answer.
- **Clarity:** The integrated activities in the online video must be stated in a clear manner with formal language.

*Table 1. Strategies for improving learners' comprehension skills using online educational videos (Mayer,2014; Brame, 2016)*

| Process | Description | Justification | Example |
|---|---|---|---|
| Indication | Use words or symbols on the screen to highlight important information. | Can reduce extraneous load. Can enhance germane load. | The appearance of keywords or symbols that draw attention to a specific part of the screen. Use the zoom of the screen area to draw attention to part of the information |
| Segmentation | Segmentation of information to allow learners to take in small portions of new information at a time and to give them control over the flow of new information. | Manages intrinsic load. Can enhance germane load. Segmentation has been shown to be important for students to be engaged with the online videos. | Make shorter online videos (6-10 minutes) that include questions for students to pause and attempt to answer before continuing to view. |
| Pruning | Elimination of information that does not contribute to the learning objectives and that may overload the learners' working memory. | Reduces extraneous load. Pruning has been shown to improve retention and transfer of new information from online videos. | Music, complex backgrounds or additional features may reduce learning. |
| Paired modalities | The use of both the auditory and visual channels to receive new information, while focusing on the most appropriate channel for each type of new information. Uses both channels to convey appropriate and complementary. | Can enhance germane load. | Present an animation of a process while narrating it. |

- **Matching modalities:** In the content of the online educational video, it is useful to integrate glossaries that simplify the information and promote understanding using an image, diagram, mind map and other meaning making multimodal stimuli. (Demirbilek, 2004).
- **Environment:** It is important to create online educational videos that are appropriate for each type of environment. Research literature suggests that student participation and engagement can be significantly reduced when online video content is borrowed from other resources and is not prepared with key considerations for the style of course in which it is used (Organization for Economic Co-operation and Development, 2007).

It is also recognized by educational research that the content seen in online videos by students in a flipped classroom context must be course content, not just as an add-on or for enrichment of the course. This allows students to better accept this new pedagogical method and to become more involved as active learners (Bravo et al., 2011; Syaparuddin et al., 2020).

## Active Learning

Active learning refers to a wide spectrum of learning and teaching strategies in terms of how and where students are engaged as active participants in their learning, rather than just as passive receivers of information. While the use of online video as a pedagogical object has many limitations, linking learners in as active participatory agents or active learners with online video, through production, or through a feral approach of finding similar or better videos which evokes an evaluative and critical mindset, or via questions, can have meaningful impact on their learning. However, two of these limitations are particularly important in the learner-centered teaching-learning paradigm (Amegan, 2011).

- Watching online videos, no matter how motivating or entertaining, remains a passive learning activity.
- Information about how students use online videos remains unknown. For example, which students watched the requested online videos, who watched the entire online videos, and of those, who was able to grasp the concepts presented in the online videos?

To help students get the maximum benefit from an educational online video, it is important to provide tools to help them process the information and probe their own learning. Several ways to do this effectively exist:

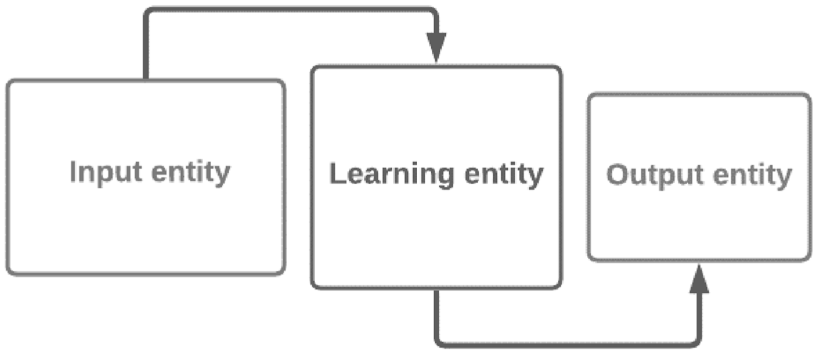
- **Use guiding questions:** The impact of providing guiding questions to students has been successful in exhibiting improved retention of information.
- **Use interactive features:** The use of interactive features give students control. It may be worthwhile to provide students with the ability to control movement during the online video, such as selecting important sections to review and going back when necessary. Giving students such control has been shown to increase learning success, and lead to greater student satisfaction. This level of interactivity can be achieved by using tools such as YouTube annotations or other tools to tag sections of online videos.
- **Integrate questions into the online videos:** Several tools, such as Zaption and EDpuzzle, allow teachers to embed questions directly into online videos and provide immediate feedback based on student responses (Yousef et al., 2014; Sablić et al., 2020). These assessment tools allow teachers to measure the level of understanding of the content at a given point during the online video presentation, ensuring that students reach a certain level of understanding before continuing to the next sections of the online video. Through carefully designed questions and interactions, the assessment tools in interactive online videos can provide continuous formative evaluation. In a study that compared the effect of online videos with integrated questions to interactive online videos without integrated questions, the authors found that the integrated questions improved student performance on exams.

Using guiding questions, integrating questions in online video, or using other interactive features can be helpful to maintain engagement, but still rely on structuring the online video engagement as well as appropriately structuring the online video within the educational context.

## ONLINE EDUCATIONAL VIDEO STRUCTURING

An online educational video is represented as a learning object that can be used for face-to-face, blended, hybrid, or distance learning. Based on cognitive and pedagogical considerations, based on our preceding sections in this chapter, we propose a structuring for educational online videos presented in Figure 3. Each educational online video is divided into three main entities.

*Figure 3. Entities (Input, Learning, Output)*




- **The Input entity** of an educational online video is typically used to verify the necessary prerequisites needed to follow the video or to introduce in a brief, original and precise way the entry of the course module or part of the course to understand the context, the objectives, and to make a favorable first impression.
- **The learning entity** of an educational online video promotes learning, simplifies the content and learning activities according to the learning objectives, and adequately takes into account the level of the target audience. The content of the online video should be presented in a clear, simple, direct, and precise.
- **The output entity** of an educational online video gives the learner the most salient and essential ideas of the video. In addition, it gives them the possible opportunity to check their understanding and memorization by evaluating the knowledge acquired.

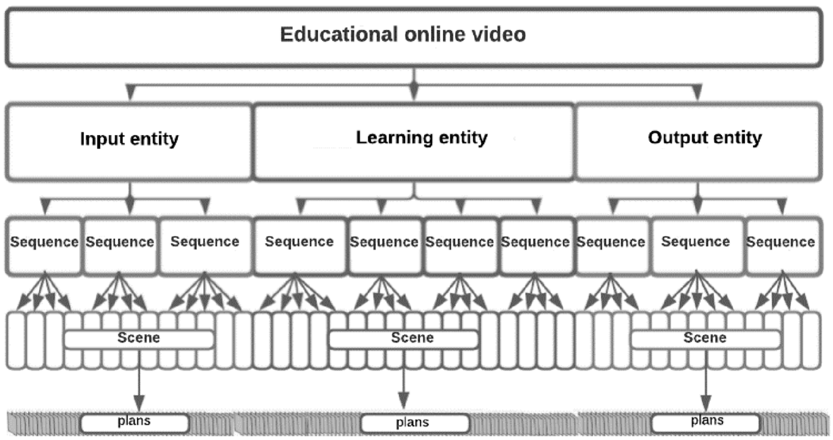
Any entity is composed of several video sequences that serve to present the content and guide learners to the poorly assimilated parts in another sequence through clickable and interactive elements that can be integrated into the video. These can be quizzes to be filled in real-time, multiple-choice questions, images to be sorted, text boxes and a host of other lower order or higher order online educational engagement methods. Figure 4 illustrates the general architecture of an educational online video. Each video sequence is a grouping of scenes, each of them comprising one or more “plans”, that comprises one or more images. A “plan” represents a series of images recorded with or without camera movement over a continuous period.

## THE STEPS FOR SCENARIO SETTING OF THE EDUCATIONAL ONLINE VIDEO

Developing an educational online video is a complex process in which images, audio, and text must be carefully arranged. The online video must have an appropriate structure that allows and encourages sustained attention and constructive learning.

Educational scenario setting is a process of modeling learning situations and educational scenarios. It is an engineering, description, and specification activity (Pernin & Lejeune, 2004). It is at the heart of the practice of the teacher or trainer engaged in the design of learning systems, whether face-to-face, distance, or online.

*Figure 4. Architecture of an educational online video*




A scenario describes a learning situation aiming at the appropriation of a specific set of knowledge, by specifying the roles, activities, tools, resources, services, and results associated with the implementation of the activities (Voepel et al., 2020; Sadati et al., 2021).

The scenario of an educational online video defines exactly the unfolding of a learning activity typically presented in the educational online video object proposed to the learners. It also specifies the objectives, the planning, the description of the learners' tasks, and the modalities of evaluation. In addition, it describes how the learner's progress will be monitored during this activity.

The scenario of an educational online video specifies and presents an approach and a strategy for a veritable scenario setting of the content of the online videos in a learning activity which is defined as a situation realized by a teacher proposed to the learner to reach pedagogical objectives and the acquisition of general or specific competencies related to one or several life domains according to the modalities and specifications of the program of study.

In our work, we have proposed the following steps in the scripting process of the educational online video:

- **Define the objective(s):** For the concept of educational online video scenario, it is essential to define the pedagogical objectives to be achieved. For this, there are a series of questions to ask (for example: What is the broad aim of the online video? Who are the target audiences of the online video? Concerning the target audiences, the skills to be mastered, the organization of the time, and the available resources.
- **Sequencing:** Through this step, it is necessary to determine the themes, activities, and/or workshops that will be used to achieve the pedagogical objectives. Each sequence associated with a notion of the entity in an educational online video must correspond to a specific learning objective that contributes to the achievement of a general learning objective.
- **Scenario development:** The scenario development stage is the stage for making the scenario of the educational online video. All sequences used in a scenario must have structure and coherence. It is essential to choose the content and the educational online video type that should be adapted

to the public. In order to develop a successful scenario for an educational online video, it is helpful to consider the following elements: characters, context, challenges, and consequences.

- **Implementation:** Following the development of the scenario and the selection of four elements, it is necessary to choose the most suitable digital tool to produce an online educational video and to implement the scripted and mediated content.
- **Evaluation:** Evaluation is an essential step for the pedagogical team to see if the learners' objectives have been achieved, but also to measure the effectiveness of the educational online video.

## TOOLS FOR THE SCENARIO SETTING OF EDUCATIONAL ONLINE VIDEO

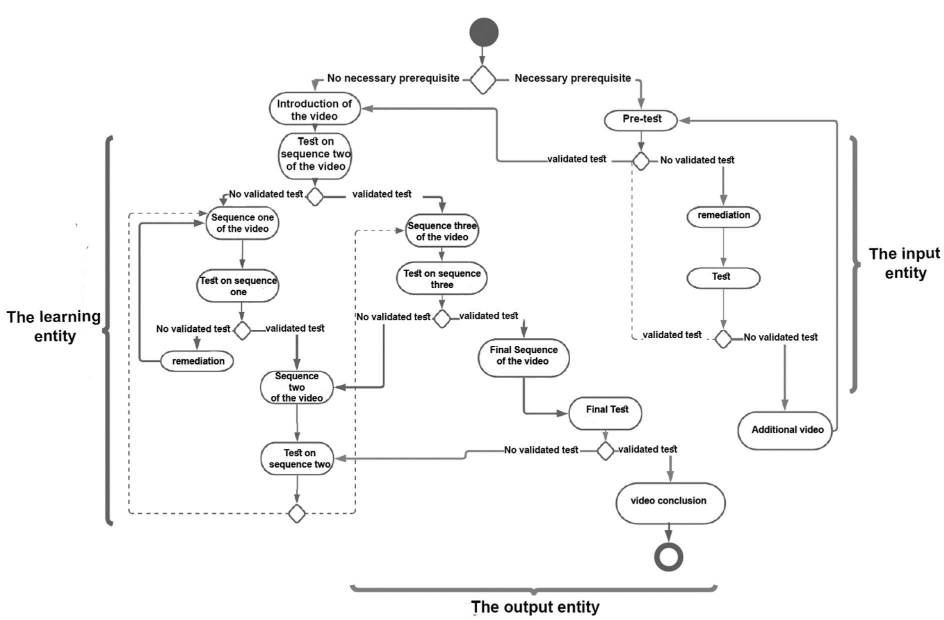
There are three main tools ranging from an activity diagram, a specification table and storyboarding that helps with the conceiving of, creation or production and editing of the online video for educational usage for the scenario setting of educational online video. These tools are effective in that they allow the scenario setting process to follow an organized and rational methodology.

1. Activity diagram

The activity diagram (AD) clarifies the role of the learner in the scenario. It defines the structure of the online educational video. It is semantically similar to communication diagrams (called collaboration diagrams in UML: Unified Modeling Language) or state-transition diagrams.

The AD should demonstrate the sequence of the scenario by situating the intervention of the video and the learner in the chain of activities in the three entities. In the following activity diagram (Figure 5) we present two cases of educational online video in general.

*Figure 5. Activity diagram for two cases of educational online video*



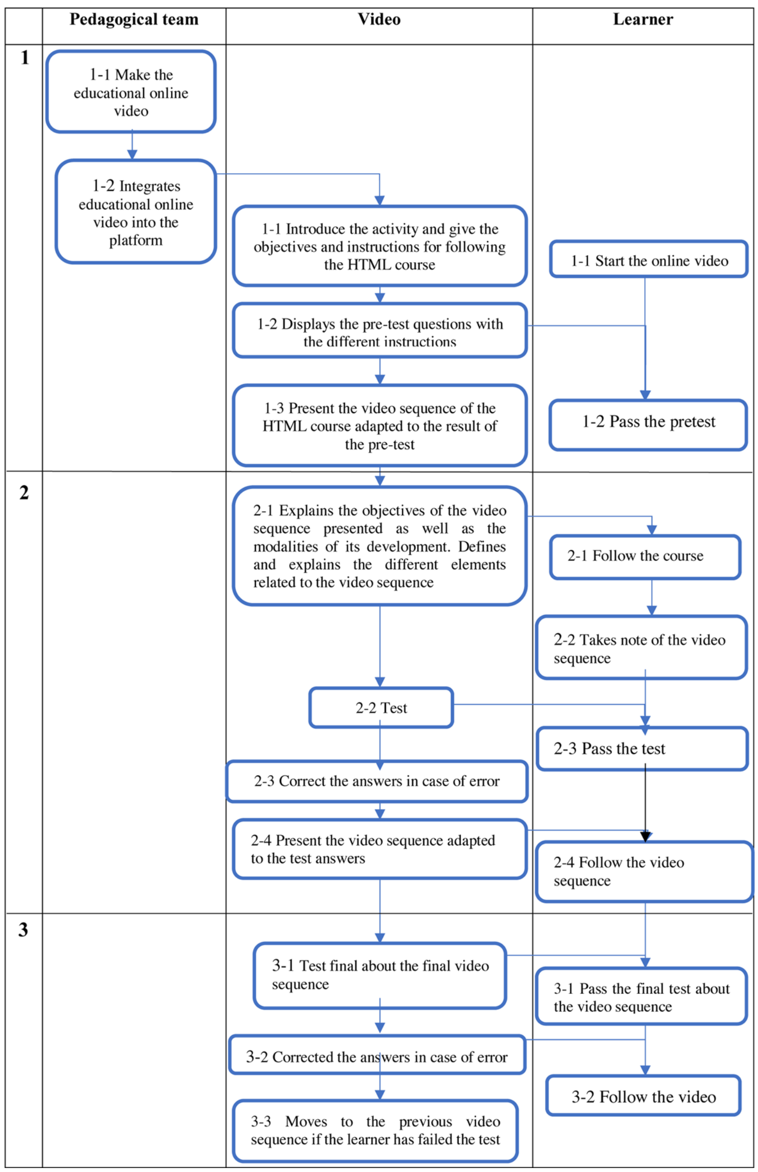
In the first case, prerequisites are necessary to follow the video. The first step here is to verify the user's prerequisites. According to the results, the user will be able to follow all the online video sequences.

In the second case, it is not necessary to have any prerequisites to follow the online video sequences.

In both cases, the user must take a placement test to follow the video at a rhythm adapted to his level at the end of each sequence to avoid forgetting and optimize the learning process until the acquisition of the presented information.

The activity diagram below Table 2 illustrates the sequence of the scenario by situating the intervention of the three categories of actors (the learner, the pedagogical team, and the video) in the sequence of learning activities which are designated by their order from 1 to 3.

*Table 2. Example of Activity diagram for an HTML educational online video*



2. The Specification Table (TS)

The specification table, Table 3, presents a list of dimensions describing each of the tasks that the learner will be faced with in an activity presented by a video sequence, including:

- An overview of the video, its origins, purpose, and goals.
- Sequencing of tasks and defining the criteria for sequencing.
- Monitoring and interaction procedures.

*Table 3.Example of a specification table*

| Activity | The pedagogical team | Video | Learner |
|---|---|---|---|
| 1 | Determines the objective(s) of the online video pre-test sequence and proposes them | Introduce the online video and the objective(s). | Follow the online video |
| 2 | Identifies the different levels of online video sequence | | |
| 2 | Provides the questions to be asked with the different instructions | Present the pre-test questions with different instructions | Interaction with the video to answer the questions |
| 4 | | Determines the learner's level. | |
| 5 | | Automatically proposes a video sequence adapted to the learner's level | Follow the online video sequence |
| 6 | Propose a formative test | Present the test | Answer the questions |
| 7 | Provides an overview of what information needs to be acquired and what skills are to be mastered for this activity. | Presents the rest of the online video sequence | Attend the online video |
| 8 | | | Interaction with the online video sequence |
| 9 | Present the end of the online video sequence. | | Follow the video |
| 10 | propose a summative test | Present the test | Answer the questions |
| 11 | | corrects the answers | Interacts with the results obtained |
| 12 | Remedies the difficulties. | Present the remediation video sequence | Overcomes obstacles |

For the activity diagram, it is proposed to complete the following table in Table 4:

3. Storyboard

The storyboard is a creative reflection that originates from the world of cinema, cartoons, and comics. In the early 1920s, the Walt Disney studio produced storyboards for popularization. Each scene was drawn separately, then pinned onto a board as a storyboard before being presented and discussed with the director. In fact, the storyboard is always done in teamwork to integrate all the points of view of all the designers, it is located at the border of the images and the text (Hart, 2013; Furini et al., 2009).

*Table 4. Specification table for activity diagram*

| Nature of expected results | Sequencing of tasks Follow-up | Monitoring procedures | Structuring and regulation tools | Modalities of interaction |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |

Consequently, this tool has great potential for exposing problems of use. It allows for presenting through drawings the advantages or disadvantages of concepts or products based on their effectiveness, efficiency, and satisfaction. Using storyboards as a method for designing solutions seems most relevant to us (Soukup & Lužný, 2019; Lamya et al., 2021).

During the pre-production of an educational online video, a storyboard is created in the form of a prototype or document (digital or paper). It identifies the main elements and actions of each video sequence. The storyboard tool allows you to organize and present the course content in a way that interests the learner, for example using dialogue and interactivity.

The storyboard is presented as a series of boxes. Each box represents a video entity. When the group agrees on the shot they want; they must draw it in the corresponding box. The process continues until you have an educational video.

*Table 5.Basic storyboard table*

<table>
<tr><th colspan="4">Title</th></tr>
<tr><th colspan="4">Entity</th></tr>
<tr><td rowspan="3">Scene title</td><td>Scene number</td><td>1</td><td>2</td></tr>
<tr><td>Image</td><td></td><td></td></tr>
<tr><td>Voice over</td><td></td><td></td></tr>
</table>

a. Storyboard example for online video capsule

The dictionary, “Le Littré”, defines the capsule as a membrane envelope of certain seeds. In the different definitions, we are talking about small elements that enclose or envelop a material in small quantities (Bissonnette, 2012). A capsule is equivalent to a video in Quebec and refers to any work that deals, in a condensed manner, with a given topic or theme, whether written, oral, or audiovisual.

In the beginning, video capsules were mainly used as “informational capsules” in textbooks. Later, different formats were developed for diverse purposes (Eliakim, 2004). Videos capsules have become common learning support since they are short, easy to share, and appreciated by users (Julien, 2020). This video capsule is meant to provide information, provide a testimonial, introduce a question, and show a problem to support the learning.

The video capsule generally follows a basic three entity structure derived from the educational online video structure

- Input entity:
    - Objective: Presentation of the problem
    - Description: In this first part the learner will have to understand the context and the objectives of the online video.
- Learning entity:
    - Objective: Problem solving
    - Description: Is the division of the different theoretical elements necessary to answer the objective and present each of them in order to construct the answer to the initial question.
- Output entity:
    - Objective: Call to action
    - Description: Position the theoretical content in the general learning process in which it is included.

## APPROACH TO THE PRESENTATION OF A SCRIPTED EDUCATIONAL ONLINE VIDEO IN ADAPTIVE HYPERMEDIA SYSTEMS (AHS)

Adaptive E-learning consists of adapting different features of the learning environment based on the learner's needs. It is a new approach to E-learning that adapts the presentation of information to the knowledge, behavior and attitude of each learner based on Hypermedia System's structure (Phelps, 2020). The Adaptive Hypermedia system (AHS) represents an important advancement in E-learning. The main objective of these systems is to propose adapted contents based on the learner's needs and present the resources in an appropriate way in accordance with the learner's preferences.

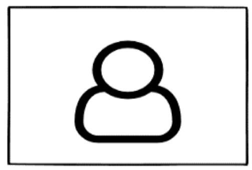
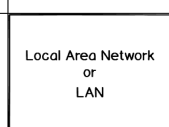
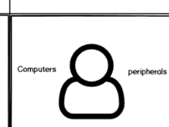
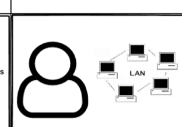
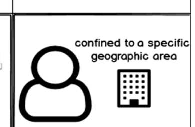
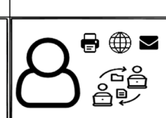
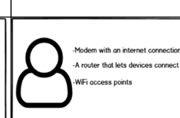
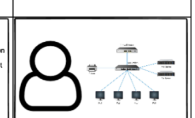
Adapting the learning content of an educational online video for a specific objective typically requires modifying the video's content, structure, or format. There are three main characteristics of adaptations in educational online video: presentation, organization, and granularity described in the following table.

Adapting the content of educational online videos to learners depends on understanding two essential elements in an adaptive hypermedia system: Learner model and Domain knowledge.

A learner model is the most essential component of an adaptive e-learning system, as it typically represents the learner's characteristics based on which educational system will offer specific recommendations (Nguyen & Do, 2008). A learner model can have information about the learner's learning style. A learner's learning style refers to the way in which s/he grasps and treats information (Hawk & Shah, 2007). It is considered a main component of the learner model since it is indicative of how he interacts with the eLearning environment. We can classify learners into a variety of learning style categories based on their behavior during the learning process (Mustafa & Sharif, 2011). These categories can then be used to construct a learning style model. However, there are many learning style models such as 4MAT, VAK, Dunn and Dunn, and Kolb as well as Felder-Silverman which are considered the most popular for their ability to quantify students' learning styles (Kolb & Kolb, 2005; Felder & Silverman, 1988; Dunn & Dunn, 1974). Both the Felder-Silverman Model and the Kolb Model propose to categorize each learner in several categories according to his or her abilities, aptitudes, and preferences. Next we elucidate the Felder-Silverman as well as the Kolb model in relation to how it can be leveraged for use with online video within learning contexts.

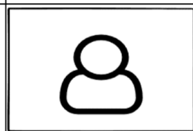
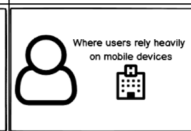
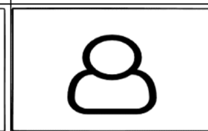
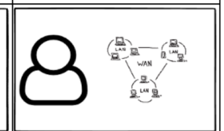
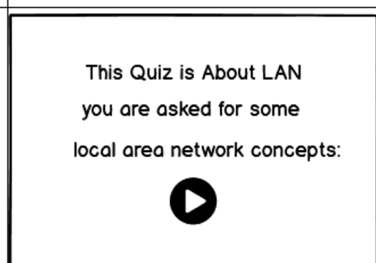
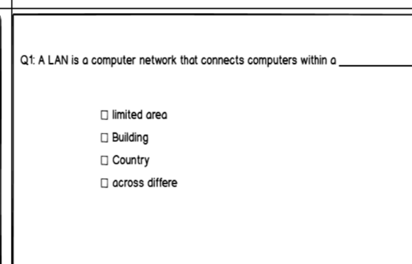
- Felder-Silverman Model

*Table 6.Example of a storyboard for a video capsule*

| Title: Network Types | | | | | |
|---|---|---|---|---|---|
| **Input entity** | | | | | |
| Introduction scene | **Number** | **1** | | | |
| | image |  | | | |
| | Voice over | Hello everyone, in this video we're going to talk about the different network types. And Each network type is defined by its size and geographic coverage. So, let's first talk about LAN | | | |
| **Learning entity** | | | | | |
| Description scene | **Number** | **1** | **2** | **3** | **4** |
| | image |  |  |  |  |
| | Voice over | Local Area Network, or LAN | is defined as a collection of computers and peripherals | that share communication line or wireless link to a server. | As the name suggests, LANs are confined to a specific geographic area, like a building or office space. |
| | **Number** | **5** | **6** | **7** | **8** |
| | image |  |  |  |  |
| | Voice over | The most common link connections go through Ethernet cables and WiFi. | Once a computer is connected to an office, it is able to access business resources such as printers, email, the Internet, and shared files and storage. | LANs are comprised of three elements: A modem with an internet connection, a router that lets devices connect, and WiFi access points. Some devices combine these functions into one device. | Alternatively, switches can be used to break up an Ethernet connection into multiple connections. In most enterprises, wired Ethernet LANs dominate. |

*continues on following page*

*Table 6. Continued*

<table>
<tr><td rowspan="3"></td><td>Number</td><td>9</td><td>10</td><td>11</td><td>12</td></tr>
<tr><td>image</td><td></td><td>
</td><td></td><td>
</td></tr>
<tr><td>Voice over</td><td>But the growing bandwidth and flexibility of wireless LANs make them affordable options for industries and organizations.</td><td>where users rely heavily on mobile devices, like hospitals LANs serve all types of workplaces.</td><td>from three users in the home office, to hundreds of users in a central corporate office.</td><td>But for even wider geographic networks, like a company with an office branch and central headquarters elsewhere, multiple LANS connect to form a wide area network, or WAN.</td></tr>
<tr><td colspan="6">Output entity</td></tr>
<tr><td rowspan="3">Interactive questions scene</td><td>Number</td><td colspan="2">1</td><td colspan="2">2</td></tr>
<tr><td>image</td><td colspan="2">
</td><td colspan="2">
</td></tr>
<tr><td>Voice over</td><td></td><td></td><td></td><td></td></tr>
</table>

According to Felder-Silverman learning style model, there are four dimensions where each dimension contains two opposite learning styles. There are four dimensions (Felder & Silverman, 1988):

- **Active/reflective:** Where the active category refers to learners who prefer to work in groups and do physical experiments, whereas the reflective category refers to learners who prefer to work individually and think about things before they act.
- **Visual/verbal:** Where the visual category refers to learners who prefer to learn by seeing information as schema, picture, diagram. While learner in the verbal category prefer to read and hear information.
- **Intuitive/Sensing:** In the intuitive category, information is preferred by learners who prefer theatrical and conceptual information.

*Table 7. Characteristics of adaptations*

| Characteristics of adaptations | Example |
|---|---|
| Presentation | Review, summary, overview, preview, full view, |
| Organization | Input entity<br>Learning entity<br>Output entity |
| Granularity | Smaller educational online videos combined to form educational online video with decreased granularity |
| | Larger educational online videos combined to form educational online video with increased granularity |

- **Sequential/Verbal:** Where the sequential category refers to the learners who prefer to learn in small steps from the details to the big picture, while in the verbal category it is more important for learners to see the big picture first, then the details
    - D-Kolb Model

Kolb defines learning style as the way individuals organize and process information in response to their environments. In other words, learning style is how learners perceive and process information which is still valid in terms of using online videos for learning. In this sense, learning style is sensory and mental at the same time (Kolb, 2005). Each learner is categorized by their preference for the concrete experience or abstract conceptualization (the way they perceive information) as well as active experimentation or reflexive observation (how they process information) (Kolb, 2013). Kolb defined four types of learners: the Diverger with concrete experience and reflective observation, the Converger, with practical application of ideas, the Assimilator taking time to build understanding as well as developing theoretical models or scenarios, and the Accommodator with yearning and practice to implement plans concretely(Kolb, 1981).

Parameters from these sources can either be static (stable) or dynamic. While stable parameters remain the same with respect to time, learning activities, learning medium, and psychological/emotional states, dynamic parameters vary with respect to time, learning activities, learning medium, and psychological/emotional states of the learner.

The Domain knowledge describe the way in which information is structured and organized (Cleland-Huang, 2015).The domain knowledge is represented by three hierarchical levels: learning objective, concept and material A learning objective corresponds to a subject in the domain to be studied, each objective is associated with a set of concepts in the domain to be studied and each concept is itself linked to a set of teaching materials that constitute the resources that the learner will manipulate during learning (Harati et al., 2020) .

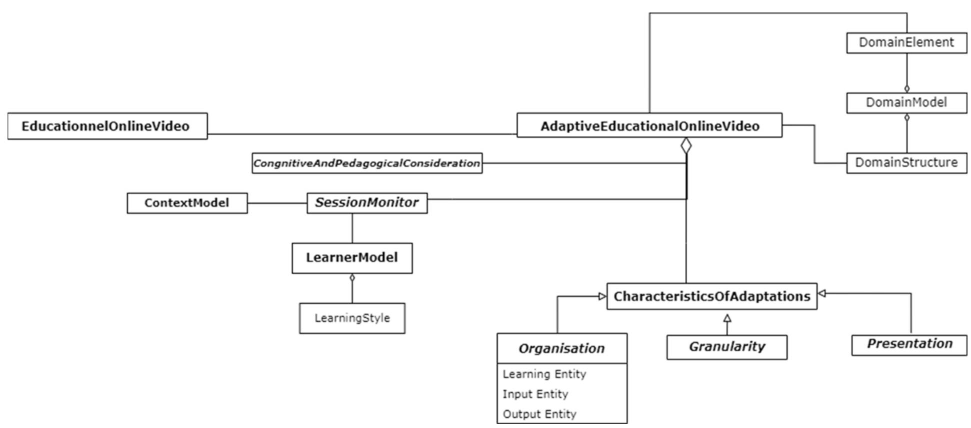
We used four types of instructional resources to illustrate a concept in an educational online video. The design of these resources on video is associated with the phases of experiential learning and reflects the dimensions related to the learning styles we adopted such as:

- An activity (computer simulation) associated with the concrete experience phase; it allows the learner to explore a concept.

- An example (illustration, analogy) associated with the reflective observation phase, it allows the learner to reflect, observe and accumulate data.
- A theoretical presentation associated with the abstract conceptualization phase, it allows the learner to organize knowledge, analyze and synthesize.
- An interactive exercise associated with the active experimentation phase, it allows the learner to apply knowledge and ideas.

The architectural design can incorporate additional components besides the learner, domain, and pedagogical models required for adaptation in AHS.

*Figure 6. A model of an adaptive Learning educational online video in hypermedia system*




Other components, such as learner, domain, cognitive and pedagogical considerations, can be incorporated into the architectural design for the Adaptive Hypermedia System (AHS). A learner model is a way to manage static and dynamic information about the learner, such as by selecting the learning style and updating the information about the learner after each learning process, assessment and interaction. Context models measure user context values such as time location, or other external environmental factors and continually update them.

A session monitor component records the activities of the learner during each entity of the online video. Such information is required to update the learner model or to trigger the system to act. The use of pedagogical agents (software agents specifically designed for learning situations) could produce realistic simulations (as tutors, assistants, co-learners), motivate students, and encourage them to take ownership of their learning and improve their overall performance by addressing their personal and sociocultural needs.

This proposal focuses on educational online video within the context of adaptive e-learning, aiming to integrate adaptive online video into an adaptive training platform that allows learners to progress according to their own rhythms, select among different learning methods according to their preferences, to develop an adaptive system that can be published in future works.

## CONCLUSION

Each online educational video is in principle the result of a combination of three factors that must be in a state of dynamic equilibrium: discipline-specific content, pedagogical activity, and video as a learning passive or active teaching and/or learning artifact. On the basis that good knowledge and simultaneous consideration of these three factors will enable teachers to effectively integrate the online video into their teaching practices, the authors showed throughout this chapter to give a general description concerning the integration of educational online video and present a novel structure based on their combination. Additionally, the scenario setting for an educational online video is a very important phase that will help us to adapt the educational online video to individuals' needs, both in terms of learning pace and content. This will allow an effective and relevant educational online video whose main objective is to improve and facilitate the teaching-learning process. The authors propose the steps of the upcoming scenario setting of an educational online video presented in five essential points (the definition of the objectives, the sequencing, the development of the scenario, the implementation, the evaluation), as well as the scenario setting tools to be used, which are presented in the form of an activity diagram, a specification table and storyboard that aim to highlight the scenario's progress within the framework of adaptation by situating the intervention of the three categories of the actor in the sequence of activities. Finally, the authors propose an approach of how educational online videos are modeled in adaptive hypermedia systems to achieve adaptive learning.

## REFERENCES

Acquatella, F. (2016). Le COOC, un autre visage du MOOC. *Distances et médiations des savoirs,* (14). doi:10.4000/dms.1386

Adam, T., Kaye, T., & Haßler, B. (2020). *The Maldives and Sri Lanka: Question & Answer Session* (No. 18). EdTech Hub.

Al-Nuaimi, M. N., Al-Kabi, M. N., & Al-Emran, M. (2021). Digitizing Learning During the Outbreak of COVID-19 Pandemic: Lessons Learned from the Most Infected Countries. In *Emerging Technologies During the Era of COVID-19 Pandemic* (pp. 291–303). Springer. doi:10.1007/978-3-030-67716-9_18

Alhumaid, K., Ali, S., Waheed, A., Zahid, E., & Habes, M. (2020). COVID-19 & Elearning: Perceptions & Attitudes Of Teachers Towards E-Learning Acceptancein The Developing Countries. *Multicultural Education*, *6*(2), 100–115.

Aoki, K. (2015). MOOCs and open education in Japan: The case of the Open University of Japan. In *MOOCs and open education around the world* (pp. 21–29). Routledge. doi:10.4324/9781315751108-4

Bissonnette, S., & Gauthier, C. (2012). Faire la classe à l'endroit ou à l'envers? *Formation Profession*, *20*(1), 23–28.

Brame, C. J. (2016). Effective Educational Videos: Principles and Guidelines for Maximizing Student Learning from Video Content. *CBE Life Sciences Education*, *15*(4), es6. Advance online publication. doi:10.1187/cbe.16-03-0125 PMID:27789532

Bravo, E., Amante, B., Simo, P., Enache, M., & Fernandez, V. (2011). Video as a new teaching tool to increase student motivation. In *2011 IEEE Global Engineering Education Conference (EDUCON)*. IEEE. 10.1109/EDUCON.2011.5773205

Casillas, R., Morán, A. L., & Meza-Kubo, V. (2017, November). Evaluation of a multisensory stimulation tool: effect of auditory, olfactory and visual stimuli for scenario identification and memory evocation. In *International Conference on Ubiquitous Computing and Ambient Intelligence* (pp. 330-339). Springer. 10.1007/978-3-319-67585-5_35

Cisel, M., & Bruillard, É. (2013). *Chronique des MOOC. STICEF*. Sciences et Technologies de l'Information et de la Communication pour l'Éducation et la Formation.

Cleland-Huang, J. (2015). Mining Domain Knowledge. *IEEE Software*, *32*(3), 16–19. doi:10.1109/MS.2015.67

Cruse, E. (2006). Using educational video in the classroom: Theory, research and practice. *Library Video Company*, *12*(4), 56–80.

Dunn, R., & Dunn, K. (1974). Learning style as a criterion for placement in alternative programs. *Phi Delta Kappan*, *56*(4), 275–278.

Egenfeldt-Nielsen, S. (2006). Overview of research on the educational use of video games. *Nordic Journal of Digital Literacy*, *1*(03), 184–214. doi:10.18261/ISSN1891-943X-2006-03-03

Eliakim, R., Yassin, K., Shlomi, I., Suissa, A., & Eisen, G. M. (2004). A novel diagnostic tool for detecting oesophageal pathology: The PillCam oesophageal video capsule. *Alimentary Pharmacology & Therapeutics*, *20*(10), 1083–1089. doi:10.1111/j.1365-2036.2004.02206.x PMID:15569110

Felder, R. M., & Silverman, L. K. (1988). Learning and teaching styles in engineering education. *Engineering Education, 78*(7), 674-681.

Feldon, D. F., Callan, G., Juth, S., & Jeong, S. (2019). Cognitive Load as Motivational Cost. *Educational Psychology Review*, *31*(2), 319–337. doi:10.100710648-019-09464-6

Fletcher, C. (2019). Educational Technology and the Humanities: A History of Control. In M. K. Gold & L. F. Klein (Eds.), *Debates in the Digital Humanities 2019* (pp. 369–381). University of Minnesota Press. doi:10.5749/j.ctvg251hk.33

Fuchs, E., Bruch, A., & Annegarn-Gläß, M. (2016). Introduction: Educational Films: A Historical Review of Media Innovation in Schools. Journal of Educational Media. *Memoria y Sociedad: Revista del Departamento de Historia y Geografia*, *8*(1), 1–13.

Furini, M., Geraci, F., Montangero, M., & Pellegrini, M. (2009). STIMO: STIll and MOving video storyboard for the web scenario. *Multimedia Tools and Applications*, *46*(1), 47–69. doi:10.100711042-009-0307-7

Ghanim, M., Abu Obaid, A., Salha, S., & Affouneh, S. (2021). The Motives and Challenges of developing and delivering MOOCs courses. *Education in the Knowledge Society*.

Guo, P. (2017). MOOC and SPOC, Which One is Better? *Eurasia Journal of Mathematics, Science and Technology Education*, *13*(8). Advance online publication. doi:10.12973/eurasia.2017.01044a

Hancock, C. V., & Bone, G. E. (1964). Producing 8mm teaching films. *Education + Training*.

Harati, H., Yen, C.-J., Tu, C.-H., Cruickshank, B. J., & Armfield, S. W. J. (2020). Online Adaptive Learning. *International Journal of Web-Based Learning and Teaching Technologies*, *15*(4), 18–35. doi:10.4018/IJWLTT.2020100102

Harris, D. (2016). Rhizomatic education and Deleuzian theory. *Open Learning*, *31*(3), 219–232. doi:10.1080/02680513.2016.1205973

Hart, J. (2013). *Art of the Storyboard: A Filmmaker's Introduction*. CRC Press LLC. doi:10.4324/9780080552781

Hawk, T. F., & Shah, A. J. (2007). Using Learning Style Instruments to Enhance Student Learning. *Decision Sciences Journal of Innovative Education*, *5*(1), 1–19. doi:10.1111/j.1540-4609.2007.00125.x

Ikram, C., Mohamed, E., Souhaib, A., & Mohamed, K. (2021). Integration of Pedagogical Videos as Learning Object in an Adaptive Educational Hypermedia Systems According To The Learner Profile. *International Journal of Computer Trends and Technology*, *69*(6), 1–6. doi:10.14445/22312803/IJCTT-V69I6P101

Jena, P. K. (2020). Online learning during lockdown period for covid-19 in India. *International Journal of Multidisciplinary Educational Research, 9*.

Julien, M., Bergeron, M., & Hébert, M. (2020). Programme Empreinte: Évaluation des capsules vidéo web destinées aux parents d'adolescent. *Revue de psychoéducation*, *49*(1), 27–45. doi:10.7202/1070056ar

Kolb, A. Y., & Kolb, D. A. (2005). Learning styles and learning spaces: Enhancing experiential learning in higher education. *Academy of Management Learning & Education*, *4*(2), 193–212. doi:10.5465/amle.2005.17268566

Kolb, D. (2013). *Kolb Learning Style Inventory Version 3.2 Single Copy*. Hay Group.

Kolb, D. A. (1981). Experiential Learning Theory and the Learning Style Inventory: A Reply to Freedman and Stumpf. *Academy of Management Review*, *6*(2), 289. doi:10.2307/257885

Kruger, J. L., & Doherty, S. (2016). Measuring cognitive load in the presence of educational video: Towards a multimodal methodology. *Australasian Journal of Educational Technology*, *32*(6). Advance online publication. doi:10.14742/ajet.3084

Laaser, W., & Toloza, E. A. (2017). The changing role of the educational video in higher distance education. *The International Review of Research in Open and Distributed Learning*, *18*(2). Advance online publication. doi:10.19173/irrodl.v18i2.3067

Lamya, A., Mohamed, E., & Mohamed, K. (2021). Adaptive E-Learning and Scenarization Tools: The Case of Personalization. *International Journal of Computer Trends and Technology*, *69*(6), 28–35. doi:10.14445/22312803/IJCTT-V69I6P105

Maity, S., Sahu, T. N., & Sen, N. (2021). Panoramic view of digital education in COVID-19: A new explored avenue. *Review of Education*, *9*(2), 405–423. doi:10.1002/rev3.3250

Mayer, R. E. (2001). A Cognitive Theory of Multimedia Learning. In *Multimedia Learning* (pp. 41–62). Cambridge University Press. doi:10.1017/CBO9781139164603.004

Mayer, R. E., & Chandler, P. (2001). When learning is just a click away: Does simple user interaction foster deeper understanding of multimedia messages? *Journal of Educational Psychology*, *93*(2), 390–397. doi:10.1037/0022-0663.93.2.390

Mayer, R. E., & Moreno, R. (1998). A split-attention effect in multimedia learning: Evidence for dual processing systems in working memory. *Journal of Educational Psychology*, *90*(2), 312–320. doi:10.1037/0022-0663.90.2.312

McClusky, F. D. (1947). The nature of the educational film. *Hollywood Quarterly*, *2*(4), 371–380. doi:10.2307/1209533

McGreal, R., Kinuthia, W., Marshall, S., & McNamara, T. (2013). *Open educational resources: Innovation, research and practice*. Commonwealth of Learning.

Mentor, D. (2006). Media-ting meaning via multi-modal means. In T. Reeves & S. Yamashita (Eds.), *Proceedings of E-Learn 2006--World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education* (pp. 763-769). Association for the Advancement of Computing in Education (AACE). Retrieved November 14, 2021 from https://www.learntechlib.org/primary/p/23784/

Michel, E., Roebers, C. M., & Schneider, W. (2007). Educational films in the classroom: Increasing the benefit. *Learning and Instruction*, *17*(2), 172–183. doi:10.1016/j.learninstruc.2007.01.005

Mirrlees, T., & Alvi, S. (2014). Taylorizing Academia, Deskilling Professors and Automating Higher Education: The Recent Role of MOOCs. *The Journal for Critical Education Policy Studies*, *12*(2).

Mishra, P., & Koehler, M. J. (2006). Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge. *Teachers College Record*, *108*(6), 1017–1054. doi:10.1111/j.1467-9620.2006.00684.x

Misirli, O., & Ergulec, F. (2021). Emergency remote teaching during the COVID-19 pandemic: Parents experiences and perspectives. *Education and Information Technologies*, *26*(6), 6699–6718. doi:10.100710639-021-10520-4 PMID:33814956

Moghli, M. A., & Shuayb, M. (2020). *Education under COVID-19 Lockdown: Reflections from Teachers, Students & Parents*. Social Sciences and Humanities Research Council of Canada.

Molenda, M. (2008). Historical foundations. Handbook of research on educational communications and technology, 3, 3-20.

Mustafa, Y. E. A., & Sharif, S. M. (2011). An approach to adaptive e-learning hypermedia system based on learning styles (AEHS-LS): Implementation and evaluation. *International Journal of Library and Information Science*, *3*(1), 15–28.

Mutlu-Bayraktar, D., Cosgun, V., & Altan, T. (2019). Cognitive load in multimedia learning environments: A systematic review. *Computers & Education*, *141*, 103618. doi:10.1016/j.compedu.2019.103618

Nguyen, L., & Do, P. (2008). Learner model in adaptive learning. *World Academy of Science, Engineering and Technology*, *45*(70), 395–400.

Nordmann, E., Horlin, C., Hutchison, J., Murray, J.-A., Robson, L., Seery, M. K., & MacKay, J. R. D. (2020). Ten simple rules for supporting a temporary online pivot in higher education. *PLoS Computational Biology*, *16*(10), e1008242. Advance online publication. doi:10.1371/journal.pcbi.1008242 PMID:33001990

Orgeron, D., Orgeron, M., & Streible, D. (Eds.). (2011). *Learning with the lights off: Educational film in the United States*. Oxford University Press.

Paas, F., & Sweller, J. (2014). Implications of Cognitive Load Theory for Multimedia Learning. In R. Mayer (Ed.), The Cambridge Handbook of Multimedia Learning (pp. 27-42). Cambridge University Press. doi:10.1017/CBO9781139547369.004

Pappano, L. (2012). The Year of the MOOC. *The New York Times, 2*(12), 2012.

Pernin, J. P., & Lejeune, A. (2004). Dispositifs d'apprentissage instrumentes par les technologies: vers une ingénierie centrée sur les scénarios. Actes du colloque TICE 2004, 407-414.

Phelps, L. E. (2020). Adapting to Adaptive Learning. *Peabody Journal of Education*, *95*(2), 160–172. doi:10.1080/0161956X.2020.1745615

Potdevin, F., Vors, O., Huchez, A., Lamour, M., Davids, K., & Schnitzler, C. (2018). How can video feedback be used in physical education to support novice learning in gymnastics? Effects on motor learning, self-assessment and motivation. *Physical Education and Sport Pedagogy*, *23*(6), 559–574. doi:10.1080/17408989.2018.1485138

Quilty-Dunn, J. (2019). Is Iconic Memory Iconic? *Philosophy and Phenomenological Research*, *101*(3), 660–682. doi:10.1111/phpr.12625

Ranasinghe, N., Karunanayaka, K., Cheok, A. D., Fernando, O. N. N., Nii, H., & Gopalakrishnakone, P. (2011, November). Digital taste and smell communication. In *Proceedings of the 6th international conference on body area networks* (pp. 78-84). Academic Press.

Rapp, A. K., Healy, M. G., Charlton, M. E., Keith, J. N., Rosenbaum, M. E., & Kapadia, M. R. (2016). YouTube is the most frequently used educational video source for surgical preparation. *Journal of Surgical Education*, *73*(6), 1072–1076. doi:10.1016/j.jsurg.2016.04.024 PMID:27316383

Saadatdoost, R., Jafarkarimi, H., Sim, A. T. H., & Hee, J. M. (2019). Understanding MOOC Learners. *International Journal of Web-Based Learning and Teaching Technologies*, *14*(1), 93–112. doi:10.4018/IJWLTT.2019010107

Sablić, M., Mirosavljević, A., & Škugor, A. (2020). *Video-Based Learning (VBL)—Past, Present and Future: An Overview of the Research Published from 2008 to 2019*. Technology, Knowledge and Learning. doi:10.100710758-020-09455-5

Sadati, L., Motaharipour, M., Farajidana, H., & Abjar, R. (2021). Designing, implementing and evaluation of educational program of ethics in education by scenario based discussion: A Scholarship study. *Journal of Medical Education and Development*. doi:10.18502/jmed.v16i2.7145

Schmid, R. F., Bernard, R. M., Borokhovski, E., Tamim, R. M., Abrami, P. C., Surkes, M. A., Wade, C. A., & Woods, J. (2014). The effects of technology use in postsecondary education: A meta-analysis of classroom applications. *Computers & Education*, *72*, 271–291. doi:10.1016/j.compedu.2013.11.002

Sciutti, A., Damonte, F., Alloisio, M., & Sandini, G. (2019). Visuo-Haptic Exploration for Multimodal Memory. *Frontiers in Integrative Neuroscience*, *13*, 15. Advance online publication. doi:10.3389/fnint.2019.00015 PMID:31156402

Setyowibowo, F., Sabandi, M., & Sunarto, M. (2017). Structural Relationships between Technological Knowledge, Content Knowledge and Pedagogical Knowledge. In *International Conference on Teacher Training and Education 2017 (ICTTE 2017).* Atlantis Press. 10.2991/ictte-17.2017.51

Snelson, C., & Perkins, R. A. (2009). From silent film to YouTube™: Tracing the historical roots of motion picture technologies in education. *Journal of Visual Literacy*, *28*(1), 1–27. doi:10.1080/23796529.2009.11674657

Soukup, M., & Lužný, D. (2019). The Story of Storyboards from East Sepik, Papua New Guinea. *Annals of the Náprstek Museum*, *40*(1), 59–74. doi:10.2478/anpm-2019-0005

Spector, F., & Alsemari, A. (2018). Echoic Memory. In Encyclopedia of Clinical Neuropsychology (pp. 1264–1265). Springer International Publishing. doi:10.1007/978-3-319-57111-9_1121

Stone, C., & Springer, M. (2019). Interactivity, connectedness and'teacher-presence': Engaging and retaining students online. *Australian Journal of Adult Learning*, *59*(2), 146–169.

Syaparuddin, S., & Elihami, E. (2020). Improving student learning motivation through the utilization of video media in education students. *Jurnal Edukasi Nonformal*, *1*(2), 228–235.

Tajik, F., & Vahedi, M. (2021). Quarantine and Education: An Assessment of Iranian Formal Education during the COVID-19 Outbreak and School Closures. *International Journal of Education and Development Using Information and Communication Technology*, *17*(1), 159–175.

Tana, A., Hasa, E., Shengjergji, A., & Osmanaj, E. (2021). Roma children's access to education during COVID-19 pandemic: The case of Albania. *Linguistics and Culture Review*, *5*(S3), 1527–1533. doi:10.21744/lingcure.v5nS3.1824

Tochon, F. V. (2007). From video cases to video pedagogy: A framework for video feedback and reflection in pedagogical research praxis. *Video research in the learning sciences*, 53-65.

Vanneste, P., Raes, A., Morton, J., Bombeke, K., van Acker, B. B., Larmuseau, C., & van den Noortgate, W. (2020). Towards measuring cognitive load through multimodal physiological data. *Cognition Technology and Work*, *23*(3), 567–585. doi:10.100710111-020-00641-0

Voepel-Lewis, T., Malviya, S., Grant, J. A., Dwyer, S., Becher, A., Schwartz, J. H., & Tait, A. R. (2020). *Effect of a brief scenario-tailored educational program on parents' risk knowledge, perceptions and decisions to administer prescribed opioids*. *Pain*. doi:10.1097/j.pain.0000000000002095

White, T. L., Møller, P., Köster, E. P., Eichenbaum, H., & Linster, C. (2015). Olfactory Memory. In Handbook of Olfaction and Gustation (pp. 337–352). John Wiley & Sons, Inc. doi:10.1002/9781118971758.ch15

Winkler, I., Reinikainen, K., & Näätänen, R. (1993). Event-related brain potentials reflect traces of echoic memory in humans. *Perception & Psychophysics*, *53*(4), 443–449. doi:10.3758/BF03206788 PMID:8483708

Yousef, A. M. F., Chatti, M. A., & Schroeder, U. (2014). Video-based learning: A critical analysis of the research published in 2003-2013 and future visions. In *eLmL 2014, The Sixth International Conference on Mobile, Hybrid, and On-line Learning* (pp. 112-119). Academic Press.

## KEY TERMS AND DEFINITIONS

**Adaptive E-Learning:** A combination of strategies, techniques, and methods that provide online students with a unique and personalized learning experience aiming to maximize the learning experience and performance.

**Cognitive Load Theory:** Is an instructional design theory that considers our cognitive architecture and the way that we process information.

**Formative Evaluation:** The process of assessing learning throughout a project or course, to identify problems and resolve them effectively.

**Information and Communication Technologies in Education (ICT):** The use of technology to enhance, support and optimize the delivery of information.

**Learner Model:** Is the representation of the learner's information based on which an educational hypermedia system will make specific recommendations.

**Learning Style:** The ways that learners process, understand, absorb, and use information.

**Mediating Setting:** Using media tools to make an idea, information, product, or service accessible.

**Pedagogical Scenario:** The progress of a learning activity, the definition of pedagogical objectives, the planning of tasks of learners, and the methods of assessment.

**Scenario Setting:** The process of making or creating a scenario. It is the division of the pedagogical content into sequences based on general and specific objectives.

# Chapter 12
# The Rising Battle for the Planet of the Apps:
## Moving From an L-Class to an M-Class Planet

**Dominic Mentor**
*Teachers College, Columbia University, USA*

## ABSTRACT

*This chapter introduces mobile learning for individuals, groups, and macro-level mLearning for personal and professional development. The chapter offers practical application of theories to be leveraged within pedagogical and andragogical approaches. There are multiple layers of considerations offered in terms of context, content, and collaboration to optimize mLearning. There are more mobile devices in the world than people, and many more of the world's population already has some type of mobile phone, making it the most wide-spread technology and most common electronic device in people's hands. Tapping into this ubiquitous technology creates a wide array of educational possibilities. Hence, a mobile first learning design is crucial in personal, organizational, leadership, and professional development contexts to help bridge the gap between personal lives, schools, colleges, and the workplace. The chapter illuminates how mobile learning brings to life that learning is everywhere as a natural segue for ownership of learning and ripe for dynamic, interactive, educational engagement.*

## INTRODUCTION

Mobile learning was prevalent (Naismith, 2004) prior to the launch of the Palm Pilot, PocketPC, BlackBerry or the launch of the iPhone. However, the iPhone launched a rising battle of applications (apps) to help or entertain people in their daily lives. Yet, mobile learning is still battling to be recognized as if educators, trainers, and facilitators are still treating their classes like L-Class planets, which are marginally habitable, with vegetation, lush for growth, but with no animal or human life (Howell, 2017). Even amidst the forced shift to online classes and many students using their mobile phones to participate and

DOI: 10.4018/978-1-6684-3996-8.ch012

engage with live and asynchronous classes, the new shift to our educational engagements becoming an M-Class planet of m-learning thriving in a seamless, theoretically informed, and integrated manner in educational settings, is still a work in progress.

Mobile technologies came to the rescue for many during the pandemic, but the hope of challenging the role of teachers or trainers, by students or workers as active participants via integrated mobile learning is still not as ubiquitous as mobile devices. Mobile learning is still offering micro- and macro-moments of learning in a multitude of multimodal stimulating means cultivating opportunities for transformation. People now have access to a wealth of multimodal information and stimuli, which can either be forces of distraction, tools of engagement or convert waiting times into productive learning opportunities. Mobile phones and tablet devices have become devices of choice for producing, consuming and engaging with content. Content ranging from texting, calling and checking email, to Internet connected smart Television (TV) for the usual suspects of social media, online video, news, podcasts, weather, or connecting to, producing and/or listening to music via smart speakers (Chaffey, 2021). In the United Kingdom (UK), the 2020 Ofcom Online Nation report indicates that people in the UK spend four-fifths of their time on their mobile phones. Whereas ZDNet, citing a report from a St Louis source that sampled 2000 multigenerational Americans, indicate that from that data, most Americans across generations spend 5 hours per day on their smartphones, with 18% indicating that they spend over 12 hours per day on their phone (Brown, 2019). Notably, the World Economic forum, cites a PricewaterhouseCoopers' (PWC) report which indicates that "the COVID-19 pandemic has helped drive an increase in smartphone data usage" (Myers, 2021). Understandably, the mobile phone prior to the pandemic was already a major source of social connectedness for many people through all or some of the activities mentioned above (Mentor, 2011; 2018). The Ministry of Social Development of New Zealand's government also regularly checks on New Zealanders social connectedness, which they use as an indicator of well-being and public mental health, and the mobile phone has consistently shown to aid people's social connectedness (2016, 2018). Opposing views to this literature review are reports of the dangers of digital engagement in the form of anonymous and nefarious online engagement, as well as social media companies designing algorithms to promote addictive smartphone behavior (Hanes, 2018). However, there are also reports of smartphones, apps, and new computer technology use, aiding mental health by keeping people connected to their loved ones during numerous pandemic lockdown restrictions (Sharma, Batra, and Flatt, 2021). While David and Roberts's 2021 article title captured the dichotomy best with their article "*Smartphone Use during the COVID-19 Pandemic: Social Versus Physical Distancing*" with the virtual connectedness making up for the social distancing and helping to combat feelings of isolation and even more so during various stages of the pandemic lockdown periods that we experienced.

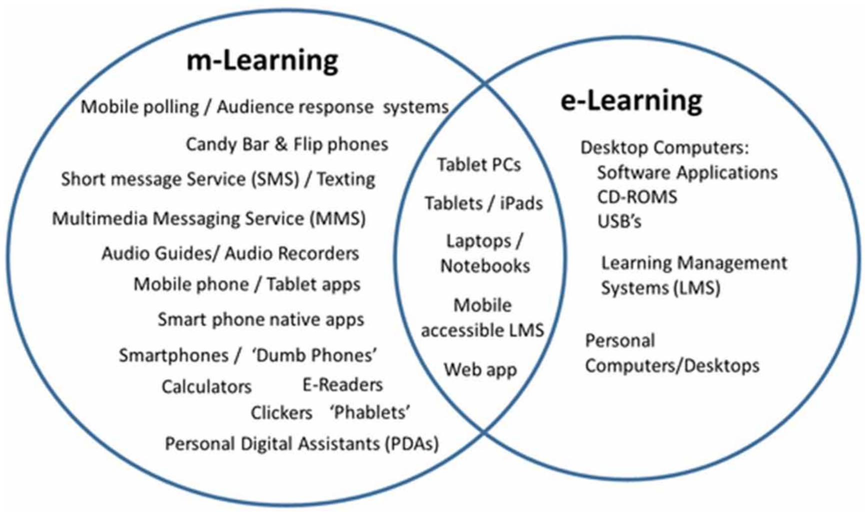
The smartphone was also overused during the pandemic as indicated by Ratan, Zaman, Islam, and Hosseinzadeh (2021) who decried smartphone overuse as a hidden crisis during stretches of COVID-19 lockdown periods. Increased media device usage due to the coronavirus outbreak among internet users worldwide as of March 2020, was also reported (Watson, 2020). The global average increase of smartphone use during the pandemic was cited at a 70 percent average worldwide where people were using their smartphones or mobile phones more as a direct result of the coronavirus outbreak (ibid.). The report indicates that different countries like Germany, Australia, and the United Kingdom, where the average was lower, but for countries like China and the Philippines, the percentage was reported at 86 percent (ibid). Granted, China and the Philippines already show higher number of mobile phone use in general, and it is useful to note that the mobile phone has become the extension and remote controller to other devices like home security, television, sound speakers and so forth. For example, 44 percent of

Brazilians used Smart TV and media streaming service more due to the COVID-19 pandemic (ibid). While there was an increase in smartphone use for all of the reasons and activities mentioned above, the mobile phone, as indicated and predicted by Mentor and Ahmad (2010) has been integrated into our lives in innumerable ways. From using it as a TV remote, step counter, fitness tracker, or navigating a route, the activities and integration into our lives do not stop there. Additionally, capturing or syncing data between smartphone and smart watches, connecting to, monitoring and/or controlling smart home devices ranging from security, locks, heating, electrical plugs/outlets, video calling, as well as smart bathroom scales, smoke alarms and baby monitors with the list ever growing. Mainly because of ready-in-hand access, easy interfaces, quick start-up times as well as the availability of a plethora of applications (apps) and connected smart devices. Amidst the integrated use of the smartphone into our lives, we still do not necessarily see this integration in K - 12 or Higher Education (HE) settings. While there was an uptick of people connecting via smartphones to participate in school and HE courses that switched to synchronous and asynchronous engagement, m-Learning has still not been adopted formally as a practice. Granted, in many places in the world, like rural and urban parts of India, Brazil, Egypt, China, and the United States the digital divide still persists (Pick & Sarkar, 2020). From conversations with peers in India, Indonesia, South Africa, the USA, and further supported by reports from UNICEF and other researchers, many educators, government officials and economists are still concerned about the digital divide based in part on lack of infrastructure and economic disparities that they themselves and their students must endure (Dreesen, Akseer, Brossard, Dewan, Giraldo, Kamei, Mizunoyai, and Ortiz, 2020; Rich and Pather, 2020; Prathapagiri, 2020; Van Dijk, 2020).

In K- 12, Higher Education and other industry settings, philosophies, policies, practices, and professional development offerings are still slow in aiding mobile learning to become fully adopted. The same is true for primary and high schools around the world with only a handful of teachers being brave enough to embrace smartphone use into the classroom or online educational activities. Additionally, teachers are already suffering from major time-poverty, which makes it difficult to seek professional development in educational technology, but as the pandemic has shown us, is much needed. However, mobile learning can help to save time, energy and can help to put their students' learning interest first while making them active participants rather than passive receivers. Other industries and arenas can also benefit from mobile learning (m-learning). The same learning and productivity advantages are true in the workplace, but with additional adult learning theories needed. Of course, work has gone beyond the office or site of work, but mobile learning is still off to a slow start in terms of generating m-learning opportunities as well as adoption in formal space. Mobile devices are changing the way we work and offer a multitude of formal and informal m-learning opportunities.

Mobile technologies can be incorporated into formal and informal learning spaces as they extend the formal educational time and bring to life a basic tenet that learning is everywhere. Furthermore, mobile technologies extend and blend formal and informal educational spaces in a manner that can help to engender authentic and autonomous learning habits. Through the multi-screen world that many people live in, mobile learning can help for seamless movement between desktop and mobile devices. The mobile phone can either be the main or supportive, just-in-time device. Still, learning designs need to be updated to accommodate this new extension of learning possibilities. Updates to or new learning designs can be adjusted or accommodated in innumerable ways from updating to mobile friendly Learning Management Systems or leveraging various mobile applications including social media or mobile learning in training programs. Additionally, mobile learning offers to overcome challenges or extend opportunities related to workplace training. And if not affected by the app-attack hype (Mentor, 2014), then delivering content

*Figure 1. Mobile learning*




on devices with different operating systems, catering to different worker's schedules, or learning styles, as well as real time and asynchronous learning analytics. If the mobile learning is designed well, with a smooth user experience, workplace or educational organizations can benefit from individuals' mobile engagement. Through push and pull, an adult or any learner can be offered a personal learning journey or agency. Some examples of push learning are reminders for bio-behavioral change or needs like quitting smoking, adherence to medication regimen, sending words of affirmation, or pushing one new word per day to learn. Push examples range from the receipt of MCAT, TOEFL or GRE offering one question at a time, or notifications of news, updates, or information on a topic of interest. There are also native and web-based apps that can pull users back during inactivity with reminders, or flash alerts or alluring offers of app-based rewards. While behaviorist in form, both the push and the pull learning, offers its own strengths and cons. The push and pull also aids breaking the dichotomous view of education, taking learning beyond the confines of formal settings. And with informal learning probably occurring more frequently, naturally occurring, and aided by the ubiquity of the mobile phone with internet access, the opportunities of push and pull mobile learning is that the motivation differs as assigned or self-sought.

Currently, very few dedicated teacher or instructional design preparation programs exist for exploring the relationship between mobile technologies and learning. By offering a course or program of mobile learning technologies with solid theoretical foundations, teachers-in-training, adult trainers, curriculum designers, strategic learners, and instructional designers can learn which theories and practical pedagogical considerations should inform their mobile and multi-screen teaching and learning initiatives. One graduate course in Organizational Leadership and Adult Learning (ORLD) hosts the possibilities and promises to overcome the perils of incorporating mobile learning and how it can offer transformative learning opportunities. Interlocking, hybridizing, or considering all of the theories present in a context, or which theories are being ignored and/or can be added with a new initiative, is a valuable and useful approach. It allows for multi-lens processing and provides one with multiple perspectives to view mobile learning projects, research, readings, field observations, classroom contexts, online learning, and many other formal, and informal learning contexts. Hosting a hybrid of theories, especially given different contexts, a plethora of devices, goals, objectives, target audiences and levels; will aid the mobile mediated learning. For example, incorporating behaviorist theory is still a factor, especially when it comes to adding gamification elements, or incremental goal attainment during mobile and computer mediated learning is one to note. Or considering from a mobile learning perspective when to employ situated cognition, perhaps through Near Field Communication (NFC) or Bluetooth technology while on the move.

But why offer a course on mobile learning? With the exponential use of mobile phones, it is imperative to understand how mobile technology can be used for learning and how to design for, and/or incorporate micro-learning. Mobile learning is still slow out of the gate and not widely adopted. By offering a course on mobile learning technologies, students will have the opportunity to keep abreast of current mobile technologies that people are already using as part of their daily lives and activities. And to provide a clearer framework for analyzing the growth of mobile and micro-learning, as laid out in the background below.

## BACKGROUND

Naismith, Sharples, Vavoula, and Lonsdale's literature review published in 2004 is still considered to be the seminal piece of research that proposed mobile learning as a field of study, different from electronic learning (eLearning). Their approach moved away from the dominant view of mobile learning as an isolated activity, to explore mobile learning as a rich, collaborative and conversational experience, whether in classrooms, homes or the streets of a city. In this way, they hosted the term mobile learning for the mobile learning opportunities available to individuals, a bigger target audience, its scope, and the increasing scalability of mobile learning opportunities. Through the sheer ubiquity of mobile devices, mobile learning rivals the size, breadth, and depth of computer access to the internet, influencing how people work, and, even though m-learning is still slow to catch on, how people learn, live and work is very mobile.

Mobile technology has changed how people work, learn and live. While slow to catch on in corporate, higher education and K-12 settings, mobile learning, even in micro learning format, in informal settings, has become the norm. The individual to mass-mobile online culture has proliferated to be adopted as common practice in the form of comments to media accessed via mobile means, sparking conversations and debate, influencing beliefs and policy. With mobile devices becoming the computer technology of choice, it is well perched and exploited for mass distribution of digitized content. Albeit, with a strong mobile first design approach aiding the mass distribution of digital content. Yet, many of their problems persisted during the initial uptake of mobile devices – from delivering content to various mobile device sizes, to content push and pull aggregation, to content development for diverse operating systems. Somewhat thought to be addressed by native apps, but not necessarily a sustainable method with high costs and native app design talent not as plentiful as one would expect. The native app approach is still popular, but the agnostic web app approach is gaining ground, and web responsive designs are aiding the conversion of content to being more mobile accessible and mobile friendly, with mobile learning initiatives following suit.

This chapter describes the characteristics of m-learning, the value of mobile first design approaches, micro moments of learning, and showcases examples of impact and untapped formal learning opportunities. One of which is learning from mobile learning, especially with regards to digital data tracking and analytics. However, mobile learning plans can be undone by not considering the plethora of diverse devices. M-learning still struggles to be adopted as part of traditional formal training or learning; even though mobile learning ideas are abounding and have been created to serve communities. In some cases, breaking out of defined restrictions according to geography, intellectual discipline, or specific end users. M-learning has been fueled by rapid technological growth trajectories, but still struggles to live up to its promise as people still think of mobile learning designs with traditional lenses and expect it to transcend such limits as output and input. Small screen real estate and input options on mobile devices require a cognitive load consideration of element interactivity (Cabañero, Hervás, González, Fontecha, Mondéjar, & Bravo, 2020; Pass, Renkl & Sweller, 2003; Zhonggen, Ying, Zhichun, & Wentao, 2019).

A graduate course pioneered and offered at Teachers College, Columbia University, explores how one can utilize mobile technologies for adult, K-12, and organizational learning as well as the factors to consider for designing m-learning (Mentor & Ahmad, 2010). The course highlights theoretically informed processes that can stand up to the ever-changing mobile technology landscape and support practical pedagogy and andragogy. Adding practical pedagogy and andragogy, the project-based m-learning designs takes a progressive structure to elucidate lessons learned and offer directions for growth to adapt to changing m-learning environments. The mClass offers in-service and pre-service teachers, as well as adult learning designers and practitioners from many different disciplines, examples, and opportunities to directly engage learners virtually, in real-time and asynchronously. The mobile learning course also highlights the multimodal stimulation of digital curation through mobile technologies and their ability to prepare and engage any learner, child or adult, better autonomous learning opportunities within different learning contexts. Apart from the theories, practical pedagogical guides could be served well if informed by the m-Learning guild's three C's of context, content, and collaboration (2011), which further frames the course. Context informs which theories and practical processes to consider as well as the how, when, and the what of educational devices and/or apps to use, to meet the planned goals and objectives of interactive educational engagements. While context is crucial, core curriculum and content on a mobile device is dynamic. Taking note of the goals, objectives, context and content can promote learners as active agents and collaborative participants, rather than passive receivers. Many other factors to consider range from teacher preparation, teacher engagement, student personalities, students' prior experience and more. All of which could influence the class dynamic, and how that plays out in an in-person or online context. At times, even in blended or mobile learning contexts, over-talkative personalities could even influence the virtual engagement space. In short, drawing on several theories and practices, a hybrid approach to teaching and learning with tablets is necessary for successful and engaging activities that address the needs of mobile technological integrated teaching and learning. With the ubiquity of mobile devices, there is a general need for a mobile first approach (Wroblewski, 2011), as well as a mobile first e-learning design need (Curinga & Svaranos, 2016). To note, as with many new approaches and technologies, there is still resistance and many questions holding back the adoption and integration of m-learning into the learning and development processes. Some questions that are asked as people try to differentiate m-learning from e-learning are:

- What does the phrase "mobile first design" mean for learning designs?
- What are some of the educational possibilities offered by mobile devices?
- What are concrete examples of mobile learning?
- How does e-learning differ from mobile learning?

The next section of this chapter will offer a response to those questions. The chapter will also offer some diagrams to help with the understanding and differentiation.

## MOBILE FIRST LEARNING DESIGN

A "mobile-first learning design" responds to the critique that mobile learning is a weaker alternative to traditional eLearning accessed via computers with bigger screens. Instead, this approach assumes that people will more likely, first and more frequently access a website or conduct a query via a mobile device.

Given the rise in mobile device use, in particular mobile phones, that growth has prompted software and learning designers to take a "mobile first" approach—which demands an alternative, high-quality mobile experience to maintain learner interest. Mobile-first learning design recognizes the limited element interactivity afforded by a device with a small screen without compromising a quality user experience. A mobile first design approach can aid instructional designers to adapt the way they design for larger screens to a more realistic multi-screen learning experience.

Luke Wroblewski (2011) introduced the concept of a mobile first design approach. He posits that—by designing with mobile devices foremost in mind—learning designers are better prepared for the current explosive growth and new user opportunities via the mobile internet.

An approach of making everything mobile is similarly fraught with issues. The conversion of everything to PDF approach as e-learning, was, and still is a danger to e-Learning. So too is the make everything mobile approach dangerous without considering the form factors from an element interactivity perspective. Form factors that influence and impact input and output decisions in terms of producing or consuming activities on a smartphone. Making everything mobile makes an assumption of universality, but becomes a disservice to all as it does not take into consideration the multitude of diverse devices, and it does not address limited input and output realities of mobile devices. From an element interactivity perspective to, input and output considerations that tie in with physiological conditions, ranging from eyestrain on small screen sizes to thumb tendonitis on small keyboard inputs. Why is this important to consider from an m-learning perspective as well as cognition and handheld device position? For one, because it will help you the progenitor in many contexts, or rather facilitator of mobile learning to consider where and how the receiver or dynamic active learner agent will interact with the learning and assessment pieces. Endeavoring to 'mobilize' or convert everything, is not so much an approach to open learning to everyone, but rather a flawed approach giving in to more perils and pitfalls than living up to the promise of mobile learning.

## EXAMPLES OF EDUCATIONAL POSSIBILITIES OFFERED BY MOBILE DEVICES

While teaching English as a Second Language in a rural area 60 km outside of Cape Town in South Africa, there were many creative efforts needed to convince the majority of students to learn English as a second language. Speaking in English on the farms and in that rural area was frowned upon, ridiculed, but moreover envied. Computers were a scarce resource, but calculators were required and abundant. The simple idea of making words with the numbers, turned into a competition of generating English words and building vocabulary. This was the start of an m-learning idea that would develop into wanting to leverage the power of mobile devices for learning. And as calculators became more powerful and Personal Digital Assistants (PDAs) became more widely adopted, the idea grew exponentially. Prior to the launch of the iPhone, a mobile learning course was conceived and co-designed to offer graduate students a theoretical and practical foundation to leverage alphanumeric mobile phones for learning. Even with technology advancements of PDAs and early smartphones from Palm, the idea of mobile learning was not necessarily understood or warmly welcomed. However, with the advent of the iPhone the same year that the graduate mobile learning course was piloted, the interest shot up well beyond the peak of Gartner's hype cycle (Fenn, & Linden, 2005), and maintained its interest beyond the trough of disillusionment (ibid).

By 2009, a graduate seminar and project-based course was piloted (Mentor & Ahmad, 2010). The course was designed for students who were not programmers, but who were interested in exploring and applying theories into practical pedagogies that could inform mobile learning or app development. While working on the design of a mobile phone app or mobile phone learning activity, students gained valuable design insights that would empower them to speak to a programmer on what and how they wanted their app designed. In this intensive course, students learned how to design and develop mobile learning activities and could design and build native or web apps for mobile devices. If a native app, they could decide whether they wanted to design for iOS or Android, and could do so from multiple perspectives of UI\UX designer, develop and run user testing, and also as a developer. Throughout this course on mobile phone apps the instructors melded theory, design, and the development with real-world experiences.

Students who have taken a graduate mobile learning course have been from the USA as well as from around the world. The adult learners came from many different professional backgrounds ranging from learning & development consultants, professional developers, medical professionals and practitioners, coaches, teachers, principals, as well as law firms, policy, and government institutions. Some examples of student projects range from informing mobile app development and strategy at the Metropolitan Museum of Art in New York City, as well as the highly successful Explain Everything app. Other examples that have been discussed in the past depending on students' interests were:

- designing virtualized or augmented reality tours via mobile devices to help prepare a learner for a new context or orient them to learning objectives/content, as in museum education
- tracking and learning about emotions
- designing a math ninja game with interaction between parents and young children
- spirituality and wellness
- exploring film noir snippets and concepts via mobile device engagement
- military training guides
- formative assessment practices
- invigorating the teaching of credit bearing Tai Chi in a college setting with videos and using the Learning Management System (like a social media platform)
- fitness exercise involving children, parents and/or teachers
- an alphabet learning activity teaching and offering learning of identifying and writing alphabet letters.
- sexual health and training
- nutrition, food training and community kitchens
- a community of educators sharing, and rating lesson plans
- young adult workforce development
- Team building and Human Resource training
- concussion testing and training for sport athletes
- medical diagnostic training

One area that was seen to be useful in mobile development is audience, or participant response systems. Classtalk mentioned in the seminal mobile literature review (Naismith et. al., 2005), and iClickers were different types of classroom response systems (Mentor, 2011). Classtalk as cited in the Naismith *Literature Review in Mobile Technologies and Learning* was used with first year physics students at the University of Massachusetts. Classtalk offered students opportunities to participate in class discussions via mobile devices and exploited the near synchronous aggregating and displays of collated responses. While the first iterations of iClickers came with its own devices that could be numbered as a means of tracking students' in class responses, that system was soon abused by students when they would be absent from class, but their friends would have their clickers to answer a professor's question. iClickers could also integrate with Learning Management Systems and be used for both formative and summative assessments (iClickers conference 2011). In addition to the mobile clickers, referred to as student remotes, the new versions of iClickers include Android and iOS native apps accessible via mobile phones, as well as mobile friendly browser access. In addition to these live class audience response systems, Poll Everywhere which launched in 2007 and others like Quizbox, Merida and Nearpod have grown in popularity. While Quizbox hosts their questions online, Merida also offers native app incorporation. Additionally, Nearpod is a newer option. When it was first introduced it was only available for iOS' iPads, but it has since become hardware agnostic. Nearpod mimics are considered older technologies where teachers could share their screen on their students' devices, guiding them through a lesson. Students can now answer questions via their mobile phones either through native or web apps when prompted. They can do so either with text, or even drawing an answer. Additionally, there are numerous collaborative tools (i.e. Google Docs, Popplet, Padlet, Mural.ly, Minecraft, Peergrade to name a few that allow for brainstorming and collaboration in real time. While QR codes have also been researched as mobile learning interaction and engagement tools with mixed results (Gao, Liu & Paas, 2016; Jamu, Lowi-Jones, & Mitchell, 2016; Mousa, & El-Salam, 2016; Rikala & Kankaanranta, 2012). During the pandemic force shift to online learning, many people also started to leverage web and mobile accessible interactive game and polling tools like Kahoot, Socrative, Aha slides, Quizizz, PollEverywhere, Direct Poll, Slido and Mentimeter synchronously and asynchronously for educational engagement. While some of these tools like PollEverywhere, Socrative and Kahoot have been around for a while, many experienced these as newly sliced bread experiences.

Many of the mobile learning interventions, applications and others are shared with the mobile learning graduate class as examples of approaches with applied theories. The course was the USA's first graduate course on mobile learning (Mentor & Ahmad, 2010) and catered to students from various industries and fields. As part of our teaching and learning philosophy, we surveyed the students learning progress on the relevant mobile learning areas at the start of the semester, at the end of each class session, and at the end of the semester.

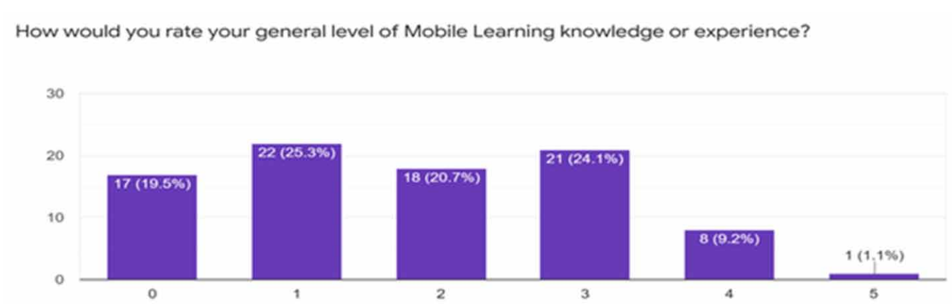
## SURVEY RESULTS

When we started facilitating the course in 2009, we introduced the concept of anonymous electronic session reviews after every session. We used that feedback on a weekly basis to tailor the class to the students' areas of interest regarding mobile learning, their course of study and disciplines, and their preferred mix of learning styles and approaches, as well as the technical or non-technical level. In 2015, a self-reflective pre- and post-review was added to the survey. Students were asked to rate themselves about their mobile learning knowledge at the start of the semester. They rated themselves about mobile learning as a whole, as well as on specific topic areas like mobile learning literature, mobile assisted language learning, mobile activism, mobile learning in K- 12 settings, with adults in the work settings, and other areas like mobile health, mobile journalism and mobile gaming for educational benefit. Students were asked to reflect and rate themselves before a specific session on their knowledge of that area as it pertains to mobile learning. Apart from students rating themselves with an overall rating at the beginning of the semester, they completed a post-survey at the end of the semester, and rated their mobile learning knowledge, as well as perceived growth in mobile learning. Apart from demographic questions like their level of study (masters, non-degree, or doctorate), country of origin and length of stay in the USA up until taking the mobile learning course and their program or area of study. The latter questions were included to aid discussion in class around mobile technology, mobile learning and mobile cultural practices.

About 54 percent of the students taking the class were from the USA, while Chinese students made up 30% of the class participants as captured from data collected between 2015 - 2019. Students from other countries listed themselves as being from Argentina, Brazil, Canada, Hong Kong, Jamaica, Japan, Kenya, Korea, India, Indonesia, Mexico, Nigeria, Philippines, Taiwan, Thailand, Turkey, South Africa, and the Ukraine. Students came from various disciplines over the years: Arts and Humanities, Applied Linguistics, Bilingual/Bicultural Education, Communication, Computing and Technology in Education, Dental School, Human Development, Instructional Technology and media, Mathematics, Science and Technology, Teaching English as a Second Language, Organizational Leadership and Adult Learning, Transcultural and International Studies, School of International Policy and Administration, and the School of Public Health. Twenty-five percent were doctoral level students, while 75% were at the Masters level.

The following data comes from surveys and graphs from students' collated responses for Spring and Summer semesters of 2015 - 2019. An example of survey results for one Spring semester asking students about their own rating of their prior knowledge regarding mobile learning literature.

*Figure 2. Self-rated prior knowledge where zero reflects no knowledge of the area and five indicated very high knowledge of the mobile learning area.*



Also see figure 3 self-rated prior knowledge about m-learning in the workplace:

*Figure 3.*

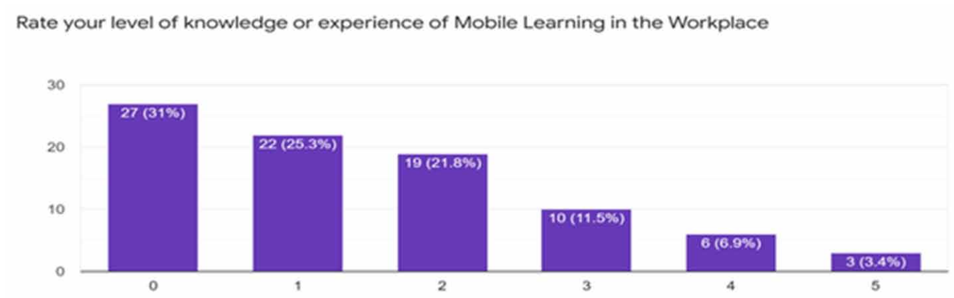
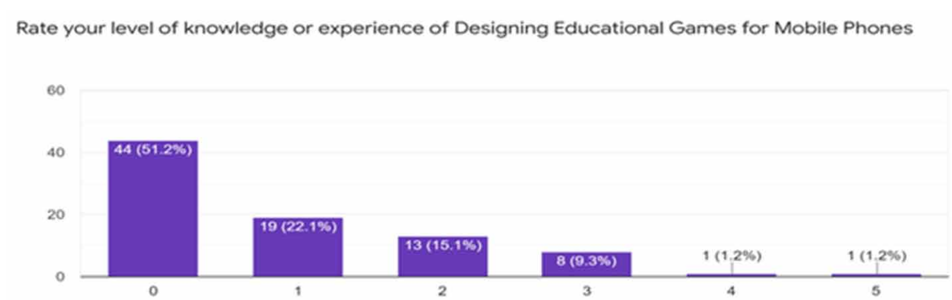



*Figure 4. Designing mobile learning educational games.*

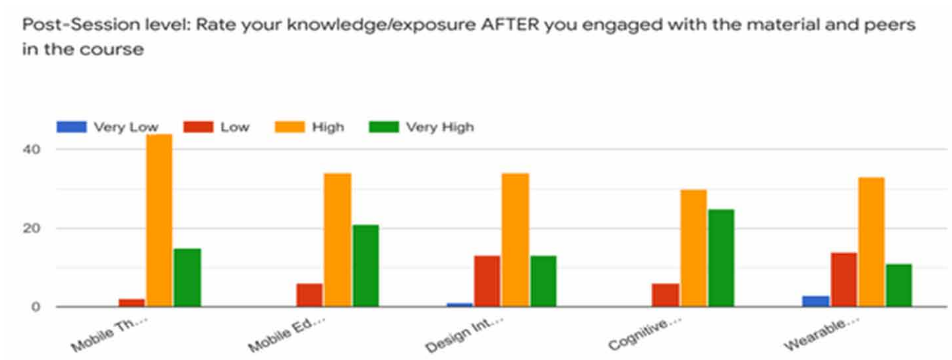



Then knowledge of mobile activism

*Figure 5. Knowledge of Mobile Activism*

At the end of the semester, students were shown their responses on where they self-rated their knowledge about mobile learning before commencing with the course. They are then asked to complete a post-survey, where they enter open-ended qualitative feedback about their experience learning about mobile learning during the semester.

*Figure 6. Pre- & Post Self-Rating*




As can be observed from the graph, students rated themselves as having low knowledge and experience of m-learning at the start of the semester, but the overwhelming majority rated themselves very highly at the end of the semester. In the qualitative comments, one point to highlight was that the notion of learning is everywhere took root, as well as the possibility of entertaining micro-learning moments as part of a mobile learning initiative.

These mobile learning activities or applications also had the potential to be used in many different ways within one context or outside of its intended target audience or setting. For example, depending on the museum or subject area (e.g., history, mythology, natural sciences, commerce, culture), a targeted approach can aid follow-up experiences or bring a distally located experience within reach of students and teachers. Similarly, other museums for art, and history embraced mobile learning to engage both their physical and virtual target audiences. Contrary to some beliefs, designs for museums' mobile first engagement approach, has actually increased physical visitors to the museum. Additionally, mobile online engagement increases the possibility for fundraising due to its delivery of valuable click and view statistics. Five minutes of mobile access by a virtual or physical visitor can offer valuable moments of micro-learning for both the museum staff interested in the data analytics.

## Mobile learning for Micro-learning

Apart from mobile devices being one tool on the utility belt of educational engagement that can be used in tandem with others, mobile learning can further support a micro-learning approach. Learning in short bursts can be described as stringing learning moments together in bite size fashion or as ComLabIndia calls it, snack learning (2016). In this way, mobile learning supports micro-learning by accommodating adults suffering from time poverty, and accommodating the commuter's learning journey (Mentor, 2016)

It offers valuable micro-learning of the museum and the artifacts. Grovo (2017) defines micro-learning as possibly consisting in part, of:

- *Five minutes of learning a day*
- *Digestible, point of need learning experiences*
- *Learning, and applying what you have learned, in small, focused steps*
- *Learning done within the limits of working memory*
- *The shortest path between aha moments*
- *Not a weapon of mass instruction*

Of course, micro-learning could be longer or shorter than five minutes a day. Also, it could be more than one instance of five or more minutes, but can be moments strung together like a string of pearls and contribute to transformative learning. While some consider micro and mobile learning not as a tool for mass instruction for the most part, there are contexts where mobile learning can be pushed out to a virtual mass audience or delivered in-person to a large audience via something as simple as a mobile digital project like the earlier InnoCube Pico Projector (UNESCO 2014 Mobile Learning Week exhibit) or an add-on click on device such as a Moto Mod (2016). Alex Khurgin does make a strong point in the title of his webinar "*Microlearning for Transformation, Not Information Transfer* (Grovo, 2017)", that micro learning is not just information transfer, but rather micro-learning for transformation (2017). Mobile devices can offer unique opportunities for mobile and micro learning to support transformative learning opportunities.

Looking at mobile learning as an additional tool as part of a utility belt, to make available at the right time, or as part of the overall holistic approach, moves away from the mistaken view of mobile learning as an isolated activity to explore. But rather "to embrace mobile learning as a rich, collaborative and conversational experience, whether in classrooms, homes or the streets of a city" (Naismith et al. 2004), or the workplace.

## Workplace m-Learning

The increase in mobile phone ownership and people's reliance on their devices, has driven the Bring Your Own Device (BYOD) to work movement. Many corporations and other workplaces are making sure that their learning suite of compliance training or data dashboards are available for their workers. Mobile learning designs take into consideration various theoretical frameworks to inform the adult learning experience and differentiate instruction. Notably also is that introverts participate more easily where mobile learning is a part of the blended learning approach, partly because it is personal device where they thrive, offers them ease of use and immediacy in action, result and visibly displayed responsiveness, and they can operate with believed anonymity, hence increasing collaboration and student participation more broadly (Al-Sudani, 2019; Dwikoranto, Setiani, Prahani, and Mubarok, 2020; Han, 2019). While it should also be noted that both children and adults thrive in personal learning environments.

## Enabling Personalized Learning Environments (PLEs)

The hypermedia capabilities of mobile devices correspondingly enable learners to map out and navigate their own learning path and they can do so on-the-go—thus meeting differentiated learning styles, interests, levels, and needs. The mobile learning approach can convert students into active agents as opposed to passive participants. If the mobile learning design is done well, students can take on new roles, for example with mobile journalism, mobile activism, filmmakers or documentarians. Moving learners from passive consumers to active producers of learning content through mobile devices are now simpler and tapping into practices many participate in already as active agents. The latter could be used as part of formative or summative assessments and both of the latter assessment approaches should form part of a PLE design (Patterson, Stephens, Chiang, Price, Work, & Snelgrove-Clarke, 2017; Hricko, 2017; Mentor, 2014; Mentor, 2016).

Catering for mobile friendly PLE's, demand that instructional designers cater for automated learning designs where both linear and non-linear paths are made available to the learner. In a rich hypermedia world, accessible via mobile device, the learner should be able to have the freedom to create his or her own learning path. Allowing the mobile learner to jump to any learning link, just like they would be navigating a hypermedia or Wikimedia environment or any online source, jumping from interest to interest or whatever fits their available time. Be it that they decide to watch shorter videos first due to time limitations, or to build up a knowledge or an understanding in bite-size fashion, the freedom to choose, could aid and increase motivation/engagement.

The freedom to choose from various hypermedia artifacts can also aid transformative learning. Especially if it encourages and incorporates learner feedback where the learner is navigating its own learning path towards the established objectives of the assembled artifacts working together towards the learning goals. While there might be a fear of losing a clear vision of the learner's growth and proficiency, rather than just reporting on learning metrics such as content watched, quizzes answered, or lesson completions, there is instead opportunity to assess and report on transformative learning that can be observed through data analytics beyond just the learning analytics of clicks and completions.

Taking a hypermedia approach, can open the learning design for learners and their learning experience, and instead of restricting learning to a single event, they can follow up on previous learning, stitch learning pieces together in their own way, or re-watch videos or content, spaced out within a specific required or their own time frame, and do so for review, and reinforcement. Rather than offering grades or badges, or progress bars, the mobile learning design could proactively ask the learner to apply what they've learned and to supply examples of that learning application as part of the mobile learning process.

While providing performance progress and perhaps learning support, learning checklists, and to make transformative learning more visible to other learners in the virtually accessible mobile learning space, it can similarly have the effect of putting current and future learners at ease, gauge and manage their own learning expectations against the previous learners and either match the expectations or set the bar higher for themselves. Building in a social collaborative approach can also make the learning less of an information transfer, but more of a social engagement, which can be considered more supportive and less intimidating, and further promote the transformative learning to be more than just on an individual plane, but on a larger departmental level or organizational scale. Turning the goals and objectives from individual accomplishments to an organizational benefit, while transforming and establishing a new status quo.

Students or workers can learn how to use mobile polling for garnering organizational direction or for policy setting or consensus building. Students will learn how to use live polling to check prior knowledge, gauge interests, taste or preferences as well as for formative or summative assessments, and for mobile data collection with personal tailoring via conditional questions. Mobile polling and surveys, if designed from a mobile first approach, yield higher participation rates.

There are also opportunities for how students will learn to mobile games and learning activities. For example, in health applications, they can be used to stimulate smoking cessation, biometric or nutritional tracking. Other self-monitoring or recording frequencies of a target behavior to change (e.g., wellness mapping or nail biting) can make optimal use of the personal mobile device. With the rise of mindfulness practices, mobile learning opportunities abound for users to own and track their learning journeys in this regard.

Many multinational and national corporations, universities and other workplaces host multicultural workforces. Mobile devices in these contexts can aid in leveling the playing field, lowering device learning curves, and increasing accessibility beyond a desktop computer. Participants of the mobile learning courses learned how to extend the learning engagement on mobile devices and use learning analytics to tailor activities for adult learners of various, or educational and personal interest backgrounds. Other mobile learning opportunities lie within organizational training or leadership development. Students will learn how mobile phones in the workplace can offer electronic performance support systems, peer-to-peer availability, and support as well as personal and organizational tracking of learning.

Through mobile social media and communication, mobile devices offer social connectedness at work—defined as a sense of belonging or affiliation. In higher education and other life arenas, social connectedness can be cultivated through mobile devices at a faster rate and far more frequently than a computer. From practical examples and hands-on projects, course participants will see how mobile devices allow for learning to seamlessly move, from personal engagement, to virtual collaboration and to the multi-screen reality of modern learners.

Reliance on mobile devices at work—not just younger generation workers—provides opportunities for just-in-time, anywhere, informal learning when confronted with work challenges; as well as making learning more accessible to busy professionals when they have the opportunity or need to learn. Another challenge to overcome, based on students' positions at the start of the course, is that mobile learning does not have to be thought of as a replacement to face-to-face or eLearning models, but rather, as another useful method to pull out of the utility belt of educational tools, within appropriate contexts. Similar to using the right tools for particular tasks. Additionally, in many developing countries, mobile learning is accessible in locations where computers and online learning are not, and some still wonder, how is mobile learning different from e-learning.

## HOW DOES M-LEARNING DIFFER FROM E-LEARNING?

For one, the User Interface and User Experience (UI/UX) is completely different from the UI/UX of online teaching and learning. Hence, the form factors of input and output with regards to screen real estate and production or interaction on a mobile device, will influence the cognitive load, from an element interactivity perspective. And these are considerations to be aware of for mobile online teaching and learning with additional considerations, limitations, and advantages.

Online teaching and learning are different from mobile learning in its approach, form factors, theoretical frameworks, and affordances. With mobile learning for professional growth, context is key, just-in-time content is core, while collaboration and individual engagement are crucial. Understanding the "why" and "how" of mobile learning is the first step in deciding what kind of training should be designed for mobile devices. Mobile learning is not about putting online or e-learning course materials into a smaller package so that they can be played on a mobile device. Rather, it is thinking differently about learners and the new possibilities that being both mobile and connected can offer to employees who want to learn something "on the go". The opportunity to extend or continue their learning engagement from a previous screen to a mobile device offers just-in-time learning and information. Designing mobile learning content demands considerations of a complex mix of different forms of mobility, different technologies, a variety of types of learners who learn in different contexts, with different learning styles, and trainers with many different approaches to instructional design. Moreover, content and experiences are somewhat restricted by the element interactivity of different mobile devices, which also demands different approaches for engaging young learners, young adults, and adults on mobile devices.

## MOBILE PEDAGOGY AND ANDRAGOGY

With the planet still battling the onslaught of apps for almost every aspect of life, and the blitz of hype on wanting to create an app for everything ranging from conferences to courses, the question becomes, is an app, that will only be used once by a user, and will take up unnecessary mobile phone space and battery power, really that useful? Additionally, investing in designing an app for one course, a conference or other once off events of learning engagement, how is mobile learning changing the role of teachers? In the broader context, mobile access and mobile learning is already changing the role of teachers, as students now have access to a wealth of multimodal information and stimuli. These mini-computers with powerful applications at their fingertips, can either be forces of distraction or could be utilized as tools of engagement. Thus, how do mobile technologies improve pedagogy and strengthen education quality? One response here is that mobile technologies offer teachers and training facilitators opportunities to directly engage the students or trainees virtually, in real time and asynchronously. Furthermore, students and trainees can integrate their informal and feral learning into their formal mobile learning. However, how should mobile technologies be integrated into formal and informal learning environments? Mobile technologies can be incorporated into formal and informal learning spaces through creative means. For one, it can extend the formal educational time and honor a basic tenet that learning is everywhere. Secondly, mobile technologies can extend and blend formal and informal educational spaces in a responsible manner that can help to engender authentic and autonomous learning habits.

From an adult learning perspective, mobile learning lends itself to Self-Directed Learning (Candy, 2004; Marsick & Volpe, 1999) and increases the opportunities for incidental and informal learning (Marsick & Watkins, 2001) and could do so in smaller chunks of time (Mentor, 2016). An award-winning mobile first learning approach example within a corporate setting (Freifeld, 2020) leveraged the M-Class principles from the Mobile learning class. The one-person training unit introduced self-directed learning systems to have adult workers pursue a mapped-out orientation and onboarding training schedule and learning of a new data governance model. The vision and strategy entailed the building of and use of hypermedia artifacts with the ability to provide automated learning analytic data and ensured that all training material would be mobile accessible and would occur within the data governance application itself. The effort involved capturing the complex data modelling concepts to create a sustainable training model to (i) increase digital learning engagement of the data model, (ii) to increase employee and client success, as well as (iii) retention of the data governance knowledge for a multi-industry data analytics system ranging from Investments, Securities, Bonds, Trades, Insurance, and a whole host of other industries. The mobile friendly learning design created new structured training that could be delivered a/synchronously and could be accessed via mobile or traditional devices. These innovative methods and novel training approaches at that time (2017-2020) was hailed as industry leading by an independent big four auditor, enabled new hires and users to be empowered and self-directed in their learning from the onset of their orientation and onboarding, but with the support of a virtual facilitator/trainer during scheduled one-on-one sessions (Mentor, 2020). The digitally structured, scaffolded approach demarcated with levels of data governance complexity, hosted a text enhanced and visual training map, which offered duality as a control sheet, and allowed for flexibility that could accommodate a new hire's learning pace. They could go as fast or as steady as they wanted to go with the structured in-app training materials and hands-on assignments, but at the same time, meet their managers' time frame demands. Apart from having created interactive online multimedia documentation and training materials for the company's cloud-based enterprise technology solution, including text and video, the mobile first learning design, offered and delivered a sustainable training framework informed by the practical use of adult learning theories and practices. The scope of the mobile first learning design work was multifold and was made that much more expansive by ensuring that the training material that was created, could easily be migrated for use by new or veteran employees, contract workers, consultants, clients and independent reviewers of clients or auditors. In this way, a fluidity was created between the employee and client's learning space, so that lessons can be learned and applied across those spaces. Furthermore, building capacity of new and veteran employees to better support work with and the clients' staff.

## M-LEARNING FOR PROFESSIONAL DEVELOPMENT

How do mobile technologies build the capacities of teachers and support their work with students? Gaible and Burns (2005) show the link between well-informed instructors and Mills (2013) highlights the multimodal wonder of digital curation through tablet computers and their ability to prepare and engage students to become better autonomous learners within different K – 12 contexts; be it grade level, subjects or specific projects inside or outside of the classroom. However, many teachers are still resistant to, or ill prepared during teacher training, and are at odds with students' mobile technology savviness and proclivities to mobile technology adeptness.

Questions then remain; how are educators trained to utilize new technologies to improve teaching and learning? How are training institutions ensuring that pre- and in-service teachers receive adequate and ongoing training about mobile learning? Training for pre- and in-service teachers are still sparse or non-existent and not adequately informed by theoretical foundations. The mobile technology landscape changes rapidly and a theoretical grounding would help any mobile technology integration initiative, with in-services for teachers or during the training of pre-service teachers.

## POLICY CHANGES TO ACCOMMODATE M-LEARNING

A mobile first approach can help explore how one can utilize the mobile devices for learning (Curinga, & Saravanos, 2016) and the factors to consider for maximizing transformative learning (Marsick, 1998; Nicolaides & Marsick, 2016). Tablet devices, like the iPad, Kindle and many Android tablet options, are rapidly becoming devices of choice and losing favor in the sway of the ephemeral adoption of tablet only devices for consuming and producing content. For the former, partly because of the simple and easy interface, quick start up times as well as the availability of a plethora of applications (apps).

And for the latter, partly because computers in general have become more powerful and manufacturers are answering the need for hybrid computer and tablet devices. However, apart from policy changes needed regarding students and teachers allowed to use mobile devices, very little guidance or professional development offerings are available for K – 12 and other area teachers. Teachers already suffering from time poverty or lack of time, could benefit greatly on how to use tablets to save time, saving their energy and putting their students first. But, what policy environments – at the national, district or local levels, could help teachers effectively leverage new mobile technologies to improve educational outcomes? What approaches, such as awareness-raising and advocacy, can increase the efficacy of policy implementations? And how have policy implementations been monitored and/or aligned with ICT competency standards for teachers?

## M-LEARNING EXAMPLES

A few examples arise in this regard. Many examples from all around the world, and two examples that the author was directly involved in, saw the benefits of policy changes, and pilot efforts that influenced policy changes. Examples from around the world can be found in recent research on mobile learning initiatives ranging from Science Learning and Engagement in the Digital Age: Understanding the Effect of Mobile Technology on Adult Engagement Experiences at a Natural History Museum (Kounaves, Archer, King, & Pegram, 2016), and in the realm of new language learning and teaching environments, there is Mobile Learning Languages, Literacies and Cultures by Pegrum (2014), and using mobile game technology to enhance student engagement and learning (McGregor & Bartle, 2016; Villanueva & Vaidya, 2016) to name but a small handful. Apart from the growth at the mLearn Conference (2011 – 2016) and UNESCO's Mobile Learning Week Symposium, mobile learning presentations have grown significantly at other conferences in Asia (Woodill, 2013), and further rapid adoption in the Asia-Pacific region, Africa (Nordin, Embi, Norman, & Panah, 2017), the Middle East (Masrom, Nadzari, Mahmood, Zakaria, & Ali, 2016; Sarrab, Al Shibli, & Badursha, 2016) and elsewhere in the world (Khaddage, Müller, & Flintoff, K. (2016), there have also been research handbooks on mobile learning that has either made the case for the need for a wider adoption of m-learning or that offered research initiatives on mobile learning (Briz-Ponce, Juanes-Mendez, & García-Peñalvo, 2016; McQuiggan, McQuiggan, Sabourin, & Kosturko, 2015; Mentor, 2016; Traxler & Kukulska-Hulme, 2016).

One area that has seen useful mobile development is audience, or participant response systems. Classtalk mentioned in the seminal mobile literature review (Naismith et. al., 2005), and iClickers were different types of classroom response systems. Classtalk as cited in the Literature Review in Mobile Technologies and Learning was used with first year physics students at the University of Massachusetts. Classtalk offered students opportunities to participate in class discussions via mobile devices, and exploited the near synchronous aggregating and display of collated responses.

While the first iterations of iClickers came with its own devices that could be numbered as a means of tracking students' in class responses that system was soon abused by students when they would be absent from class, but their friends would have their clickers to answer a professor's question. iClickers could also integrate with learning management systems, and be used for both formative and summative assessments (iClickers conference 2011; Chan and Ko, 2018).

In addition to the mobile clickers, the new versions of iClickers include Android and iOS native apps accessible via mobile phones, as well as mobile friendly browser access. In addition to these live class audience response systems, others like Poll Everywhere which launched in 2007, while others like Quizbox, Merida and Nearpod have grown in popularity. While Quizbox hosts their questions online, Merida offers native app incorporation. Additionally, Nearpod is a newer option. When it was first introduced it was only available for iOS' iPads, but it has since become hardware agnostic. Nearpod mimics older technologies where teachers could share their screen on their students' devices, guiding them through a lesson. Students can answer questions when prompted either with text or even engaging with an illustration board, and there is a collaborative tool that allows for brainstorming in real time. Other tools deserving a mention again in terms of contemporary student response systems that have seen an increase in adoption and use during the pandemic's forced shift to online synchronous engagements are Aha slides, Direct Poll, Kahoot, Mentimeter, NearPod, Quizizz, PollEverywhere, Slido, and Socrative. Other tools that also offer wonderful formative assessment opportunities via mobile devices include the award winning Explain Everything and Pear Deck with many other non-app mobile learning examples.

Other examples include the great mobile learning projects created by the 2011 New York Mayor's Office of Adult Education Fellows (Mentor, 2011), as well as with a National training organization, where a mobile-first approach expanded the social connectedness and skills training of entry level trainees (Mentor, 2016). Furthermore, the 2020: A Case Odyssey Training for a Data Governance Software Technology Company, which was hailed as industry leading by one of the big four global auditor companies, was another mobile first learning design example that had a global impact for its internationally placed workers and multinational clients and client workers (Mentor, 2020).

## CONCLUSION

A hybrid consideration of theories is definitely a good approach as you might find different scenarios applicable and helpful for design, testing, use and response to mobile learning contexts. Considering a combination or a mix of theories also caters for differentiated instruction and different learning styles which would then allow for catering to the majority and minority as well as the marginalized mobile technology user, be it a student or adult learner. A cautionary note of interest relates to mobile and cyber privacy issues. Is ethical use of user data and data learning analytics assumed? How is responsible use of user data defined and by whom? Should we consider thoughts on 1984 Orwellian implications - especially given privacy issues highlighted by the repeal of net neutrality (Schaub, 2018) and other substantiated Social Media companies' privacy invasion news stories over the last few years (Henry, 2020), as well as complaints about the collusion with major technology companies without proper adherence to constitutional and legal frameworks (Van Cleynenbreugel, 2020)? Is there also a need for better education or future research in this regard so that users can apply critical thinking and hopefully also make informed decisions on their privacy?

## FUTURE RESEARCH DIRECTIONS

While mobile learning is still battling the concept of the rising popularity of a planet of the apps, the forced shift to online learning during the pandemic forced many to access the synchronous and asynchronous learning and training engagements via their mobile phones. Hopefully this forced shift will leave an indelible mark on post-pandemic educational and training engagements, with more mobile learning becoming the order of the day. Not just in an accidental or incidental manner, but in a more intentional, integrated, mapped out and planned manner, with mobile first learning at the forefront of learning designers' mindsets. With further hope that mobile learning is not thought of in a binary either/or manner that will replace blended, hybrid or eLearning, but is part of parcel of the utility belt of tools that can and should be employed in a twenty-first century training, teaching, learning and development context. Future research should focus on expanding and cultivating other m-learning projects, transformative learning opportunities with, and through mobile devices. Current and future research should also interrogate the gains made with and for mobile learning during the forced shift to online learning to ascertain and document with data, how often mobile devices were used during the forced shift to online learning during various periods of pandemic lockdown as well as study and work from home time frames. Additionally, future research should focus on the improvements and enhancements regarding mobile devices and m-learning integrated with virtual and augmented reality, privacy, work, wearable technology and the interplay for mobile learning with situated cognition between sensors in the Internet of Things (IoT) and mobile devices. There is also a need for specific research on database management systems and privacy as it relates to mobile learning data.

While mobile learning is still in a battle to be recognized by learning designers, educators, trainers, and facilitators, there are various learning contexts that are like L-Class planets- marginally habitable, with vegetation (Howell, 2017), but lush with opportunities for growth. Amidst the battle for the planet of the apps, we are becoming an M-Class planet, rife with opportunities for and of leveraging mobile learning in theoretically informed practical manner, and hopefully will be seamlessly integrated manner in educational settings. Starting with teacher education programs where mobile learning becomes a compulsory or common core course as part of the education technology training requirements for every teacher in training as well as required for all professional development programs of teachers and trainers.

## REFERENCES

Al-Sudani, S. (2019, October). The Impact of In-Class Mobile Learning on Students' Engagement and Performance. In *European Conference on Games Based Learning* (pp. 13-XII). Academic Conferences International Limited.

Astatke, Y., Ladeji-Osias, J. O., James, P., Moazzami, F., Scott, C., Connor, K., & Saka, A. (2016). Improving and Expanding Engineering Education in the Middle East and Africa Using Mobile Learning Technology and Innovative Pedagogy. In *Advances in Engineering Education in the Middle East and North Africa* (pp. 235–260). Springer International Publishing.

Briz-Ponce, L., Juanes-Mendez, J. A., & García-Peñalvo, F. J. (Eds.). (2016). *Handbook of Research on Mobile Devices and Applications in Higher Education Settings*. IGI Global.

Brown, E. (2019, April 28). *Americans spend far more time on their smartphones than they think*. Retrieved December 19, 2021, from https://www.zdnet.com/article/americans-spend-far-more-time-on-their-smartphones-than-they-think/

Cabañero, L., Hervás, R., González, I., Fontecha, J., Mondéjar, T., & Bravo, J. (2020). Characterisation of mobile-device tasks by their associated cognitive load through EEG data processing. *Future Generation Computer Systems*, *113*, 380–390.

Candy, P. C. (2004). *Linking thinking: Self-directed learning in the digital age*. Department of Education, Science and Training.

Chaffey, D. (2021, March 30). *Mobile marketing statistics compilation*. Retrieved December 18, 2021, from https://www.smartinsights.com/mobile-marketing/mobile-marketing-analytics/mobile-marketing-statistics

Chan, S. C., & Ko, S. (2018). The Impact of Personal Response Systems on Students' Learning Performance: Research Implications and Future Research Directions. In *Computer-Mediated Learning for Workforce Development* (pp. 234–250). IGI Global.

CommLabIndia. (2016, February 24). *Top Mobile Learning Trends*. Retrieved December 02, 2017, from http://blog.tristit.com/top-mobile-learning-trends/271

Curinga, M. X., & Saravanos, A. (2016). Mobile First E-Learning. In D. Mentor (Ed.), *Handbook of Research on Mobile Learning in Contemporary Classrooms* (pp. 23–36). IGI Global. doi:10.4018/978-1-5225-0251-7.ch002

David, M. E., & Roberts, J. A. (2021). Smartphone Use during the COVID-19 Pandemic: Social Versus Physical Distancing. *International Journal of Environmental Research and Public Health*, *18*(3), 1034. PMID:33503907

Dreesen, T., Akseer, S., Brossard, M., Dewan, P., Giraldo, J. P., Kamei, A., Mizunoyai, S., & Ortiz, J. S. (2020). *Promising practices for equitable remote learning: Emerging lessons from COVID-19 education responses in 127 countries*. UNICEF Office of Research.

Dwikoranto, D., Setiani, R., Prahani, B. K., & Mubarok, H. (2020). Mobile learning to improve student collaborative skills: An alternative to online learning in the era of Covid-19 pandemic. *Jurnal Penelitian dan Pengkajian Ilmu Pendidikan: e-Saintika, 4*(3), 259-271.

Fenn, J., & Linden, A. (2005). *Gartner's Hype Cycle Special Report for 2005*. Academic Press.

Freifeld, L. (2020, September 8). *2020 Emerging Training Leader Winners*. Retrieved December 28, 2021, from https://trainingmag.com/2020-emerging-training-leader-winners/

Gao, Y., Liu, T. C., & Paas, F. (2016). Effects of mode of target task selection on learning about plants in a mobile learning environment: Effortful manual selection versus effortless QR-code selection. *Journal of Educational Psychology*, *108*(5), 694.

Han, I. (2019). Investigating lecturers' reasons for adoption of mobile learning in higher education: A case study. *Research Repository*, 435.

Haynes, T. (2018, May 1). *Dopamine, Smartphones & You: A battle for your time* [Web log post]. Retrieved December 18, 2021, from https://sitn.hms.harvard.edu/flash/2018/dopamine-smartphones-battle-time/

Henry, J. C. (2020). *Management Ethics: How Social Media Affects Employees' Privacy and Organizational Climate?* (Doctoral dissertation). Northcentral University.

Howell, E. (2017, May 20). *Planet Classification: How to Group Exoplanets*. Retrieved December 27, 2021, from https://www.space.com/36935-planet-classification.html

Hricko, M. (2017). Personal Learning Environments. In *Handbook of Research on Instructional Systems and Educational Technology* (pp. 236–248). IGI Global.

Jamu, J. T., Lowi-Jones, H., & Mitchell, C. (2016). Just in time? Using QR codes for multi-professional learning in clinical practice. *Nurse Education in Practice*, *19*, 107–112. PMID:27428702

Khaddage, F., Müller, W., & Flintoff, K. (2016). Advancing mobile learning in formal and informal settings via mobile app technology: Where to from here, and how? *Journal of Educational Technology & Society*, *19*(3), 16.

Khurgin, A. (2017). *Microlearning for Transformation, Not Information Transfer* (Webinar video). Training Magazine Network. https://youtu.be/kGff91akTJ0

Kounaves, S., Archer, L., King, H., & Pegram, E. (2016). Science Learning and Engagement in the Digital Age: Understanding the Effect of Mobile Technology on Adult Engagement Experiences at a Natural History Museum. *Mobile Learning Futures–Sustaining Quality Research and Practice in Mobile Learning*, 361.

Lynch, B. (2008). *Startup Poll Everywhere invented the technology to conduct real time polls through cell phones*. Boston Business Journal.

Maher, D. (2020). Video conferencing to support online teaching and learning. *Teaching, technology, and teacher education during the COVID-19 pandemic: Stories from the field*.

Marsick, V. J. (1998). Transformative learning from experience in the knowledge era. *Daedalus*, *127*(4), 119–136.

Marsick, V. J., & Volpe, M. (1999). The nature and need for informal learning. *Advances in Developing Human Resources*, *1*(3), 1–9.

Marsick, V. J., & Watkins, K. E. (2001). Informal and incidental learning. *New Directions for Adult and Continuing Education*, *2001*(89), 25–34.

Masrom, M., Nadzari, A. S., Mahmood, N. H., Zakaria, W. N., & Ali, N. R. (2016). Mobile learning in Malaysia education institutions. *Issues in Information Systems*, *17*(4), 152–157.

McQuiggan, S., McQuiggan, J., Sabourin, J., & Kosturko, L. (2015). *Mobile learning: A handbook for developers, educators, and learners*. John Wiley & Sons.

Mentor, D. (2011). We Are New York Social Media for Adult Education. In C. Ho & M. Lin (Eds.), *Proceedings of E-Learn 2011--World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education* (pp. 1499-1504). Association for the Advancement of Computing in Education (AACE). Retrieved December 24, 2017 from https://www.learntechlib.org/p/38929/

Mentor, D. (2014, February 14). Symposium Presentations. In *UNESCO Mobile Learning Week 2014*. Retrieved March 12, 2017, from http://www.unesco.org/new/en/unesco/themes/icts/m4ed/unesco-mobile-learning-week-2014/

Mentor, D. (2016). *Handbook of Research on Mobile Learning in Contemporary Classrooms*. IGI Global. doi:10.4018/978-1-5225-0251-7

Mentor, D. (2016). The Commuter's Learning Journey: Field Observations Informing Mobile Learning Initiatives. In Handbook of Research on Mobile Learning in Contemporary Classrooms (pp. 315-335). IGI Global.

Mentor, D. (2016). EMxC3= e&m-learningCultivating Connected Communities: Sustainable Workforce Talent Development. Handbook of Research on Mobile Learning in Contemporary Classrooms, 240-259.

Mentor, D. (2018). Micro to macro social connectedness through mobile phone engagement. In *Encyclopedia of Information Science and Technology* (4th ed., pp. 6184–6194). IGI Global.

Mentor, D. (2020, June 21). *2020: A Case Odyssey – Training for a Data Governance Software Technology Company*. https://www.learningideasconf.org/programs/2020

Mentor, D., & Ahmad, N. (2010). Teaching America's First Course on Mobile Phone Learning. *EDUCAUSE Quarterly*, 33.

Ministry of Social Development New Zealand. (2016). The Social Report 2016 – Te pūrongo oranga tangata (pp. 1-332, Rep.). Ministry of Social Development New Zealand Government.

Ministry of Social Development New Zealand. (2018, October 10). *Social connectedness and wellbeing literature review*. Retrieved from https://www.msd.govt.nz/about-msd-and-our-work/publications-resources/literature-reviews/social-connectedness-and-wellbeing.html

Mousa, A. A., & El-Salam, M. A. (2016). Employing QR Code as an Effective Educational Tool for Quick Access to Sources of Kindergarten Concepts. *World Academy of Science, Engineering and Technology, International Journal of Social, Behavioral, Educational, Economic*, *Business and Industrial Engineering*, *10*(7), 2358–2361.

Myers, J. (2021, August 10). *This is how much data we're using on our phones*. Retrieved December 19, 2021, from https://www.weforum.org/agenda/2021/08/how-the-pandemic-sparked-a-data-boom/

Naismith, L., Lonsdale, P., Vavoula, G., & Sharples, M. (2004). Literature Review in Mobile Technologies and Learning (Futurelab Series Report 11). Bristol: Futurelab.

Nicolaides, A., & Marsick, V. J. (2016). Understanding Adult Learning in the Midst of Complex Social "Liquid Modernity". *New Directions for Adult and Continuing Education*, *2016*(149), 9–20.

Nordin, N. M., Embi, M. A., Norman, H., & Panah, E. (2017). A historical review of mobile learning research in malaysia and its implications for malaysia and the Asia-Pacific region. In *Mobile learning in higher education in the Asia-Pacific region* (pp. 137–150). Springer.

Pass, F., & Renkl, A. (2003). *Cognitive Load Theory and Instructional Design: Recent Developments*. Academic Press.

Patterson, C., Stephens, M., Chiang, V., Price, A. M., Work, F., & Snelgrove-Clarke, E. (2017). The significance of personal learning environments (PLEs) in nursing education: Extending current conceptualizations. *Nurse Education Today*, *48*, 99–105. PMID:27744138

Pegrum, M. (2014). *Mobile learning: Languages, literacies and cultures*. Springer.

Pick, J. B., & Sarkar, A. (2020). Geographies of global digital divides. In *Geographies of the Internet* (pp. 115–135). Routledge.

Prathapagiri, V. G. (2020). Digital Divide and Its Dimensions: A Study in India. In Leveraging Digital Innovation for Governance, Public Administration, and Citizen Services: Emerging Research and Opportunities (pp. 79-100). IGI Global.

Ratan, Z. A., Zaman, S. B., Islam, S., & Hosseinzadeh, H. (2021). Smartphone overuse: A hidden crisis in COVID-19. *Health Policy and Technology*, *10*(1), 21–22. doi:10.1016/j.hlpt.2021.01.002 PMID:33520635

Rich, M. J., & Pather, S. (2020). A response to the persistent digital divide: Critical components of a community network ecosystem. *Information Development*.

Rikala, J., & Kankaanranta, M. (2012, October). The Use of Quick Response Codes in the Classroom. In mLearn (pp. 148-155). Academic Press.

Rikala, J., & Kankaanranta, M. (2013). Mobile learning. A Review of Current Research. *Reports of the Department of Mathematical Information Technology Series E. Educational Technology,* 1–65.

Schaub, F. (2018). The implications of the fcc's net neutrality repeal. *Media and Communication*, *6*(3), 69–72.

Sharma, M., Batra, K., & Flatt, J. (2021, July). Testing the multi-theory model (MTM) to predict the use of new technology for social connectedness in the COVID-19 pandemic. *Health Care*, *9*(7), 838. PMID:34356216

Traxler, J., & Kukulska-Hulme, A. (2016). Introduction to the next generation of mobile learning. *Mobile learning: The next generation*, 1-10.

Van Cleynenbreugel, P. (2020). Article 101 TFEU's association of undertakings notion and its surprising potential to help distinguish acceptable from unacceptable algorithmic collusion. *The Antitrust Bulletin*, *65*(3), 423–444.

Van Dijk, J. (2020). *The digital divide*. John Wiley & Sons.

Villanueva, K., & Vaidya, J. (2016). Transforming Learning with Mobile Games: Learning with mGames. In D. Mentor (Ed.), *Handbook of Research on Mobile Learning in Contemporary Classrooms* (pp. 260–278). IGI Global. doi:10.4018/978-1-5225-0251-7.ch013

Watson, A. (2020, June 18). *Coronavirus impact: Global device usage increase by country 2020*. Retrieved December 19, 2021, from https://www.statista.com/statistics/1106607/device-usage-coronavirus-worldwide-by-country/

Woodill, G. (2013, September 3). *MobiLearnAsia: Asia's Growing Mobile Learning Conference*. Retrieved December 03, 2017, from https://gowithfloat.com/2013/09/mobilearnasia-asias-growing-mobile-learning-conference/

Wroblewski, L. (2012). *Mobile first: Préface de Jeffrey Zeldmann*. Editions Eyrolles.

Zhonggen, Y., Ying, Z., Zhichun, Y., & Wentao, C. (2019). Student satisfaction, learning outcomes, and cognitive loads with a mobile learning platform. *Computer Assisted Language Learning*, *32*(4), 323–341.

## KEY TERMS AND DEFINITIONS

**Agnostic App Approach:** That are designed to be accessible on any operating systemand compatible across operating systems. See web app.

**Educational Technology:** Any technology, including digital equipment leveraged to facilitate learning.

**Mobile Learning:** Also known as m-learning is educational strategies that uses mobile technologies to promote and enable learning.

**Native Application (App):** A software program that is developed for use on a particular Operating System's platform or device like Android OS or Apple iOS.

**Web Application (App):** Are accessed by the user through a web browser that interacts with a web server versus native apps that rely on the operating system of a device.

# Chapter 13
# A Review of Personal Response Systems in Higher Education:
## Theoretical Model and Future Research Directions

**Simon C. H. Chan**
*The Hong Kong Polytechnic University, Hong Kong*

**Stephen Ko**
*The Hong Kong Polytechnic University, Hong Kong*

## ABSTRACT

*Personal response systems (PRSs) are still prevalent in a wide range of educational settings, and this increasing importance has prompted many researchers to examine their various aspects. PRS effects on student learning performance are generally divided into three main categories of factors: (1) learner characteristics (learner interface and learner interactions), (2) instructor characteristics (instructors' technical skills and attitudes toward students), and (3) other contextual factors (content and types of questions). This chapter discusses the characteristics of PRSs, reviews their advantages and disadvantages, and proposes a theoretical model of the factors affecting student engagement and performance in learning. The chapter concludes by exploring the research implications of the findings and directions for future PRS research.*

## INTRODUCTION

Academic institutions have used advanced technologies and information systems as strategic resources to create better educational environments. Teaching and learning are evolving at a steady pace, and the learning formats used by instructors to prepare their work using information technology are being reorganized to enable changes in teaching. The way students learn to meet challenges is also changing, as is the way their learning needs are met (Eastman et al., 2011). A more interactive way to learn new

DOI: 10.4018/978-1-6684-3996-8.ch013

knowledge in an academic environment with a variety of teaching and learning tools can enhance students' involvement in the whole learning process.

The value of personal response systems (PRSs) is increasingly recognized in the literature review. PRSs are defined as integrated information systems that can support the learning process in a timely manner (Moss & Crowley, 2011; Stuart et al., 2004). These systems are instructional technology tools that consist of a proprietary software application in computers, mobile phones, and other response tools used by instructors and students (Pearson, 2020). As a result, their use to provide information and receive responses has revolutionized learning for both instructors and students.

PRSs are discussed using a wide variety of labels, including audience response systems, classroom communication systems, electronic voting systems, group response systems, wireless keypad response systems, student response systems, mobile phone polling, and "clicker-based technology," although there is no universally accepted term. This chapter uses PRSs to refer to these systems.

To support effective teaching and learning, it is beneficial to know the formats and types of PRSs being used. This chapter can help academics and practitioners better understand these issues. This chapter has four main objectives: (1) describe the characteristics of PRSs, (2) evaluate their advantages and disadvantages, (3) develop a theoretical model of their key factors as a strategic tool to support student engagement and performance in learning, and (4) generate research implications and directions for future research.

## BACKGROUND

The growing popularity of PRSs has substantially improved the quality of teaching and student learning performance (e.g., Blasco-Arcas et al., 2013; Li & Wong, 2020; Mishra et al., 2020; Rana & Dwivedi, 2018). Specifically, PRSs have generated new teaching and learning practices in education. Research has raised awareness among researchers of the importance of PRSs in teaching and learning (Mishra et al., 2020; Rana & Dwivedi, 2018; Voith et al., 2018). Li and Wong (2020) examined the use of PRSs with learning analytics during the 2008–2017 period to evaluate student engagement, their learning experience, and the effectiveness of teaching and learning. The design of questions in PRSs that higher education students are asked to answer in class has also improved clarity (Stowell, 2015).

Most studies have examined the impact of PRSs on student learning and performance (e.g., Buil et al., 2019; Chan et al., 2019; Shapiro et al., 2017). Putwain et al. (2018) examined the relationship between students' academic enjoyment, boredom, and achievement. Their results indicated that the relationship between academic enjoyment and boredom was mediated by achievement. Chan and Ko (2019) examined PRS user interfaces as an important antecedent of student engagement and performance in learning. They found that the impact of PRSs on learning performance was mediated by student engagement in learning across a wide range of educational settings.

PRSs are widely used across disciplines and educational settings, including accounting, business, management, information systems, psychology, mathematics, biology, chemistry, engineering, and computer science (Addison et al., 2009; Carnaghan et al., 2011; Keough, 2012). For example, Rana et al. (2016) reviewed the use of PRSs in business and management. In business schools, an instructor may use a theoretical model and cases and ask students how they would act in a given business environment. PRSs have also been used in large introductory courses (Bonaiuti et al., 2015; Grund & Tulis, 2020; Trees & Jackson, 2007), small tutorial classes, online learning environments (Almusharraf & Almusharraf, 2021), and laboratory classes (Rana et al., 2016). Barnett (2006) discussed the implementation of personal response units in large lecture classes. More recently, Joshi et al. (2021) examined student engagement with course content, their lecturer, and peers using PRSs in the classroom.

Empirical studies have also found that feedback increases the effectiveness of PRSs (Lantz & Stawiski, 2014; Rana et al., 2016). PRSs can increase students' attention, improve attendance, increase participation, and enhance their learning performance (Buil et al., 2016; Hedgcock & Rouwenhorst, 2014; Roblyer & Wiencke, 2003). Specifically, when using PRSs, students are required to answer questions, which helps keep their attention, provide instant feedback for sharing with their peers, and encourage classroom participation (Boyle & Nicol, 2003). In addition, PRSs allow students to answer review questions anonymously and can help them become increasingly responsible for their own learning. Therefore, PRSs are among the most useful tools in lifelong learning and can increase its effectiveness.

## Characteristics of Personal Response Systems (PRSs)

As the use of PRSs has become widespread in educational institutions, instructors have started to use information technology and response systems using the Internet (i.e., Wi-Fi) to deliver content in their classes. Studies have shown that PRSs can increase student engagement, performance, learning, satisfaction, and motivation (Sprague & Dahl, 2010), offer an interactive platform to support engagement and provide immediate feedback to individual learners (Keough, 2012), and ensure the anonymity of responses to questions (Latham & Hill, 2014; Shapiro et al., 2017). Instructors can either prepare the review questions in advance or create questions spontaneously during class. Meanwhile, during lessons, students can simply input their responses into the software system, and the PRS provides real-time polls in PowerPoint format.

For implementation, PRSs can operate via two approaches: anonymous mode and known mode. In anonymous mode, the answers to the questions do not identify the students. In known mode, the instructor can see which students give which answers. The poll results or student feedback can be recorded, summarized, and immediately displayed on screen in class. The polling data can be transformed into a histogram or other formats to show the statistical results for each review question, which can serve as a basis for class discussions. Questions asking students to give numeric, short text, or multiple choice answers can be used. After class, the results can be saved in spreadsheets and the response logs can be kept for records.

PRSs can also be integrated into PowerPoint presentations. Instructors can collect the identification codes for further analysis. Students can receive instant feedback on the course or multiple choice tests. Questions can be displayed directly via PowerPoint presentations during lectures as yes–no, right–wrong, true–false, multiple choice, rating scale, fill in the blank, and answer-specific questions. In short, PRSs are a simple technology that provides students with interactive experiences (Blood & Neel, 2008; Trees & Jackson, 2007) and facilitates attendance, summative assessment, formative assessment, homework collection, and peer instruction (Rana et al., 2016).

# ADVANTAGES AND DISADVANTAGES of PRSs

PRSs are personal response devices that allow interactions between instructors and students through answers to review questions (Kay & LeSage, 2009). Students thus experience rapid and interactive feedback in the learning process (Stowell & Nelson, 2007). Figure 1 summarizes the advantages and disadvantages of PRSs.

## Advantages

The use of PRSs can increase the learning performance of students. Their effectiveness in this regard is indicated by their benefits (Kay & LeSage, 2009). Specifically, PRSs are inexpensive and effective teaching and learning tools for promoting student involvement in class (Trew & Nelsen, 2012). Their four main advantages are that they enable positive engagement, active collaborative learning, assessment, and instant feedback.

### Positive Engagement

PRS functionality can promote positive student engagement during lessons. If instructors ask their students well-chosen questions during lectures, the students can better reflect on and absorb the content of the course. The integration of formal questions in class can facilitate student engagement (Sun, 2014). In the classroom, PRSs provide innovative ways for students to answer review questions. As mentioned, students can answer questions during a lecture anonymously, which can increase their level of engagement (Voelkel & Bennett, 2014).

In general, students are interested and engaged in the concepts presented and discussed using PRSs (Barnett, 2006; Preszler et al., 2007; Simpson & Oliver, 2007). Blasco-Arcas et al. (2013) found that high levels of student interactivity with their instructors resulting from the use of PRSs were more likely to enhance student engagement. Studies have also shown that students' interactions with their environment can influence their perceptions of, and engagement with learning (Tloaele et al., 2014). PRSs also enable instructors to check individual learners' attendance based on their responses. As a result, PRSs can be used to ensure student attendance because they have a reason to attend classes regularly.

### Active Collaborative Learning

PRSs can enable students to engage in active collaborative learning because, as individual response devices, they allow students to answer questions anonymously during a lesson. Students can read, respond to, and reflect more actively on their learning with their instructors. PRSs greatly increase students' ability to respond critically and encourage them to give and share their opinions (Kay & LeSage, 2009). With the use of PRSs, students play an active role in creating new knowledge that contributes to the learning process. As a result, PRSs can be seen as a new teaching and learning strategy to sustain motivation for learning and engagement in constructive activities.

The increasing use of PRSs has created a platform for the promotion of active collaborative learning. By increasing the scope of discussions during lessons, PRSs can lead to more interactive discussions between instructors and students in the learning process. This creates a positive channel of communication between instructors and individual learners, which is a critical component of teaching and learning (Siau et al., 2006). By facilitating active collaborative learning, PRSs allow students to better assess their level of learning relative to their peers during lessons. Therefore, PRSs are an effective tool to encourage student thinking and provide an opportunity for active collaborative learning.

### Assessment

PRSs enable the assessment of students' knowledge when collecting their responses. Studies have shown that students generally appreciate the anonymity and ease of use offered by PRSs and participate more when PRSs are used during lessons (Kay & LeSage, 2009). These assessments can be used to evaluate student learning and determine whether they are performing well in class. PRSs can also be used to score student responses and enable students to complete tests at their own pace.

Assessment via PRSs can be done by asking students to answer questions, which provides a real-time flow of information. Instructors can then use these responses to make changes to the learning process. PRSs can capture students' attention and identify their learning needs. Students can also devote as much time as they need to the content of a lesson, allow instructors to determine whether they fully understand the important points of a lesson.

### Instant Feedback

PRSs can effectively engage students in the classroom, promote interactions between students, provide immediate feedback on their understanding of lessons, and facilitate their active participation in the learning process by prompting discussions of their responses. This instant feedback function is also beneficial to teaching and learning (Lantz & Stawiski, 2014; Simpson & Oliver, 2007). Chen et al. (2010) identified the benefits of timely and specific feedback on a task or concept provided by PRSs. They revealed that feedback occurs when students answer the instructors' questions. Instructors receive immediate feedback on student learning, and students can check whether their answers are right or wrong.

PRSs allow instructors to teach and discuss course materials differently. In particular, instructors can use the immediate feedback provided by PRSs to dynamically modify their lesson based on the nature and distribution of student responses (Yourstone et al., 2008). They can use these tools to get feedback on the whole class, as they can obtain a complete picture of the students who grasp the material and those who do not. Thus, PRSs allow instructors to explore in more depth what their students think about their teaching and their overall knowledge.

## DISADVANTAGES

The disadvantages of PRSs should also be acknowledged (Kay & LeSage, 2009). Although problems related to technology have decreased in recent years, other important problems related to the use of technology remain, including technical difficulties, access and resource issues, learner resistance, and learner boredom.

### Technical Difficulties

Although PRSs are generally easy to use, Internet service and unreliable devices pose technical challenges. PRSs often have connection problems or require long loading times when students complete polls (Stowell, 2015). PRSs must be connected to and recognized by a computer before starting the software. Students without appropriate device support cannot participate in the polling system (Caldwell, 2007). To support the use of PRSs, students are responsible for bringing the appropriate devices to class. PRSs can also lead to unsatisfactory or bad situations due to technical difficulties, such as slow loading times and poor Wi-Fi connections. Such problems can be avoided by ensuring good system maintenance, stable content delivery, and reliable loading of software.

## Access and Resource Issues

Despite their benefits, instructors may be reluctant to use PRSs because of access and resource issues. Accessibility can be an issue with information system solutions. Internet support (i.e., Wi-Fi), Internet service, mobile or computer speed, and availability must be compatible with the PRS package. Another issue is the availability of adequate hardware for the students. Instructors who use a PRS must configure the system before their lessons and consider that students may have difficulty accessing and connecting to the Internet using their mobile phone or computer to answer the questions.

The resources required to set up PRSs and pre-class preparation are important barriers (Barnett, 2006). Most PRSs are password-protected and require students to log into the system. Instructors may feel that there are certain elements that students need to master before discussing a particular topic further. Class-wide discussion takes too long; therefore, institutions must support instructors by providing them with relevant support.

## Learner Resistance

As the format of teaching and learning has changed with PRSs, students may be reluctant to use this new tool. Students may experience stress, frustration, and resistance to answering questions in class. These negative emotions should be monitored to ensure learner participation (Caldwell, 2007). Forcing students to learn to use PRSs creates challenges and can lead to complaints about these new polling systems.

For example, in a large classroom, lectures tend to involve the instructor providing information and sharing experiences with their students in a one-way approach (Trees & Jackson, 2007). Instructors should be aware of individual learners who are reluctant to adopt PRSs and find ways to ensure that they use them.

## Learner Boredom

Boredom is a negative emotion and indicates an individual's state of being bored due to repeated use of PRSs. Boredom is defined as unpleasant feelings, low physiological arousal, perceived lack of cognitive stimulation, task-irrelevant thinking, and impulses to escape through disengagement (Pekrun et al., 2010). In the context of PRSs, students may feel bored if they have to use this tool repeatedly in class. As a result, students are likely to stop using PRSs to enhance their learning expectations. Chan and Ko (2020) found that boredom with PRSs decreased students' perceived learning and satisfaction, but the negative relationship between these variables was weaker when instructors provided higher levels of feedback. If students receive useful feedback from instructors, they are more likely to experience high levels of perceived learning and increased learning satisfaction.

## THEORETICAL MODEL OF PERSONAL RESPONSE SYSTEMS

The literature review presented above shows that most PRS studies have focused on organizational characteristics, with little empirical research on other factors (e.g., Blasco-Arcas et al., 2013; Han, 2014). Research must identify the antecedents of the learning attitudes of students in a virtual learning and academic environment. Few studies have examined the impact of PRSs on student learning performance (Rana & Dwivedi, 2015), although some empirical studies have identified the effects of student interactivity, collaboration, and engagement with PRSs on their learning performance (Chan & Ko, 2019). However, it is also important to provide students with good learning experiences (Choi et al., 2007). Keough (2012) reviewed studies of PRSs in a management setting which indicated significance of student attention span, attendance, participation, perceptions of satisfaction, and levels of performance among students. Chan and Ko (2019) examined the learner interface when using PRSs as an important antecedent of student engagement and learning performance. Their results indicated that engagement with PRSs mediated the impact of PRSs on learning performance.

Based on the literature review, three main characteristics (i.e., learner characteristics, instructor characteristics, and contextual factors) influence student learning (Choi et al., 2007). PRSs can effectively increase student engagement, encourage interactions between students, and provide immediate feedback to individual learners in the learning process. The interactive capabilities of the system provide timely feedback for teaching and learning. These factors are the key determinants of student learning performance. Instructors play a positive role in learners' experience with PRSs. Specifically, their attitudes and technical skills affect the attitudes of learners and the effectiveness of the learning process (Hunsu et al., 2016; Simpson & Oliver, 2007). The remainder of this chapter examines learner characteristics, instructor characteristics, and other contextual factors to explain the effect of PRSs on student learning outcomes. It also shows that individual learners and instructors can benefit from the use of PRSs (Kay & LeSage, 2009; Simpson & Oliver, 2007).

Based on the literature review, a theoretical framework for PRSs is developed and shown in Figure 2. The framework links six factors representing the three main categories: (1) learner characteristics (learner interface and learner interactions), (2) instructor characteristics (instructors' attitudes toward students and their technical skills), and (3) contextual factors (content and types of questions).

### Learner Characteristics

PRSs have become increasingly important to the potential of individual learners. As mentioned, studies have shown the effects of student interactivity, collaboration, and engagement on their learning performance (Blasco-Arcas et al., 2013). In addition, the learner interface and learner interactions are two important factors that influence the learning performance of students (Choi et al., 2007).

#### Learner Interface

A learner's preference for PRSs can be encouraged by their involvement with the system (Lai et al., 2012). The learner interface, an important element in promoting the use of PRSs, is defined as the extent to which learners can use them to connect to other learners. Individual learners are expected to have enough experience with PRSs to navigate the interface (Simpson & Oliver, 2007). Easy to use learner interfaces can help save time in learning. Such PRSs are therefore user-friendly for individual learners, which makes them more comfortable using the tool.

PRSs enable individual learners to meet expectations and share their experiences by demonstrating their knowledge in classroom activities. The content they provide is easy for students to understand. Their perceived ease of use enhances students' attitudes toward their use. In the learning environment, PRSs facilitate communication between learners and instructors and can help disseminate new knowledge, keep users up to date with the latest information, help users engage in new learning experiences, and facilitate monitoring of the learning experience. The perceived ease of use of PRSs will thus positively affect students' attitudes and learning performance.

### Interactions

Interaction refers to the ability of the instructor and students to interact via the PRS. PRSs can engage students by providing them with quick and compelling interactions and feedback. It is important to determine whether students can interact with their instructor through the PRS. If so, they can easily contact their instructor and receive timely feedback (Latham & Hill, 2014).

PRSs give students the opportunity to be actively involved and engaged in lectures. Students can share their views and comment on the questions, topics, and materials provided in class (Yourstone et al., 2008). The results can help correct student misconceptions and facilitate discussions with instructors. Collaboration between instructors and individual learners enables better communication in the learning environment.

## Instructor Characteristics

The literature has shown that the student-instructor interaction improves learning outcomes and they actively interact with each other (Kang et al., 2012; Lantz, 2010). Instructor characteristics play an important role in the application of PRSs in the classroom (Choi et al., 2007), because instructors can modify their teaching and learning practices according to the attitudes and technical skills of their students.

### Instructors' Attitudes Toward Students

Instructors' attitudes toward students refer to how instructors respond to the use of PRSs. The teaching and learning practices of an instructor can help their students learn using a PRS. Instructors can increase the interest of students who seek advice on PRSs. When instructors have a positive attitude toward PRSs, the classroom environment will be more open, and by providing more direct answers to student questions, the students will be better able to recognize clear goals and receive instant feedback (Kay & LeSage, 2009). In different learning environments, instructors can use different teaching styles with the help of technology. In a more open and remote environment, instructors can use more interactive teaching styles with the help of PRSs to engage individual learners (Choi et al., 2007). When instructors have a positive attitude toward PRSs, using such systems allows them to provide more immediate feedback, use different teaching methods, and interact more with learners. Instructors should continue to use new technologies to meet the learning needs of their students.

### Instructors' Technical Skills

Instructors' technical skills refer to their knowledge of information technology or their skills in using PRSs in the classroom. Many instructors interested in using PRSs may not do so because they do not know how to implement them effectively. As a result, students may view instructors who use PRSs effectively as more competent with information technology and information systems than those who do not use them (Choi et al., 2007).

Skilled instructors can provide learners with clear goals and the necessary technical skills in advanced technologies and systems (Volery & Lord, 2000), and they can effectively explain how to use PRSs. As a result, instructors' technical skills in PRSs are positively related to the learning performance of students. Thus, the use of PRSs improves the learning experience of students in educational settings. To this end, instructors should have the ability to use PRSs effectively and attentively and to strategically develop relevant questions.

## Contextual Factors

Contextual factors, such as content and types of questions, play a key role in learners' attitudes and learning performance (Choi et al., 2007).

### Content

The use of PRSs can transform the content and format of learning in large introductory lectures and in medium-sized and small group discussions.

For students to have a clear idea of what they are supposed to learn, course content should be useful and tailored to individual needs of the students. When students answer questions, a better understanding of the content will help them develop a more positive attitude toward the use of PRSs. The content of the questions asked through PRSs can increase the students' interest in the material and their academic performance. For example, if an instructor wants to discuss thought-provoking questions in a large class, students will need to reflect on the course content for their answers.

### Types of Questions

The types of questions asked through PRSs can affect student learning. The most effective questions should be specific to avoid confusion, provide direction in a new context of PRS, and generate a wide range of answers. PRSs use questions of different formats, from yes–no and true–false to multiple choice and open-ended questions.

Gier and Kreiner (2009) argued that the type of question can significantly affect the outcomes. Their results indicated that students with experience using PRSs scored higher on exams than those without that experience, and that this increase in grades was related to the students' increased interactivity or active learning by asking relevant questions. PRSs are particularly effective in eliciting answers to low-level questions related to remembering and understanding facts. Hubbard and Couch (2018) also highlighted the importance of considering the effect of active learning strategies on students' initial level of performance.

## Student Engagement and Learning Performance

Engagement refers to the involvement of individual learners resulting from their interactions with instructors. Instructors can thus use PRSs to increase student engagement. Sun (2014) examined how the use of clickers can increase student engagement and attention. Yourstone et al. (2008) showed that instructors' effective use of PRSs facilitates positive learning attitudes and enhances learner engagement and learning performance (Blasco-Arcas et al., 2013; Keough, 2012; Scott & Walczak, 2009). Hedgcock and Rouwenhorst (2014) examined how to use PRSs to provide feedback to enhance student learning performance, as student learning performance is a crucial part of the evaluation and impact of PRSs (Nelson & Hauck, 2008; Zhu, 2012). Choi et al. (2007) explained the effect of learner's experience between learner characteristics, instructor characteristics, and content on learning outcomes. Cheng and Wang (2019) explored the effect of PRSs on learning performance using social presence and knowledge type. They showed that students with a higher level of social presence were more motivated to learn and performed better in school.

The use of PRSs integrated with peer instruction can significantly influence student performance in class settings. They are also useful for instructors to identify the proportion of students who are not participating in the discussion. Students who participate in class with PRSs generally have better academic results.

## SOLUTIONS AND RECOMMENDATIONS

This chapter makes several contributions to the literature. First, this chapter discusses the antecedents of PRSs using a theoretical model and empirically examines their effect on student learning performance. It also illustrates how developing a model of the impact of PRSs on student learning performance is a promising theoretical basis. PRSs can be useful in understanding the learning styles of individual learners. This chapter theoretically discusses relevant factors that can improve both learner characteristics and instructor characteristics to increase student learning performance. PRSs can increase student engagement in the learning experience and help instructors provide adequate feedback and a good learning interface.

Second, this chapter examines the effects of the contextual factors of PRSs on learning performance as an innovative way to deliver content in educational settings. One of the main functions of PRSs is to deliver content directly to students using different types of questions. It is important to identify what content is offered to learners. PRSs offer students an innovative way to participate in lessons, and their real-time feedback benefits both instructors and students. Future research could seek expert advice to address challenges at different levels of study on when and how to set content and types of questions to complement the learning process.

Third, PRSs can improve the awareness and attention of individual learners in the classroom. Instructors nd students benefit from the innovative educational experience offered by the effective use of PRSs. PRSs are also useful for designing curricula to capture the attention of students. This can provide learning opportunities for students with different learning styles. PRSs can help instructors design balanced teaching approaches that meet student needs and guide new teaching and learning practices by increasing student attention. Students are thus encouraged to develop problem-solving skills with flexible classroom applications. Their answers to questions can also serve as a roadmap for teaching and learning.

Finally, in terms of practical implications, this chapter encourages academics and practitioners to adopt PRSs to meet the needs of instructors and students. Their use can lead to greater achievement and understanding for students and can complement traditional teaching and learning tools as an innovative means of communication between instructors and students. This chapter also has implications for educators based on the theoretical model developed in the current competitive environment. Given the close link between teaching and learning, educators should consider how the benefits of PRSs can be achieved.

## FUTURE RESEARCH DIRECTIONS

This chapter investigates the effect of three categories of factors related to PRSs on student learning performance (i.e., learner characteristics, instructor characteristics, and other contextual factors). The results show that the learner interface and instructor characteristics are two important factors affecting the attitudes and learning performance of students. Instructors should focus on when students use technological devices to interact with them. Instructors can then develop appropriate strategies to clearly explain the concepts and create student groups to discuss the questions that arise. Other factors, such as disciplinary differences and course levels, may also affect student learning performance (Han, 2014). Future research could identify the key success factors of PRSs. What other potential variables can influence student learning performance? What are the conditions that make PRSs more effective? These questions are left for future research.

This chapter can serve as a roadmap for future PRS research by identifying different categories of variables that can improve student engagement and learning performance. The unique characteristics of PRSs are more restrictive for knowledge delivery. The characteristics of individual learners may be more important in an interactive learning environment, and their experience may be improved by changing course content, adopting an inclusive teaching method that involves everyone in the class, and enhancing classroom interactivity to bring everyone to the same level. Future research could examine individual differences in PRS use, such as gender (Kang et al., 2012), learning style, and experience with PRSs (Lantz, 2010). More research is needed to understand whether gender differences affect the overall learning experience of students.

Moreover, the characteristics of individual learners and instructors are important in enhancing student learning performance in different educational settings (Lai et al., 2015). The findings of this chapter may be generalized to various levels of business students at other universities (Rana & Dwivedi, 2015). The literature review in this chapter compares the findings with reviews of other multidisciplinary research on PRSs, such as legal studies (Farag et al., 2015). Future research could examine how instructors create review questions in PRSs, how they share information or results in the classroom, and how PRSs lead to the creation of new learning practices.

This chapter offers important insights into the development of effective PRSs, which can be aligned with different learning philosophies to maintain competitive advantages. The use of PRSs is a new trend in higher education. Their characteristics, advantages, and disadvantages are discussed. The effects of specific types of questions can create student-centered learning. PRSs can thus provide effective learning to the students who use them. Future research should evaluate their effectiveness in the classroom (Masikunis et al., 2008; Shaffer & Collura, 2009). For instance, students could rate different types of lectures as interesting, entertaining, educational, and interactive (Masikunis et al., 2009).

Finally, students' emotions are important variables that influence their motivation to learn using PRSs. Limited research has investigated students' emotions in academic settings (e.g., Pekrun et al., 2011). Academic emotions refer to "emotions that are directly linked to academic learning, classroom instruction and achievement" (Pekrun et al., 2002, p. 92). Future research should examine both positive and negative emotions (e.g., enjoyment, pride, anxiety, anger, and boredom) using PRSs in relation to students' perceived learning effectiveness.

## CONCLUSION

As educational technologies and information systems continue to evolve, the role of PRSs as an innovative way to implement interactive polling experiences between instructors and students in the classroom has grown. PRSs are increasingly accepted by academics as a supplement to support student learning. Academic institutions have benefited from their use for years as they show great promise for student learning. PRSs are effective learning platforms based on sound pedagogical practices. Students are expected to be highly satisfied with their use and to appreciate the instant feedback provided by the instructors.

This chapter explores the effect of PRSs on student learning performance and develops a theoretical model. The results show that (1) learner characteristics, (2) instructor characteristics, and (3) contextual factors have important effects on the attitudes and learning performance of students. This chapter fills a gap in the literature on the effect of PRSs in academic institutions. It shows that PRSs are effective tools for enhancing student learning performance across disciplines and class sizes in various academic contexts.

## REFERENCES

Addison, S., Wright, A., & Milner, R. (2009). Using clickers to improve student engagement and performance in an introductory biochemistry class. *Biochemistry and Molecular Biology Education*, *37*(2), 84–91. doi:10.1002/bmb.20264 PMID:21567711

Almusharraf, A., & Almusharraf, N. (2021). Socio-interactive practices and personality within an EFL online learning environments. *Education and Information Technologies*, *26*(4), 3974–3966. doi:10.100710639-021-10449-8 PMID:33584118

Anthis, K. (2011). Is it the clicker, or is it the question? Untangling the effects of student response use. *Technology Teacher*, *38*(3), 189–193. doi:10.1177/0098628311411895

Barnett, J. (2006). Implementation of personal response units in very large lecture classes: Student perceptions. *Australasian Journal of Educational Technology*, *22*(4), 474–494. doi:10.14742/ajet.1281

Blasco-Arcas, L., Buil, I., Hernandez-Ortega, B., & Sese, F. J. (2013). Using clickers in class. The role of interactivity, active collaborative learning, and engagement in learning performance. *Computers & Education*, *32*, 102–110. doi:10.1016/j.compedu.2012.10.019

Blood, E., & Neel, R. (2008). Using student response systems in lecture-based instruction: Does it change student engagement and learning? *Journal of Technology and Teacher Education*, *16*(3), 375–383.

Bonaiuti, G., Calvani, A., & Piazza, D. (2015). Increasing classroom engagement and student comprehension through the use of clickers: An Italian secondary school experience. *Research on Education and Media*, *5*(1), 95–108.

Boyle, J. T., & Nicol, D. J. (2003). Using classroom communication systems to support interaction and discussion in large class settings. *Association of Learning Technology Journal*, *11*(3), 43–57. doi:10.3402/rlt.v11i3.11284

Buil, I., Catalan, S., & Martinez, E. (2016). Do clickers enhance learning? A control-value theory approach. *Computers & Education*, *103*, 170–182. doi:10.1016/j.compedu.2016.10.009

Buil, I., Catalan, S., & Martinez, E. (2019). The influence of flow on learning outcomes: An empirical study on the use of clickers. *British Journal of Educational Technology*, *50*(1), 428–439. doi:10.1111/bjet.12561

Caldwell, J. E. (2007). Clickers in the large classroom: Current research and best-practice tips. *Life Sciences Education*, *6*(1), 9–20. doi:10.1187/cbe.06-12-0205 PMID:17339389

Carnaghan, C., Edmonds, T. P., Lechner, T. A., & Olds, P. R. (2011). Using student response systems in the accounting classroom: Strengths, strategies, and limitations. *Journal of Accounting Education*, *29*(4), 265–283. doi:10.1016/j.jaccedu.2012.05.002

Chan, S. C. H., & Ko, S. (2019). Personal response systems and learning performance: The mediating role of learners' engagement. *Journal of Education for Business*, *94*(4), 234–242. doi:10.1080/08832323.2018.1520684

Chan, S. C. H., & Ko, S. (2020). The dark side of personal response systems (PRSs): Boredom, feedback, perceived learning, learning satisfaction. *Journal of Education for Business*, *96*(7), 435–444. doi:10.1080/08832323.2020.1848769

Chan, S. C. H., Wan, C. L. J., & Ko, S. (2019). Interactivity, active collaborative learning, and learning performance: The moderating role of perceived fun by using personal response systems. *International Journal of Management Education*, *17*(1), 94–102. doi:10.1016/j.ijme.2018.12.004

Chen, J. C., Whittinghill, D. C., & Kadlowec, J. A. (2010). Classes that click: Fast, rich feedback to enhance students' learning and satisfaction. *Journal of Engineering Education*, *99*(2), 158–169. doi:10.1002/j.2168-9830.2010.tb01052.x

Cheng, L. T. W., & Wang, J. W. (2019). Enhancing learning performance through classroom response systems: The effect of knowledge type and social presence. *International Journal of Management Education*, *17*(1), 103–118. doi:10.1016/j.ijme.2019.01.001

Chien, Y. T., Chang, Y. H., & Chang, C. Y. (2016). Do we click in the right way? A meta-analytic review of clicker-integrated instruction. *Educational Research Review*, *17*, 1–18. doi:10.1016/j.edurev.2015.10.003

Choi, D. H., Kim, J., & Kim, S. H. (2007). ERP training with a web-based electronic learning system: The flow theory perspective. *International Journal of Human-Computer Studies*, *65*(3), 223–243. doi:10.1016/j.ijhcs.2006.10.002

Eastman, J. K., Iyer, R., & Eastman, K. L. (2011). Business students' perceptions, attitudes, and satisfaction with interactive technology: An exploratory study. *Journal of Education for Business*, *86*(1), 36–43. doi:10.1080/08832321003774756

Farag, D. M., Park, S., & Kaupins, G. (2015). Faculty perceptions of the adoption and use of clickers in the legal studies in business classroom. *Journal of Education for Business*, *90*(4), 208–216. doi:10.1080/08832323.2015.1014459

Gier, V. S., & Kreiner, D. S. (2009). Incorporating active learning with PowerPoint-based lectures using content-based questions. *Teaching of Psychology*, *36*(2), 134–139. doi:10.1080/00986280902739792

Grund, C. K., & Tulis, M. (2019). Facilitating student autonomy in large-scale lectures with audience response systems. *Educational Technology Research and Development*, *68*(3), 975–993. doi:10.100711423-019-09713-z

Han, J. H. (2014). Unpacking and repacking the factors affecting students' perceptions of the use of classroom communication systems (CCS) technology. *Computers & Education*, *79*, 159–176. doi:10.1016/j.compedu.2014.07.011

Hedgcock, W. H., & Rouwenhorst, R. M. (2014). Clicking their way to success: Using student response systems as a tool for feedback. *Journal for Advancement of Marketing Education*, *22*(2), 16–25.

Hubbard, J. K., & Couch, B. A. (2018). The positive effect of in-class clicker questions on later exams depends on initial student performance level but not question format. *Computer Education*, *120*, 1–12. doi:10.1016/j.compedu.2018.01.008

Hunsu, N. J., Adesope, O., & Bayly, D. J. (2016). A meta-analysis of the effects of audience response systems (clicker-based technologies) on cognition and affect. *Computer Education*, *94*, 102–119. doi:10.1016/j.compedu.2015.11.013

Joshi, N., Lau, S. K., Pang, M. F., & Lau, S. S. Y. (2021). Clickers in class: Fostering higher cognitive thinking using ConcepTests in a large undergraduate class. *The Asia-Pacific Education Researcher*, *30*(5), 375–394. doi:10.100740299-020-00525-x

Kang, H., Lundeberg, M., Wolter, B., delMas, R., & Herreid, C. F. (2012). Gender differences in student performance in large lecture classrooms using personal response systems ("clickers") with narrative case studies. *Learning, Media and Technology*, *37*(1), 53–76. doi:10.1080/17439884.2011.556123

Kay, B. H., & LeSage, A. (2009). Examining the benefits and challenges of using audience response systems: A review of the literature. *Computers & Education*, *53*(3), 819–827. doi:10.1016/j.compedu.2009.05.001

Keough, S. M. (2012). Clickers in the classroom: A review and a replication. *Journal of Management Education*, *36*(6), 822–847. doi:10.1177/1052562912454808

Lai, C., Wang, Q., & Lei, J. (2012). What factors predict undergraduate students' use of technology for learning? A case from Hong Kong. *Computers & Education*, *59*(2), 569–579. doi:10.1016/j.compedu.2012.03.006

Lai, G., Hill, V., & Ma, Y. (2015). Clickers in the classroom: A business professor's adoption of a classroom response system. *International Journal of Innovation and Learning*, *18*(4), 451–470. doi:10.1504/IJIL.2015.072458

Lantz, M. E. (2010). The use of "clickers" in the classroom: Teaching innovation or merely an amusing novelty? *Computers in Human Behavior*, *26*(4), 556–561. doi:10.1016/j.chb.2010.02.014

Lantz, M. E., & Stawiski, A. (2014). Effectiveness of clickers: Effect of feedback and the timing of questions on learning. *Computers in Human Behavior*, *31*, 280–286. doi:10.1016/j.chb.2013.10.009

Latham, A., & Hill, N. S. (2014). Preference for anonymous classroom participation: Linking student characteristics and reactions to electronic response systems. *Journal of Management Education*, *38*(2), 192–215. doi:10.1177/1052562913488109

Li, K. C., & Wong, B. T. M. (2020). The use of student response systems with learning analytics: A review of case studies (2008–2017). *International Journal of Mobile Learning and Organization*, *14*(1), 63–79. doi:10.1504/IJMLO.2020.103901

MacGeorge, E. K., Homan, S. R., Dunning, J. B., Elmore, D., Bodie, G. D., Evans, E., Khichadia, S., & Lichti, S. M. (2008). The influence of learning characteristics on evaluation of audience response technology. *Journal of Computing in Higher Education*, *19*(2), 25–46. doi:10.1007/BF03033425

Masikunis, G., Panayiotidis, A., & Burke, L. (2009). Changing the nature of lectures using a personal response system. *Innovations in Education and Teaching International*, *46*(2), 199–212. doi:10.1080/14703290902843935

Mayer, R. E., Stull, A., DeLeeuw, K., Almeroth, K., Bimber, B., Chun, D., Bulger, M., Campbell, J., Knight, A., & Zhang, H. (2009). Clickers in college classrooms: Fostering learning with questioning methods in large lecture classes. *Contemporary Educational Psychology*, *34*(1), 51–57. doi:10.1016/j.cedpsych.2008.04.002

Mishra, D., Chew, E., Ostrovska, S., & Wong, J. (2020). Personal response systems through the prism of students' experiences. *Computer Applications in Engineering Education*, *28*(5), 1232–1246. doi:10.1002/cae.22298

Moss, J., & Crowley, M. (2011). Effective learning in science: The use of personal response systems with a wide range of audiences. *Computers & Education*, *56*(1), 36–43. doi:10.1016/j.compedu.2010.03.021

Nelson, M. K., & Hauck, R. V. (2008). Clicking to learn: A case study of embedding radio-frequency based clickers in an introductory management information systems course. *Journal of Information Systems Education*, *19*(1), 55–64.

Pearson, R. J. (2020). Clickers versus Plickers: Comparing two audience response systems in a smartphone-free teaching environment. *Journal of Chemical Education*, *97*(8), 2342–2346. doi:10.1021/acs.jchemed.0c00464

Pekrun, R., Goetz, T., Daniels, L. M., Stupnisky, R. H., & Perry, R. P. (2010). Boredom in achievement settings: Control-value antecedents and performance outcomes of a neglected emotion. *Journal of Educational Psychology*, *102*(3), 531–549. doi:10.1037/a0019243

Pekrun, R., Goetz, T., Frenzel, A. C., Barchfeld, P., & Perry, R. (2011). Measuring emotions in students' learning and performance: The Achievement Emotions Questionnaire (AEQ). *Contemporary Educational Psychology*, *36*(1), 36–48. doi:10.1016/j.cedpsych.2010.10.002

Pekrun, R., Goetz, T., Titz, W., & Perry, R. P. (2002). Academic emotions in students' self-regulated learning and achievement: A program of quantitative and qualitative research. *Educational Psychologist*, *37*(2), 91–105. doi:10.1207/S15326985EP3702_4

Preszler, R. W., Dawe, A., Shuster, C. B., & Shuster, M. (2007). Assessment of the effects of student response systems on student learning and attitudes over a broad range of biology courses. *CBE Life Sciences Education*, *6*(1), 29–41. doi:10.1187/cbe.06-09-0190 PMID:17339392

Putwain, D. W., Becker, S., Symes, W., & Pekrun, R. (2018). Reciprocal relations between students' academic enjoyment, boredom, and achievement over time. *Learning and Instruction*, *54*, 73–81. doi:10.1016/j.learninstruc.2017.08.004

Rana, N. P., & Dwivedi, Y. K. (2015). Using clickers in a large business class: Examining use behavior and satisfaction. *Journal of Marketing Education*, *38*(1), 47–64. doi:10.1177/0273475315590660

Rana, N. P., & Dwivedi, Y. K. (2018). An empirical examination of antecedents determining students' usage of clickers in a digital marketing module. *International Journal of Business Information Systems*, *27*(1), 86–104. doi:10.1504/IJBIS.2018.088572

Rana, N. P., Dwivedi, Y. K., & Al-Khowaiter, W. A. A. (2016). A review of literature on the use of clickers in the business and management discipline. *International Journal of Management Education*, *14*(2), 74–91. doi:10.1016/j.ijme.2016.02.002

Roblyer, M. D., & Wiencke, W. R. (2003). Design and use of a rubric to access and encourage interactive qualities in distance courses. *American Journal of Distance Education*, *17*(2), 77–98. doi:10.1207/S15389286AJDE1702_2

Scott, J. E., & Walczak, S. (2009). Cognitive engagement with a multimedia ERP training tool: Assessing computer self-efficacy and technology acceptance. *Information & Management*, *46*(4), 221–232. doi:10.1016/j.im.2008.10.003

Shaffer, D. M., & Collura, M. J. (2009). Evaluating the effectiveness of a personal response system in the classroom. *Teaching of Psychology*, *36*(4), 273–277. doi:10.1080/00986280903175749

Shapiro, A. M., Sims-Knight, J., O'Rielly, G. V., Capaldo, P., Pedlow, T., Gordon, K., & Monteiro, K. (2017). Clickers can promote fact retention but impede conceptual understanding: The effect of the interaction between clicker use and pedagogy on learning. *Computers & Education*, *111*, 44–59. doi:10.1016/j.compedu.2017.03.017

Siau, J., Sheng, H., & Nah, F. F. H. (2006). Use of a classroom response system to enhance classroom interactivity. *IEEE Transactions on Education*, *49*(3), 398–403. doi:10.1109/TE.2006.879802

Simpson, V., & Oliver, M. (2007). Electronic voting systems for lectures then and now: A comparison of research and practice. *Australasian Journal of Educational Technology*, *23*(2), 187–208. doi:10.14742/ajet.1264

Sprague, E. W., & Dahl, D. W. (2010). Learning to click: An evaluation of the personal response system clicker technology in introductory marketing courses. *Journal of Marketing Education*, *32*(1), 93–103. doi:10.1177/0273475309344806

Stowell, J. R. (2015). Use of clickers vs. mobile devices for classroom polling. *Computers & Education*, *82*, 329–334. doi:10.1016/j.compedu.2014.12.008

Stowell, J. R., & Nelson, J. M. (2007). Benefits of electronic audience response systems on student participation, learning, and emotion. *Teaching of Psychology*, *34*(4), 253–258. doi:10.1080/00986280701700391

Stuart, S., Brown, M., & Draper, S. (2004). Using an electronic voting system in logic lectures: One practitioner's application. *Journal of Computer Assisted Learning*, *20*(2), 95–102. doi:10.1111/j.1365-2729.2004.00075.x

Sun, J. C. Y. (2014). Influence of polling technologies on student engagement: An analysis of student motivation, academic performance, and brainwave data. *Computers & Education*, *72*, 80–89. doi:10.1016/j.compedu.2013.10.010

Tloaele, M., Hofman, A., Naidoo, A., & Winnips, K. (2014). Using clickers to facilitate interactive engagement activities in a lecture room for improved performance by students. *Innovations in Education and Teaching International*, *51*(5), 497–509. doi:10.1080/14703297.2013.796725

Trees, A. R., & Jackson, M. H. (2007). The learning environment in clicker classrooms: Student processes of learning and involvement in large university-level courses using student response systems. *Learning, Media and Technology*, *32*(1), 21–40. doi:10.1080/17439880601141179

Trew, J. L., & Nelsen, J. L. (2012). Getting the most out of audience response systems: Predicting student reactions. *Learning, Media and Technology*, *37*(4), 379–394. doi:10.1080/17439884.2011.621957

Voelkel, S., & Bennett, D. (2014). New uses for a familiar technology: Introducing mobile phone polling in large classes. *Innovations in Education and Teaching International*, *51*(1), 46–58. doi:10.1080/14703297.2013.770267

Voith, L. A., Holmes, M. R., & Duda-Banwar, J. (2018). Clicking toward better grades: The use of student response systems in social work education. *Journal of Social Work Education*, *54*(2), 239–249. doi:10.1080/10437797.2017.1283268

Volery, T., & Lord, D. (2000). Critical success factors in online education. *International Journal of Educational Management*, *14*(5), 216–223. doi:10.1108/09513540010344731

Yourstone, S. A., Kraye, H. S., & Albaum, G. (2008). Classroom questioning with immediate electronic response: Do clickers improve learning? *Decision Sciences Journal of Innovative Education*, *6*(1), 75–88. doi:10.1111/j.1540-4609.2007.00166.x

Zhu, C. (2012). Student satisfaction, performance, and knowledge construction in online collaborative learning. *Journal of Educational Technology & Society*, *15*(1), 127–136.

## KEY TERMS AND DEFINITIONS

**Active Collaborative Learning:** A method of encouragement that gives students the chance to speak up, listen to others, and reflect on their own thoughts.

**Boredom:** A negative emotion and indicates an individual's state of being bored.

**Interactive Learning:** An effective two-way learning format that encourages active participation between instructors and students.

**Learner Interface:** The extent to which individual learners can use PRSs to connect to instructors and other learners.

**Learning Performance:** The relatively permanent changes in knowledge or behavior that support retention and transfer of learning.

**Personal Response Systems:** An integrated information systems that are instructional technology tools that consist of a proprietary software application in computers, mobile phones, and other response tools used by instructors and students.

**Student Engagement:** An involvement of students who result from the interactions with instructors.

# Chapter 14
# Experiential Learning for Telehealth in Sports Science and Allied Health

**Dominic Mentor**
*Teachers College, Columbia University, USA*

**Lloyd Leach**
*University of the Western Cape, South Africa*

## ABSTRACT

*This chapter offers concepts to leverage experiential learning in electronic (e-) and mobile (m-) learning environments with examples from talent development and allied telehealth disciplines. Learning goals need to cater to increasingly complex and ever-changing contexts. Experiential learning can deliver such outcomes in a digital world. E-learning and m-learning cater to the needs of learners who seek dynamic, interactive, multimodal, situated, and personalized learning. How do we incorporate experiential features in e-/m-learning talent development, sport, allied health training, and other workplace contexts? The authors weave the learnings from pilot and action research projects, as well as from real world examples to apply a model of experiential learning for e-/m-learning environments. The model will help learners critically evaluate learning applications in digital environments with tools to design their own experiential learning for e-/m-blended, a/synchronous learning environments.*

## INTRODUCTION

This chapter utilizes the Joshi-Mentor experiential learning model (2018) elucidating the application of experiential learning via virtual computer technologies. Presently, hardly any aspect of life is left untouched by technology, and more so now with the ubiquity of mobile phones and forced shift to more online involvement and engagement, due to the COVID-19 pandemic. The intentional shift to virtual engagement has gradually become a norm for many individuals and organisations, and more so during the pandemic. That will continue post-pandemic, as more and more people have become accustomed

DOI: 10.4018/978-1-6684-3996-8.ch014

to the benefits and advantages of online communication and engagement. During the various stages of lockdown, because of the pandemic, and which some countries still find themselves in, workers, students and faculty are continuing to work from home and other remote locations. Thanks to computer and mobile technologies, so too are sport and exercise science practitioners, biokineticists, physiotherapists and other sport, recreation, and medical health practitioners.

With an increase in online engagement in the aforementioned fields, telehealth grew in adoption and practice to also become the order of the day. Continuing to serve people with needs ranging from functional training for daily living or sport to professional treatment in physiotherapy for back pain, exercise therapy for cardiovascular rehabilitation and recovery after a health incident. This also extends into other professions, such as nursing, for promoting healthy habits and healing to help with the reintegration of affected individuals to normal self-care, while checking on and seeing to patients' needs. Leveraging computer and mobile technology to move from the phases of (1) acute and chronic rehabilitation and management, (2) integration into daily living, and finally (3) to independent life-long self-care are some of the hallmarks of the technology. Consequently, computer-mediated engagement offered accessibility, advanced mobility, and allowed people to experience learning in provision of the three phases shared above that fall within the scope of biokineticists, physiotherapists and other sport, recreation, and medical health practitioners who strive towards aid for their patients and the people they support.

We have progressed quite substantially from using computer and mobile technology for just interpersonal communication in the early 1990's. Currently, the affordances of the technology enable cultivating and maintaining social connectedness through mobile engagement, accessing entertainment and learning, to virtually hailing a ride or ordering groceries. Inevitably, the technology has been extended into learning about and managing our exercise habits and health needs through wearable technological devices. More importantly, using computer technology, with the help of professionals, has supported our health and well-being through telehealth. Mobile and computer-based learning continue to offer innovative and revolutionary learning opportunities in multiple environments (Mentor, 2018). Through using mobile technology, many universities, workplaces, as well as various medical and allied health professionals worldwide are incorporating technology-based learning and support to extend their footprint and enhance their reach to students, patients, and people in need of health support, irrespective of boundaries of time and geography.

This chapter acknowledges that many adult educators in schools and workplaces try to comprehend e-/m-learning through traditional education models. We believe that conceptualizing computer-mediated telehealth learning that is rooted in experiential learning, will be of great support to educators, health educators, and health professionals, who are looking to embrace computer-based support and learning opportunities, from a lens with which they are philosophically aligned.

This chapter shows how telehealth computer-based learning and support is evolving beyond the conventional presentation of a static, mono-directional approach. It also presents theories, research, as well as practical pedagogical and andragogical examples. The chapter will highlight that despite the evolution of mobile and eLearning, telehealth and computer-based learning still needs to become more versatile in a multi-dimensional and multi-screen world.

## DIGITAL LEARNING A NORM REQUIRING QUALITY INFORMED BY OBJECTIVES

Online learning can take various forms. In its earliest forms, it started as converted correspondence courses (Ko & Rossen, 2017) and others such as those delivered over the internet by for-profit universities. Today, online learning is popular in the form of Massive Online Open Courses (MOOCs) and Small Private Online Courses (SPOCs) (Kaplan & Michael, 2016). According to data collected by Class-Central, a leading MOOC aggregator, over 700 universities across the world offered 6850 MOOCs in 2016 with 48.3 million users across the top five providers - Coursera, edX, XuetangX, FutureLearn and Udacity (Shah, 2016). This is over and above Small Private Online courses (SPOCs) delivered by universities and organizations over Learning Management Systems (LMS) for example: Canvas, Moodle, and Schoology to name but a few) for closed groups of learners in the form of stand-alone, blended and/or flipped learning programs (Bonk & Graham, 2006; Friesen, 2012) where learners can interact with course material before a course or once class commences. LMS spaces can also be leveraged for telehealth educational support and online learning prior to or after a synchronous session with a professional, such as accessing MOOCs like Digital Health and Introduction to Digital Health that are offered by Coursera.

Apart from server-side educational services, computers, handheld computers, MP3 players, notebooks, mobile phones and tablets are also part of this learning revolution and are usually classified under m-learning (Mentor, 2018; Trentin & Repetto, 2013). The terms online learning, digital learning and e-learning are used interchangeably in this chapter as the differences are not significant to the research in this chapter. Mobile learning (M-learning) consists of educational strategy that uses mobile technologies to enable learning and is considered unique given the element interactivity based on form factors (Chen, Woolcott, & Sweller, 2017; Mentor, 2011; 2016; 2018). Thus, while m-learning falls under the same umbrella of online learning, there is a need for a full appreciation for its uniqueness especially in terms of the element interactivity and cognitive load considerations to consider when pulled from the educational facilitation utility belt. There are still many who are skeptical about m-learning because it is still very much misunderstood even after a seminal literature review on the field was published in 2004 already (Naismith, 2004).

However, there are also educators and some health professionals who are skeptical about technology-aided learning in general because they believe it weakens and even dehumanizes health engagement and education, leads to excess stimulation, borders on entertainment, and comes at the cost of authentic and natural ways of learning (Andrews, 2019; Buckingham, 2013; Feijt, 2017; Okan, 2003; Selwyn, 2016). However, for health professionals, as with many other industries, the forced shift during the pandemic to the online platform showed that the professional work could continue with a patient and offered the opportunity for further ongoing support. A health professional, who is a 30-year veteran in the field of sports, exercise and biokinetics indicated that, while the adoption of telehealth was swift during the pandemic, older patients expressed a yearning and preference for in-person consultations and personal attention. Furthermore, he indicates that various technological issues and challenges experienced by all patients, ranging from digital illiteracy, digital divide in resource-constrained and rural areas, exorbitant costs of the devices, incompatible devices, insufficient technological infrastructure, differential access to mobile technologies, no internet access because of electrical load shedding, expensive data costs, to unstable internet access in remote and rural locations with spotty cellular and internet reception, as well as inadequate computer and mobile technology that can handle the bandwidth for video engagement (Chitungo, Mhango, Mbunge, Dzobo, Musuka, & Dzinamarira, 2021). The educational technology skeptics seem to suggest criticisms of education and telehealth technology and can be described as solutions in search of problems (Andrews, 2019; Feijt, 2017; Selwyn, 2016). Based on the above, we surmise that as digital learning starts to become a norm, these criticisms call for deploying approaches that address concerns pertaining to quality of learning on digital platforms.

## Impactful Digital Solutions Informed by Principles of Experiential Learning

Experiential learning can simply be defined by the two words it consists of, hence as a process of learning through experience, but as Patrick (2011) more accurately unpacks it, experiential learning requires reflection as part of that 'doing'. Experiential learning has been considered a superior learning method that fosters better understanding since Dewey (1938) extolled its virtues. A reflective experiential approach also addresses learning preferences of diverse learners as compared to a one size fits all-didactic way of teaching. This form of learning has been adopted in various settings such as K-12, higher education, workplace learning as well as self-directed learning (Andersen, Boud, & Cohen, 2000). Sometimes experiential learning and e-/m-learning are considered opposites, especially when they are associated with hands-on learning and virtual learning respectively. However, there are several examples that enable us to see that these can be the same or complementary. For example, medical practitioners often learn complex surgical procedures that are both technology enabled and experiential. McKinsey Capability Centers use such experiential simulations to build new skills and attitudes as they prepare their clients for transformations (Benkert & Dam, 2015). According to a Deloitte study (Pelster, Haims, Stempel, Vyver, 2016), learning and development departments of tomorrow will provide learning that "is experiential, relies on case studies and flipped classrooms…from today's expert delivered lecture-based models" (p.60). With proven success of experiential models in classrooms and the inevitability of digitization of learning, there is an opportunity to see how e-/m-learning can be informed by principles of experiential learning or rather how technology solutions can help enhance the impact of experiential learning. Health professionals, like biokineticists and exercise therapists, work with their patients via telehealth through the phases of healing, rehabilitation, reintegration to normal movement, as well as independent self-care to avoid similar illnesses and/or injuries in the future, and to avoid second episodes. The phased approaches to effective healthcare that go from acute and chronic injury and/or disease management, integration of healing exercises and, eventually, to independent life-long self-care which closely mimics or can be applied to Kolb's experiential learning cycle model. We will go into more detail about the Kolb's experiential learning cycle model throughout the rest of the chapter while we try to equip various stakeholders from the education, training, and health professionals with experiential learning in the online learning realm.

This chapter aims to equip health professionals, educators, curriculum designers and instructional technologists with a perspective that they can use to foster experiential learning in a computer aided learning environment. We start by offering definitions of learning from various lenses notably experiential learning and e/m learning. We subsequently present examples of computer-based learning that integrate elements of experiential learning. We have chosen examples where we have been personally involved as designers, researchers, and users, even though we realize that there could be better examples of computer based experiential learning. We tie our learnings from these to present a model derived from David Kolb's experiential learning model (Kolb, 1984, Kolb & Kolb, 2012). We hope that by the end of the chapter, health professionals, learners, teachers, corporate trainers, or professional developers will be able to start critically evaluating e-/m-learning designs and be better equipped to develop experiential e-/m- based learning programs that can be handled both synchronously and asynchronously.

There are several important and related questions, notably regarding the suitability of certain contexts for technology in learning and conceptualization of experiential learning itself. For reasons of scope and focus, we have chosen to stay away from these based on our assumptions that e-/m-learning is here to stay with even higher numbers post-pandemic, amidst a digital divide that still needs to be reduced and eradicated (Adzovie, Jibril, Adzovie, & Nyieku, 2020; Almanthari, Maulina, & Bruce, 2020; Li & Lalani, 2020; Lynch, 2020). We also focus on the application of experiential learning methods, of which Kolb's conceptualization is a good representation, and showcase examples of it being applied in e-& m-learning spaces. The technology works in, and outside the classroom, as well as before, during and after a live online telehealth session between a patient and a health professional, offering flipped, reflective, and iterative experiential learning opportunities. Obviously, mobile learning also works outside the telehealth session and the classroom and breaks down the literal and artificial divide between learning institutions and the real world. The impact of telehealth digital engagements as solutions during the pandemic was knowingly and unknowingly informed by principles of experiential learning, as patients and health professionals had to mimic their in-person professional sessions. While the engagement was different and facilitated through computer and mobile technology, the telehealth sessions also helped move people from inactive to active states. Through regular telehealth engagements, the health professionals were still able to work with their patients and-move them from prophylactic or curative phases of healthcare through carefully planned and targeted exercises. These prophylactic or curative phases could be applied to occupational injuries that people in various industries encounter and endure. Individuals in various industries ranging from office workers and teachers to manual workers and emergency care workers, such as firefighters and others, often develop repetitive strain injuries, be they muscular, neural, joint, and bone-related injuries. Telehealth engagements can aid the rehabilitation phase of healthcare, for example, as firefighters work their way to become fit for duty. Many questions remain unanswered such as how to reduce and overcome the digital divide for low-income areas and students, varying levels of digital literacy and proficiency. However, given the wide scope of health professionals who exploit telehealth engagements, we hope the reader will be able to gain perspectives on the unanswered questions elsewhere, inside, or outside of this chapter and book, and find this chapter's practical application of an experiential theoretical framework useful for their own computer-mediated learning contexts.

## CONCEPTUAL THEORETICAL FRAMEWORK

In this section we offer concepts and theories to help frame the understanding of experiential learning in computer-based learning systems. Goals and objectives sometimes fall by the wayside when integrating telehealth and computer mediated learning. Goals and methods of learning have evolved over time to cater to changing needs of the society, economy, and policy. One way to look at this evolution is through the theoretical schools of learning: Behaviorist, Humanist, Progressive and Radical (Elias & Merriam,1995). Behaviorists such as Guthrie, Hull, Pavlov, Skinner, Thorndike, Tolman and Watson looked at deploying the process of stimuli and response to encourage desired behaviors (Merriam, Caffarella, & Baumgartner, 2012). Taylor's model of learning (Ralph, 1949) based on behaviorism found much use in workplace learning when organizations were responding to the needs of an industrializing society that needed to create a large workforce performing standard tasks and behaviors required by the employer. As society and industry evolved, a need was felt for a citizenry and workforce that could think for itself, be innovative and go beyond a regimen of drill and practice. Consequently, organizations moved beyond principles of scientific management, also called Taylorism, and started shifting to knowledge and team-based work (Kasworm, Rose, & Ross-Gordon, 2010). Considering this shift, human resource development started to incorporate ideas from other schools, notably the humanist and progressive schools (Watkins & Marsick, 2014). As health professionals work on lifestyle behavior change with their patients, the behaviorist model looks at where the patient is at currently, and where they need or want to be in terms of their recovery and strives to avoid or reduce preventable morbidities in the future. The health professional would continue the five stages of engagement via telehealth engagement by educating the patient in terms of good health versus poor health. This is done by progressively working through the various stages of behavior change in the transtheoretical model, namely, the precontemplation stage, contemplation stage, preparation stage, action stage, and maintenance stage, while either preventing or dealing with relapses at each of the stages.

## Emancipatory Educational Approaches to Promote Agency

As adults develop and live in a more complex world, they need learning that goes beyond the mere acquisition of knowledge, towards critical processing or transferability of that knowledge to multiple domains and the ability to critically reflect on the self in such systems (Kegan, 2009). Hence, as the world continues to change at a faster pace catalyzed by the advent and rapid development of technology as well as the pandemic that forced more people to shift to online work engagements, the nature of learning goals will continue to evolve. In some ways, this is already the need of the hour as the challenges we face in the twenty-first century are getting increasingly complex and adaptive (Heifetz,1994; Heifetz & Linsky, 2014). In ambiguity filled scenarios it is often difficult to define learning goals with the specificity when educators use models such as Bloom's Taxonomy (Bloom, Krathwohl & Masia, 1984). The Glossary of Education Reform defined Bloom's taxonomy as "a classification system used to define and distinguish different levels of human cognition—i.e., thinking, learning, and understanding" (Great School Partnership, 2014). Given the huge differences in contexts and challenges faced across a diversity of communities in an interconnected world, it is also reasonable to argue that we cannot have one school of thought that can guide us to define learning goals and processes. While we will continue to have leadership-education based on humanist and progressive tradition (Watkins & Marsick, 2014) that prepares leaders for workplaces, we will also see emancipatory education (Freire, 2000) based on deconstructive education models (Custer, Deutscher, & Haddad, 2016; Dahlgren, 2017; Peters, 2016) to empower impoverished communities and intellectually impoverished individuals. This means that an educator in today's world will need to not only identify the learning goals, but also consider the culture while choosing methods, tools and techniques to deliver learning. Likewise, educators, corporate trainers, and researchers should be mindful of the variety of contexts within which their customers operate while proposing learning models and defining the scope and boundaries of their model. With this backdrop, we humbly submit that our chapter has been written in the current digital milieu of higher education settings and workplace learning. We would be delighted if educators outside these domains find our ideas meaningful. Therefore, this chapter describes a conceptual framework that should help develop a better latitude on understanding learning and in particular, computer mediated learning for workforce development.

There are several definitions of Learning. Jack Mezirow (2000) classified learning into three types: Instrumental or technical, communicative, and transformative. Technical learning focuses on gaining knowledge, information, and skills. For example, learning a language, plumbing, carpentry and so forth. Communicative learning focuses on building understanding of self and others, and transformative learning focuses on becoming aware of one's own limiting assumptions and developing more permeable meaning making schemes. Kegan (2009) uses the words technical and transformational learning to differentiate learning into two types. The latter pertains to helping people identify their assumptions and be better prepared to deal with complexity, an increased feature of our times. According to Kegan (2009), Technical learning is about gathering more information, while transformational learning is about how we see the information that we have. In the practical world learning situations are a blend of technical and transformational goals. Watkins, Marsick and Faller (2012) make a case for transformative learning approaches in workplaces to better address today's challenges that are rooted in greater ambiguity and complexity. They suggest mechanisms such as action research, action science, action learning, and cooperative inquiry, which have a common dynamic of "collective identification, sharing, and examination of different points of view" (Taylor & Cranton, 2012, p.380). It's not difficult to argue that learning goals—which fall into the realm of dealing with complexity and ambiguity—require methods that go beyond facilitating a one-way broadcast of information. Even if the learning goals are largely technical, the learning can be strengthened if the process provides for the learner to engage in activities, and exchange ideas with other learners rather than simply accepting information from an expert. In this way the learner will be better placed to understand the know-how and create his/her own solutions. From the perspective of cognitive capacities, learning gets enhanced if multiple modes are used as the cognitive load gets distributed across various modes so that learners get to engage in their learning in their preferred way (Plass, Moreno & Brünken, 2010; Barbe, Milone, & Swassing, 1979). We believe that these ideas of using experiential learning and multiple modes should hold or pursue to be relevant whether we are using face-to-face methods or e-/m-learning environments.

In the western world, John Dewey is considered one of the earliest and foremost proponents of experiential learning. He posited that, "…all genuine education comes about through experience" (Dewey, 1938, p. 25). Various models of learning from experience have subsequently evolved that capture a host of issues involved in learning. Andersen, Boud & Cohen (2000), consider the Montessori method of teaching as essentially an experiential learning method that "supports a more participative and learner-centered approach. (p.225)". They highlight the importance of reflection and attending to feelings during and after the experience (Boud, Keogh & Walker, 1985, 2013; Kolb,1984, 2014). Considering these more dynamic, participative and learner centered approaches, experiential learning has been extensively deployed to achieve goals that seem technical, communicative and possibly even transformative.

Traxler (2007), states that e-learning and m-learning are different in that the traditional virtual learning solutions that use online computer-based platforms as e-learning, while m-learning is more situated. He sees m- learning as that which is comparatively more "personal, contextual, and situated" (Traxler, 2007, p. 1). He further mentions that advancement of technology will blur these differences, which will unbundle e-learning and bring it closer to descriptions associated with m-learning. In that vein, Sharples, Taylor & Vavoula, 2007) proposed a wider conception of mobile learning as that which is not only supported by mobile devices, but also has mobility as a characteristic of learning as the user today is mobile. They talk about the emergence of *new learning* and *new technology* while describing mobile learning. They also suggest that such learning embeds ideas of personalization of learning, anytime-anywhere learning as well as collaboration and connection opportunities between learners. They define mobile learning as "the processes of coming to know through conversations across multiple contexts amongst people and personal interactive technologies" (Sharples, Taylor & Vavoula, 2007, p.224). While Mentor posits that mobile learning consists of educational strategies that use mobile technologies to promote and enable learning, but can also expand the learning engagement time exponentially, supporting intentional and incidental learning episodes in people's daily lives while at the same time catered for more opportunities for adult and young learners to be active agents in their learning (Mentor, 2019).

## The Case and Concerns About E-/M-Learning Rooted in Experience

Carrington (2013) as well as the Mentor-Joshi model (2018), re-conceptualized the pedagogical and andragogical cycles, and laid out ways in which computer-based learning has benefits beyond enhancing content presentation or automating processes of learning delivery. They emphasized the fact that mobile devices offer opportunities to redefine learning beyond substitution, modification, and augmentation. For example, personalization of learning could be one such opportunity. Researchers, and educators are seeing increased integration and convergence across platforms, often enabled by cloud-based platforms (Mentor, 2018). Cloud computing platforms provide cost efficient access to the critical infrastructure needed for these types of solutions. With both computer and mobile device technological advancements, the lines of separation are growingly overlapping, and people switch back and forth between computer and mobile devices. And with wireless advancements, there are overlying spaces where conversations between educators and learners are facilitated using technology in a manner where learning is more personalized, situated, and connected to the context, experience, and learner. In this conception, both historically and futuristically, technology facilitates access, conversations, interactivity and enhances experiences (Sharples, Taylor & Vavoula, 2007).

With this futuristic view of blurring boundaries between e-learning and m-learning as well as the emergence of integrated platforms, we wish to define e- learning and m- learning under the same umbrella of e-/m-learning for the purposes of this chapter. Historically, computer-based learning started with applications to achieve technical learning goals. Today a large part of technical learning in organizations is being offered via e-learning modules which could facilitate more than transferring information, but also involves teaching skills, and testing knowledge. However, there is still an increased need to research and figure out how computer-based technologies can lend themselves to purposes beyond transferring or testing the absorption of content (Richards, 2012) and increase the transferability of knowledge to other contexts (Mentor, 2016). As an example, workplaces are using e-/m-based learning for teaching leadership; a process that moves into communicative and transformative realms. Several collaborative tools (e.g., Slack, Zoom, Skype, WebEx) are also helping practice effective team-ship and leadership. However, we believe that there is still a huge potential of e-/m-learning to address communicative and transformative goals lying untapped. We believe incorporation of experiential elements will be a key to realize this potential.

Mobile phone devices today are loaded with a host of functionalities. With today's computers and phone screens, you can use touch, sight, and sound at the same time, run multiple applications, navigate in hypermedia fashion, and connect to a community of learners and educators. At the same time the multifunctional ties of these devices are being leveraged to enhance learning experiences. As mentioned earlier in the chapter, there are also concerns about the potential of these devices to distract learners. The possibility of distraction and over stimulation at one end and the opportunity to offer an experience that may not be possible in traditionally designed teaching, training and learning settings, ups the ante for UI/UX professionals, instructional designers, and educators using these platforms. We illustrate a few examples where e-/m- learning, in our view, has been meaningfully used to create experiences in the service of learning that is personalized, situated, contextual and blurs the line between formal and informal learning. We hope these will seed some ideas for our readers before we present our own conceptualization of an e-/m- based experiential learning cycle.

It is encouraging that educators, UX/UI designers, technologists, and instructional designers are incorporating tools and techniques to make learning more hands on and experiential. Models such as Rogers' diffusion of innovation (Rogers, 2010), Columbia Center for New Media Teaching and Learning's (2013) learning design model informed by Bereiter (2002), Edelson, (2002) and others (for example: Bannan, Cook, & Pachler, 2016; Obrenović, 2011; Van der Stappen & Zitter, 2016) theorize putting into practice, how an educator or instructional designer could conceptualize and design such learning. At the same time, many health professionals and adult educators in schools and workplaces try to comprehend e-/m-learning through models based on traditional education models. We believe that conceptualizing computer-based learning rooted in experiential learning will be of great support to educators who are looking to embrace computer-based learning from a lens they philosophically align with.

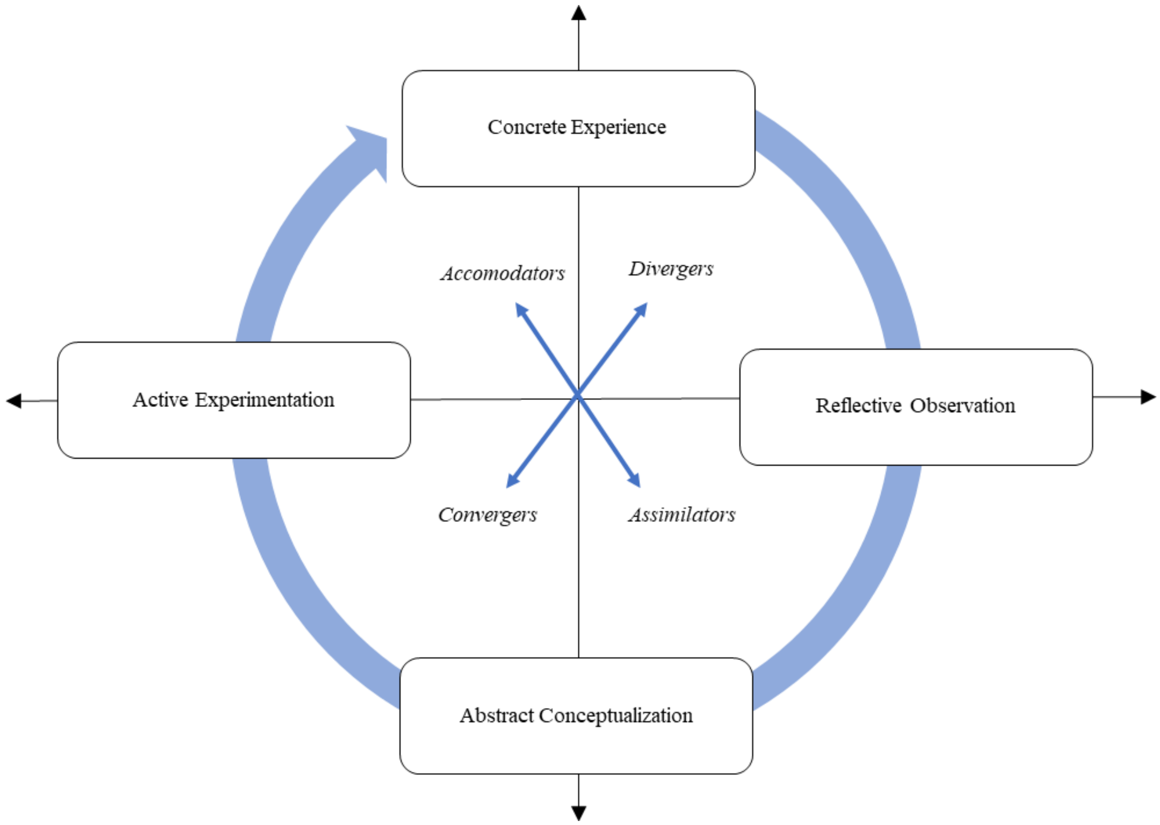
As previously indicated, this chapter provides a vignette of some examples that build a case for an experiential learning model to be used as part of computer-based learning. The next portion of the chapter elaborates how computer-based learning is evolving beyond the conventional presentation of a static, mono-directional content approach. We also present research to show that despite the long-term evolution of e-Learning, computer-based learning still needs to become more versatile in a multi-screen world. This is of consequence as contemporary learners are prone to even more hypermedia distraction, and at the same time prefer to use micro-moments of learning. We believe these ideas can be explored using Kolb's learning cycle as an anchor.

## Creating Transformative Experiences Through Knowledge Generation and Transfer

David Kolb's cyclical learning model is one of the most widely used concepts of experiential learning. As per Kolb (1984), "Learning is the process whereby knowledge is created through the transformation of experience (p.38)." David Kolb describes an experiential learning cycle that comprises the steps of Concrete Experience (CE), Reflective Observation (RO), Active Reflection (AE), Abstract Conceptualization (AC), and Active Experimentation (AE). In other words, a cycle of learning requires that a learner reflects on an experience, which can lead to meaning making and conceptualization of that meaning. This is followed by active experimentation where one might explore possible applications of an idea which informs further experiences and meaning making.

Figure 1 depicts the four steps in Kolb's Experiential Learning Cycle (Kolb, 1984). Kolb also mentions that learners have their own preferred learning styles formed because of an interplay of preferences along the CE-AC and AC-RO axes. Hence, when they learn, learners go through the entire cycle, but each has her preferred step or location in the cycle. Kolb names four unique learning styles and hence four types of learners: Divergers, Assimilators, Convergers and Accommodators. We believe that Kolb's learning cycle and the idea of diverse learners can be a useful idea to guide the design of computer mediated learning for workforce development. If we are talking about a conversational approach facilitated in mobile learning, then Kolb's idea of meaningful experiences reflected upon in conversation with others seems a powerful idea to leverage in e-/m-learning design.

*Figure 1. A representation of Kolb's (1984) Experiential Learning Cycle*




## EXAMPLES OF COMPUTER BASED EXPERIENTIAL LEARNING

We now present four examples of computer mediated learning that we believe are exemplars of experiential learning. The first example pertains to an online leadership development course offered at a leading USA business school, while the second explains a few mindfulness teaching apps developed for mobile devices, an example of employability skills development as part of a workforce training organization, and the last example focuses on telehealth engagement by health professionals, such as biokineticists. The first two examples provide a micro picture of experiential learning design while the last example provides a macro picture of a force shift to online that used experiential elements.

### Online Executive Education for Leadership Development

A leading business school offers online leadership courses targeted at working professionals. The courses already have face-to-face instruction-based versions that continue to be popular with MBA students and corporate executives. The online courses were developed to expand the reach of these courses to audiences who couldn't attend these courses for reasons of time, distance, and money. It also gives MBA students and corporate executives, who are working a full-time job, the flexibility to continue their education. Later, it emerged that online modules could also enhance the impact of the face-to-face versions and today, many face-to-face programs have an embedded online component as well. The courses are examples of how the positive experience of an in-person program can be retained when adapted to a digital format.

A typical online course gives the learner access to an e-/m-platform. Thus, the learner can access the content on both a smartphone and/or a computer. There are various aspects of the course that ensure that the instruction is not reliant on one-way communication. The professionally filmed lecture videos are the centerpiece of experience. These videos have the professor share interesting stories, cases, thought provoking information, situations, and questions. The questions posed at the end of videos become reflective stems. Participants post their reflections on a shared forum, thus getting an opportunity to learn from each other's perspectives. Key concepts are shared through videos or Portable Document Format (PDF) files that participants can download for future reference. Post learning of the key concepts, the professor poses application-based questions and/or assignments that help participants apply learning in real life and facilitators assess the impact of their teaching. One remarkable example of such application is role-play assignments. Participants watch video role play situations, built around their work situations, and are asked to respond as one of the actors. They video record their responses and share them with computer assigned peers for assessment and feedback. The peers provide quantitative feedback on a ten-point scale on predefined dimensions such as clarity of communication, strength of arguments and so forth. They can add Qualitative comments that comprise open ended feedback. The application pushes notifications to let participants know when they have received feedback. Notifications are also used to remind participants of upcoming tasks, new posts on the forum that might interest them and the release of new modules. You can probably recollect that typical leadership programs conducted in a face-to-face format have presentations by facilitators, exercises, reflective pauses, assignments, and role plays. These online courses mirror such elements using a judicious blend of experiential elements in an e/m learning environment. In addition, the format offers the benefit of anytime-anywhere access, opportunities for learners to study at their own pace and review content multiple times, something which becomes challenging in a face-to-face program. Despite having a pre-designed structure and flow, the online course offers greater flexibility and choice to the learner compared to a face-to-face program. Another aspect of the application is that the entire learning interaction is recorded on the shared platform for post program reference and reflection. This is a rich source that can also be used to inform follow-up assessments and exercises in three or six-month timeframes to take steps to ensure that the program meets its goals.

## Meditation and Mindfulness Training App

Mindfulness training has become popular in the west as a means of beating stress and training attention control. While earlier influences and applications emerged from yogic and meditation practices of the east, it gradually entered the world of scholarship in mental health notably through the work of Kabat-Zinn (2003). A meta-analysis by Khoury, Sharma, Rush, and Fournier (2015) examined 29 studies and concluded that mindfulness-based stress reduction is moderately effective in "reducing stress, depression, anxiety and distress and in ameliorating the quality of life of healthy individuals" (p.1). Today, meditation and mindfulness applications have applications beyond mental health to address needs of healthy individuals. While workshops and in person classes have been the popular mechanisms to deliver meditation/mindfulness learning and practices, mobile meditation/mindfulness applications (apps) are increasingly becoming popular with more than 52 million people downloading meditation apps and more than 3 million users daily (Srivastava, 2021; Stankov, Filimonau, Gretzel & Vujičić, 2020; Weekly, Walker, Beck, Akers & Weaver, 2018). In a preliminary review of a few applications, the authors found that applications to teach mindfulness practices rely heavily on guided instructions, or videos, making it a very passive and didactic process. This experience is validated in a review of various mindfulness apps by Plaza, Demarzo, Herrera-Mercadal, and García-Campayo (2013) where they mention that these applications are mostly instructional and non-interactive and that there were opportunities to leverage social learning and to track data regarding practice and health benefits. Since 2013, the mindfulness meditation mobile app design and use have grown to be more interactive (Lukoff, Lyngs, Gueorguieva, Dillman, Hiniker & Munson, 2020; Mrazek, Mrazek, Cherolini, Cloughesy, Cynman, Gougis, Landry, Reese & Schooler, 2019).

A leading mindfulness app has several features that address issues raised above. While it continues to have recorded animated videos that teach basic concepts, in contrast to several other applications that offer a one-size fits all model of meditation, this app offers an array of options based on the meditator's needs. It asks the learner a series of questions about her/his mood and feelings and based on responses, suggests a few meditation options to pick from. This supports personalization of the mindfulness practice. The guided meditation provides the learner detailed instructions and options to vary the length of time devoted to the practice. For advanced learners, it offers options to self-time and meditate without guidance. The application helps the learner to keep a record of their meditation sessions and pushes daily reminders to promote a regularity in one's practice. It also integrates with a tracking application in the phone to record health data by capturing active use of the app and subsequent activity related to the app. In another application with a similar approach, the learner has the option to regulate length of one's breathing cycles of inhalation and exhalation. This is aided by the timed dimming and brightening of the screen, which is based on learner inputs. Use of this feature avoids a disturbance one might experience in applications based on vocal guiding instructions. Such an application helps one learn meditation in ways that mimic face-to-face methods or even surpass them in certain outcomes. Such applications, while not replacement for a personal trainer or a group class, have several features that help the learner experience meditation, track their progress, and seek expert inputs in their own contexts outside the classroom. While there is still a long way to improve functionalities, like communication with other learners to seek support, these apps have surpassed earlier versions of computer mediated meditation training, which were simply recorded videos of an expert with scrolling text—and/or accompanying booklets—summarizing key steps. They are also more visually appealing with digital enhancements such as high pixel graphics, clear sound and seamless video.

## Employability Skills for the 21st Century Economy

An innovative social enterprise Empowered Professionals for Internship and College Credits (EPICC) secures internship opportunities with corporate partners for young adults from predominantly disadvantaged backgrounds. Its educators have believed in the power of experiential learning to foster meaningful skill building to empower these young adults. While undergoing the training, the interns get trained in professionalism and career development, and are held to an employability skills development contract. Earlier, the training program ran for six months conducted through in-person training and followed by six months of internship. The learning and development (L&D) courses were redesigned to solidify EPICC's high expectations and high support model and to go beyond traditional higher education objectives to include actual experiences that trainees would encounter during the internship. The practical exercises of the courses developed an experiential knowledge that would help convey possible career trajectories with opportunities to hone their employability. Digitization was an important aspect of the redesign process and technology was leveraged to support the trainees, interns, and alumni. Social connectedness formed a part of the experiential learning and theoretical framework to cultivate communities of practice (Mentor, 2017). Prior to digitization, experiential elements of internship training were offered in a cyclical paper-based fashion of modules and programmatic elements. In that model, students were highly reliant on physical textbooks and were time bound at the physical location to print and submit their work.

After digitization of the training program, the trainees could also earn college credit recommendations for the training and the internship experience. For example, as with all the courses, a professional skills course was rebuilt for college credit recommendations and designed for e-/m- blended learning delivery and engagement. Workplace scenarios were embedded and integrated throughout the training and students were trained. For example, on how to overcome challenges of punctuality, meeting work assignment deadlines, committing to workplace level professionalism, delivering work at appropriate quality levels, and developing confidence during their Learning and Development (L&D) stage for the internship phase of the program and beyond. Online access, interaction, and virtual learning communities of support offered real time support and data. The latter strengthened the visibility and transparency of the trainers' and trainees' work. Leveraging mobile technology in hand, both instructors and trainees were also provided a network of supportive relationships. The digitization of the learning community further fostered a powerful sense of agency for the students—encouraging them to be active agents in their workforce learning and development, internship and preparing them for a career path. The virtual communities of practice were formed through career track sorting after a foundational phase of training as well as through in-person and virtual computer-mediated interactive exercises. The sense of belonging and community affiliation was further promoted through an 'academic facebook' style learning management system. Trainees could message one another and their instructors to crowdsource or ask a one-on-one question of a peer or an instructor, query a concept, or just post an inspirational quote or message.

Since the adoption of the academic vision and strategy, with e-/m-learning as an integral tool in support of those efforts, the academic program could now offer valuable data learning analytics faster than it could before and be replicated and scaled faster as a model to other city's training centers. This tracking also helped the educators assess where learners' levels were in knowledge, skills building and transference of knowledge and skills, and offer them appropriate support to further their learning. The addition of the digital engagement enhanced the organization's traditional model and helped better prepare the trainees by offering multimodal stimulation which could be revisited, shared, and offer real time and asynchronous collaborative learning opportunities. The L&D organization won an Optimas Gold Award from Workforce Magazine for enacting this e-/m-learning vision in 2014, and an award for best blended learning from the International E-Learning Association (2015) for several of its own built curricula and courses.

## Employability Skills for a Digitally Infused World

Telehealth, telemedicine, or m-Health are terms used interchangeably, as a subset of e-health, and refer to the use of technology to provide health care through the internet or telecommunications by using a variety of telecommunication devices, including computers, telephones, smartphones, and mobile wireless devices, with or without a video connection (Almubark, Majrashi, Alghusun, Alhammad, Alhthifi, & Alyahya, 2021; Omboni, 2019; Dorsey & Topol, 2016; Yusif, Hafeez-Baig & Soar, 2017). Mobile technology presents a real opportunity to develop advanced telehealth solutions that can transform health care and people's lives, both nationally and internationally. For example, virtual consultations remove the costs and time-delays associated with travel and sitting in waiting-rooms and allows more equitable access to quality healthcare and increased patient satisfaction. Another example, prior to the pandemic, was the use of UNICEF's RapidSMS system in Ethiopia in 2008 when field workers and monitors responding to a famine caused by drought needed to quickly report on severely impacted regions, and then an even more successful version 2.0 in Malawi (UNICEF, 2010) was introduced to track children's' health. The RapidSMS system was in effect an early Mobile Health (m-Health) data collection system which offered and resulted in a reduction of delay in children's records being transmitted as valuable data and cutting months of paper processing delays (Mitchell, 2019). Prior to the RapidSMS system, the paper-based system took 1–3 months to process child nutrition data, whereas with RapidSMS, it takes mere minutes to transmit the data via simple SMS (Bhattacharyya, Mossman, Ginther, Hayden, Sohal, Cha, Bopardikar, MacDonald, Parikh, Shahin & McGahan, 2019). The child's data was protected through a unique identifier applied in the system and allowed for faster error corrections on the data submitted as well as the ability to identify areas of water pollution or other disease outbreaks allowing for faster response times from the government and agencies (Malanga, 2017).

During the pandemic, individuals, and organizations in general, including health-care systems and entities could review what is possible and desirable, and to adapt models of care to the rapidly evolving situation. Many countries have seen a shift towards online telecommunications and video consultations, including the health sector. Furthermore, some hospitals have introduced robots and tablet computers to facilitate physical distancing, while monitoring and communicating with patients (Blandford, 2020).

The use of digital health technologies is cost-effective and has provided and improved access and service to quality healthcare, especially for historically marginalized and underserved communities and persons in remote or rural locations (Chiauzzi, Clayton, & Huh-Yoo, 2020; Kisicki, Becker, Chaple, Gustafson, Hartzler, Jacobson, Murphy, Tapscott & Molfenter, 2021; Lin, Dievler, Robbins, Sripipatana, Quinn & Nair, 2018). Some of the affordances of telehealth include opportunities to disseminate health information and improve access to health services, opportunities for online counselling to reduce the backlog of cases, improved patient monitoring, tracking and adherence to medication, ease of access to health training and information (Shah & Tomljenovic-Berube, 2021).

Telehealth enables convenient delivery of health care services and involves experiential interactions between patients and health practitioners through telephone, e-mail, video chats or conferences, the internet and, in developed countries, it can include voice-activated household devices, especially for patient monitoring and tracking. Technologies to support telehealth are proliferating and include wearable devices, smart phones, and instrumented (smart) homes. Nowadays, smart homes can be equipped with personal and environmental sensors that are interconnected using the Internet of Things. Patients have been sent home with digital devices, such as pulse oximeters and instructions on self-management to minimize the load on healthcare systems. These devices can monitor patient health and communicate to responsible health care workers and clinicians, when emergency situations are detected (Blandford, 2020). With the use of video visits in the home, even care for acute conditions such as stroke and pneumonia is moving from the emergency department to the doorstep or bedroom, and is mirroring the trend in banking, in which automated teller machines and the internet have moved basic client services from the bank lobby to mobile devices (Dorsey & Topol, 2016; Goran, 2020; Gumzej, 2021; Pereira and Fife, 2021).

Across the four examples above, the underlying learning elements closely connect with experiential learning. Table 1 lists certain connections we saw between elements in the above four examples and Kolb's (1984) learning cycle organized by underlying steps.

*Table 1. Experiential elements in examples of e/m learning*

| | Concrete Experience | Reflective Observation | Abstract Conceptualization | Active Experimentation |
|---|---|---|---|---|
| **Online Executive Education Program** | Video cases and stories, feedback | Discussion boards, assessments, personalized responses | Video lectures, tool kits | Quizzes, role plays |
| **Mindfulness Applications** | Guided meditation | Mood prompts, usage statistics | Guided meditations, video lectures and animations | Self-timed meditation |
| **Employability Skills** | Workplace scenarios | Virtual learning communities and feedback | Online content messaging features | Practical trial implementation |
| **Allied Health Digitalized Data** | Data input, tracking and feedback | Alerts, reminders, automated responses, video, data visualizations and confirmations | Sequenced data, personalized and global learning analytics | Record, trial course correct & repeat, exercises |

If we look across the above four examples and literature references, we can conclude that the learning goals and context of the talent developer, and medical health learner contributed to the choice of the learning elements, nature of conversations and process. Each of the examples demonstrated how learning design moved beyond knowledge transfer to one in which there was an opportunity for the participant to engage with the subject, experience personalized learning, and engage outside classrooms in situated contexts. These could be construed as cases of Communicative Learning if not Transformative (Mezirow, 2000). While these apps encourage learners to construct their own meaning, there remained certain aspects of learning that stayed constant and at an informational level. These include the specific techniques in the meditation app, the knowledge for the ideas about professionalism such as punctuality in the EPICC examples, and key principles and tools on which the leadership development program was based. Across examples, assessment and tracking was a key feature. Learners were helped to become aware of their progress and use that to guide further learning and improvement. Additionally, even though the applications used e-/m-technologies, they strongly incorporated doing or conducting experimentation connected to real life situations as a learning element with examples ranging from customer service troubleshooting, offering mock interviews with people from industry, and unpacking real world business examples. The meditation practice, role plays, and assignments are examples of learning by doing. The applications also differed from each other in many ways. In the meditation app and leadership training app, the entire course was offered over the e-/m- platform whereas in the L&D example, the e-/m- features were blended with face-to-face elements of the internship. The differences between the applications can be attributed to differences in technical capability available to the designers, their own philosophy of teaching, and the context for which they were developing the applications.

Hopefully, the above examples elucidated emergent themes that informed our conceptual model for learning programs using e-/m- methods that incorporate experiential elements. We now move on to describe our pilot research before showcasing our conceptual model mentioned above.

## MOBILE ENHANCED APPLICATION PILOT TO TEACH MINDFUL BREATHING

We tested the concept of applying our experiential learning in e-& m-learning initiatives and research using a pilot model of a mobile app that teaches the regulation of breathing because breathing is one of the core processes across various mindfulness techniques. Breathing has been identified over millennia by ancient cultures ranging from Africa's communities, their indigenous knowledge, as well as India and China's ancient cultural practices as is evident in such practices as chanting, yoga, tai-chi, body-oriented psychotherapy, body awareness therapy, mindfulness-based therapies, meditation, Alexander technique, and breathing therapy (Wahbeh, Elsas, & Oken, 2008; Ospina, Bond, Karkhaneh, Buscemi, Dryden, Barnes, & Shannahoff Khalsa,2008). According to Bennett (2011), "although diverse in their specific orientation and application, these fields all share the common belief that the body, mind, and spirit are inherently interconnected and utilize the body as a resource for learning, spirituality, wellness, personal growth and development, and diverse methods of healing" (p.128). Learning to regulate attention focused on breath as part of mindfulness techniques can help us achieve psychological well-being (Wielgosz, Schuyler, Lutz, & Davidson, 2016; Fernros, Furhoff, & Wändell, 2008; Krygier, Heathers, Shahrestani, Abbott, Gross, & Kemp, 2013).

Since our primary goal was to test experiential learning in an e-/m-learning environment, our learning design incorporated all aspects of Kolb (1984)'s experiential learning cycle-experience, reflection, analysis and experimentation. We also incorporated elements of assessment that could serve the purpose of tracking and motivation.

The goal translated to the following objectives for the process:

1. Leverage experiences to teach aspects of breathing.
2. Facilitate reflections through technology enabled conversations (conversation theory; Pask, 1976).
3. Limit instructions to the conceptualization process (this was both an objective and a parameter of the exercise).
4. Enhance learning by assessment:
    a. Making learning goals explicit to learners (Richards, 2012),
    b. Appraise one's breathing patterns to inform corrective action.

The design was tested with graduate school students and their responses were analyzed through qualitative thematic analysis (Braun & Clarke, 2006). The research questions concerned their views about efficacy of the process, ways in which the process was superior or inferior to conventional face-to-face or linear instructor lead designs, and design elements they saw as most useful in furthering their learning. Overall, the learner-users preferred the proposed design as compared to conventional and linear approaches. No single feature or element emerged as a winner. Based on the following observations, we interpret that learner-users latched on to different elements (videos, reflections, or practice) based on their individual learning preferences.

They mentioned, as other key benefits of the approach:

- flexibility of navigation an exploration
- the choice of skipping uninteresting elements.

- learning through different elements appealing
- No need or coercion to follow all the elements in the sequence presented in the application.
- They could spend greater time in elements that looked meaningful.

For example, some learner-users did not see meaning in trying to understand how others experienced the meditation process. Instead, they were keen to learn the tips and tricks shared by the expert and practice. Others wanted to practice and reflect on what difference it made and how they could enhance their practice. These learner-users mentioned shortage of time as one of the reasons why they would not go through all elements, but rather pick the one they thought were most useful. This phenomenon is a small example of how an experiential learning cycle creates the space for learners (who are also users) to step into the learning using methods they are more comfortable using, prior to stretching themselves in another part of the cycle.

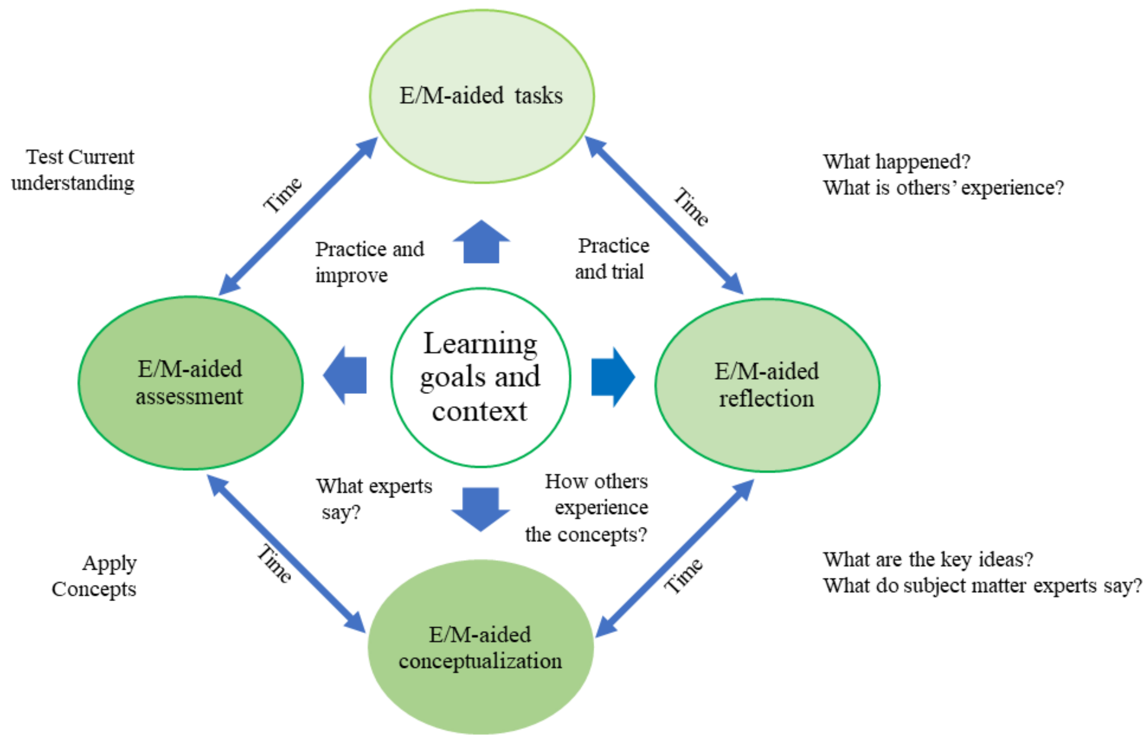
## ELUCIDATING AND APPLYING THE JOSHI-MENTOR MODEL

This next section will tie the concepts together and distill this discussion down to a few key ideas. Our separate research of implementing experiential learning cycles, and collaborative reflection, led to the creation of the Joshi-Mentor model, which is depicted in Figure 2, and was developed based on concepts used in the chapter. The model has several features of Kolb (1984)'s experiential learning model. It has tasks that facilitate active experimentation and/or concrete experience. The learner's experience, often captured through assessments or reflection stems, facilitates RO. The reflection component could take the form of individual or community-based reflection in online or face-to-face contexts. The conceptualization phase could happen through content transfer using videos from experts, and subsequent discourse amongst peers. In addition, the computer-based tasks often incorporate assessment, feedback and/or tracking. We also introduce the added dimension of time as a global factor surrounding all elements in this model as there are many underlying time dependent variables: Access to the device, availability of time and synchronicity, or a-synchronicity of learning design that guide the app.

E-/m-learning environments also facilitate hypermedia technology, i.e. flexibility of not following a rigid process but navigating based on interests, which becomes difficult in classroom as well as sport science and biokineticists experiential contexts. E/m learning makes it possible to allow the learner to enter anywhere in the learning cycle rather than necessarily start with an experience. The authors of the chapter believe that the freedom of choice depending on telehealth preferences, temporality, synchronous and asynchronous choices of engagement, or other considerations and constraints, is a definite advantage of experiential learning in a computer-based environment based on, but not limited to the options listed in this sentence. Further, the cost of providing such learning is less than providing face-to-face learning especially if one needs to transcend significant boundaries of time and space. Hence this becomes appropriate for deployment where high quality must be provided on scale.

A brief description of the individual components follows:

*Figure 2. E/M-based Experiential Learning Model developed based on mindful breathing application pilot study and Kolb's experiential cycle*




## Learning Goals and Context

Experiential learning can rely on past experiences of the learner, use structured experiences designed to achieve specific goals, or a combination. With the current stage of technological development, most e-/m-learning is likely to focus on specific knowledge, skills, and attitudinal goals. These goals will influence the nature of the components placed in the periphery. Similarly, the context of the learner will influence all the peripheral elements. Often, in the healthcare setting, we find that many individuals grapple with the challenge of successful behavior change from previously negative health habits, such as cigarette smoking and/or excessive alcohol consumption. This is due to the lack of self-control, suitable support in the form of regular monitoring and tracking of patient behavior, which is more possible through mobile technology alerts, reminders, and online communication, particularly for reinforcing positive behaviors and preventing relapse. Telehealth used in sport contexts, offers training support before games that can help to reduce injuries, can be leveraged at a sporting event, reduces visits to the Emergency Rooms, and can provide ways for patients to visit their health professionals and/or doctors when the athlete is not mobile and benefits from not having the stress of travel to the health facility (OrthoLive, 2018; Toresdahl, Young, Quijano & Scott, 2021).

## Time

Learning or the facilitation of learning could be synchronous or asynchronous. Learning design needs to be informed by how the tech-educator envisions or anticipates the learner will use the application. Would the learner be able to undertake bite-sized learning in small chunks or would the learner need to carve out extensive durations of time? These aspects too will influence all the components placed in the periphery. It is also possible to imagine that time is a vertical axis placed perpendicular to the figure. This makes it possible to conceive that the learning goals and hence the nature of e-/m-aided tasks will change with time as the learner progresses to advanced levels of understanding. Currently, teaching and learning is shifting increasingly from in-person to blended, synchronous and designated online offerings that also include flexible and asynchronous delivery that is student-friendly and easily accessible 24-7. Which is relevant in the healthcare training environment as well. Learning, therefore, needs to be more closely aligned to the students' needs and constraints that allow for a more flexible interaction and engagement between the student and the learning materials or resources.

## e-/m-Aided Tasks

These tasks facilitate engagement of the learner with the subject matter. They could be considered akin to experiences that are designed to facilitate achievement of learning goals. Depending on the purpose of e-/m- learning, these could take various forms such as guided meditation, puzzles, games, simulations, audio-video cases or challenges. The tasks are closely connected to other elements in the periphery and often the integration may be seamless. For example, a game (the task) and its scoring (assessment) may be experienced by the learner as one and the same. However, it is important for the tech-educator and the designer to be informed of the sub-component purposes (assessment, experience, reflection, conceptual input) underlying an integrated task. A common practice in health professional education is the use of case studies made available more easily through digital means, in which to expose students to real life scenarios that they will confront in practice. This learning method provides an excellent opportunity for exposing students to the critical reasoning and clinical thinking skills required in the healthcare setting for optimal patient management, and more so during the COVID-19 pandemic, where access to face-to-face patient contact has been severely restricted.

## e-/m-Aided Reflection

At this stage, a learner is trying to make meaning of the task and/or the conceptual input. Social connectivity through computers and mobile devices offers the fascinating possibility of this meaning making being informed by experiences of fellow learners in the community. As an example, this could take forms such as a discussion thread to share how a suggested guided meditation played out for learners, what learners think of a communication technique offered by a professor in an instructional video, or learners responding to video recordings of each other posted on the e-/m-learning platform. While the reflection can be individual or group, in the case of communicative and transformative learning where questioning and challenging one's perspective in dialogue with others is involved, social reflection becomes a necessity. As indicated earlier, e-& m-learning can help with flipped, reflective, and iterative experiential learning opportunities in telehealth contexts as well where a person progressively works through the various stages of behavior change mentioned in the transtheoretical model. Flipped and reflective engagement, internally and externally through auto scheduled reminders, homework, or follow-up activity, or through active telehealth engagement with an allied health professional, can aid the person's precontemplation stage, contemplation stage, preparation stage, action stage, and maintenance stage, while either preventing or dealing with relapses at each of the stages.

## e-/m-Aided Conceptual Inputs

It emerged in our pilot study and examples that given the situated nature of such learning, learners expect expert inputs and concise presentation of key concepts and ideas that they can immediately apply. This often takes forms of instructional videos, audio-visual presentations, or text and visual models summarizing key ideas, rules, and concepts. These conceptual inputs can also become the triggers for subsequent reflection or assessment. Especially in health education, where reinforcement of student learning and education, like other industries and fields is often through the form of YouTube educational videos and resources, such as the Khan Academy and CrashCourse A & P. These resources complement mainstream teaching and learning as well as enhance the feral, independent, and self-directed educational experience of the students.

## E-/M-Aided Assessment

Learners do wish to be able to keep track of and be informed about their progress. Health management applications are great examples wherein they track and present key statistics which act as motivators and metrics. E-/m-learning applications not only capture the digital footprint of the learner within the app (time taken to accomplish tasks, accuracy etc.) but also the context in which learning took place (what was the learner doing while learning, which places was the learner in) using the telemetry-based affordances of mobile devices such as Global Positioning Systems (GPS) and other location features like Near Field Communication (NFC) for situated cognition). These possibilities can help draw fascinating insights on aspects such as learner preferences and styles that can help individual learners and tech-educators. Assessment also serves to motivate the learner. Educators can incorporate reward and recognition elements to enhance motivation. More recently, the introduction of artificial intelligence (AI) and virtual reality (VR) to support the teaching and learning of students in health professions education have provided students with simulated examples and experiences that closely mimic reality. The affordances of VR scenarios have provided the dual benefit of exploiting the experiential learning of students and simultaneously presenting opportunities for practical and functional assessments of students with minimal risk to the patient, student, and the public.

## Connections and Flow

Our pilot revealed to us that e-/m-learning offers the possibility to not be stuck with any sequence of the various components. Such flexibility can be a distinct advantage of e-/m- based learning as compared to non-digital formats of experiential learning. A learner should be provided options to enter the learning cycle at places according to her preference, spend greater time or even repeat components that support better learning. Each of these components can create bi-directional triggers towards other components as depicted in Figure 2. Providing current health information and up-to-date health knowledge to health science students is a major problem for many developing countries that are still grappling with the transition to online learning, because of a lack of suitable resources to support the technology and host reliable access to the internet. The opportunities offered via e-/m-learning technologies provide excellent means for overcoming the practical difficulties of access to basic education and quality healthcare that can be exploited to great benefit for all in most developing countries.

## CONCLUSION

Educators, Talent Developers, Sport Health Professionals, Biokineticists, and other health care professionals adapted experiential learning approaches to models of online learning to enhance the teaching-learning process and reach more learners. The authors of this chapter believe that computer-mediated learning also needs to become more experiential in a judicious and educationally informed manner. Flexibility, lower cost of experimentation failure, and responsiveness to peoples' learning preferences seem to be clear advantages over experiential learning in just an in-person context. Such approaches can be applied and used for personal health, technical as well as communicative learning goals. We would be keen to see how this can extend to transformative learning goals in other industries. For the latter goals, it is imperative that technology help promote inter-connection between perspectives of different people in various personal and work contexts, as that is at the heart of facilitating communicative and transformative learning (Mezirow, 2000) and help build the capabilities of hosting multiple perspectives beyond binary views of the world.

We explored examples of e/m learning from a micro and macro perspective. The workforce development, leadership teaching application and mindfulness application focused on experiential learning embedded in one application and interfacing with the learner while the employability skills example focused on a macro perspective beyond a single application in a blended manner with virtual distance learning components interacting with other processes in the organization. The examples mentioned in this chapter will need to be revisited on a regular basis (semi-annually to annually) as technological innovations will continuously impact these target audiences and influence the contexts. From these examples we concluded that models rooted in basics such as Kolb's model can be effective frameworks to inform design approaches and shared our conceptualization of one such model as a possible takeaway for practical application. However, with rapid pace of change, these models will need to continuously evolve, and will require further research.

## FUTURE RESEARCH DIRECTIONS

Technological advances continue to facilitate greater diffusion between the virtual and real boundary. We are going to see greater integration of mobile devices in all aspects of our life. Augmented and Virtual Reality are already seeing increased application in educational settings, even as their efficacy is being debated as one would expect to happen whenever changes occur (Merchant, Goetz, Cifuentes, Keeney-Kennicutt, & Davis, 2014; Bower, Howe, McCredie, Robinson, & Grover, 2014). The learning machines will become more intelligent, and this will lead to enhancement of personalization features. Greater convergence between machines and aspects of life, more availability of learner data too, will inform mobile learning. It might be feasible to identify unique aspects of a learning cycle that suit a learner, thereby letting one completely minimize or eliminate the other aspects. However, deep personalization also comes at a possible cost of learners getting used to learning in their preferred way but not developing the abilities to learn in ways outside their preference. This could lead to efficient learning in the short run but narrow learning approaches in the longer run that could filter out new learning possibilities or become limiting in certain situations. How flexible should such learning be and how can designers and educators balance the twin aims of greater personalization in learning methods yet retaining the stretch element is an issue we foresee requiring research. On almost the counter side of deep personalization of learning, social connectedness through computers and mobile devices require further research into the building of abilities to entertain multiple truths, discern tropes from truths, and further meaning making being informed by experiences of fellow learners in the digital community As mentioned earlier in the chapter, our conceptualization is based on our experiences limited to the contexts of our higher education, research and workplaces. Further research could validate the model and verify its applicability in other learning contexts. Finally, from our research and pilot we see that such models can facilitate technical and communicative learning. It still needs to be researched as to what extent and in what ways can e/m learning support transformative learning. In most developing countries, medical skill and expertise, equipment, information, and resources are often concentrated in the urban centers with the associated infrastructure to support the technology that adversely affects patients living in rural and remote areas, resulting in professional isolation and health care stagnation in many underserved and isolated communities, that undermines the capacity for professional and community development in these areas. The benefits afforded by e-learning initiatives, such as access to quality health care and current information, can go a long way to solving the difficulties in most low-income countries, because of the inequitable distribution of skills, expertise and resources, the differential access to care, and the fragmentation of services. Within the health professions, the need for remaining current in practice by earning continuing professional development (CPD) points through short courses, webinars, etcetera, is an imperative for health practitioners. This can be navigated quite easily through online education and training that is user friendly, cost-effective, and accessible by all. Especially to address the challenges of technological and digital illiteracy, facilitate the empowering of healthcare staff and workers as well as support in-service training and capacity development.

## ACKNOWLEDGEMENT

My utmost appreciation to Himanshu Joshi for his inspiration, dedication, and contributions. Sadly, we lost Himanshu before we could revisit our efforts to update this chapter, but his spirit, creativity, and unique insights informed our processes. We updated this chapter to pay tribute to the way in which Himanshu used academic disciplines to bring rigor and depth to educational research. Himanshu was just weeks away from defending his dissertation when he passed away due to COVID. My heartfelt thanks to those who rallied as a community, and with the encouragement of Teachers College, Columbia University leadership, was able to add the finishing touches to his dissertation. My deepest gratitude also to Teachers College, Columbia University for holding a posthumous dissertation hearing and for filing his dissertation so that his thinking can be available to other scholars interested in reflection practices and the way learning and development might influence these practices. I am honored that I had the opportunity to work with Himanshu and collaborate with him through discourse that enriched my thinking processes and life.

## REFERENCES

Adzovie, D. E., Jibril, A. B., Adzovie, R. H., & Nyieku, I. E. (2020, July). E-Learning resulting from Covid-19 pandemic: A conceptual study from a developing country perspective. In *7th European Conference on Social Media ECSM 2020* (p. 19). Academic Press.

Almanthari, A., Maulina, S., & Bruce, S. (2020). Secondary school mathematics teachers' views on e-learning implementation barriers during the COVID-19 pandemic: The case of Indonesia. *Eurasia Journal of Mathematics, Science and Technology Education*, *16*(7), em1860. doi:10.29333/ejmste/8240

Almubark, B. M., Majrashi, N., Alghusun, N., Alhammad, M., Alhthifi, F., & Alyahya, R. S. (2021). Telehealth Clinical Practice Guide for Occupational Therapy, Physical Therapy, and Speech and Language Pathology: A Saudi and Middle Eastern Guide. *Telemedicine Journal and e-Health*, tmj.2021.0021. doi:10.1089/tmj.2021.0021 PMID:34529497

Andersen, L., Boud, D., & Cohen, R. (2000). Experience-based learning. In G. Foley (Ed.), *Understanding adult education and training* (2nd ed., pp. 225–239). Allen & Unwin.

Andrews, K. L. (2019). *Technologies, Pedagogies, and Ecologies: First-Year Writing Faculty's Attitudes toward Technology and Technological Uptake in the Composition Classroom*. North Carolina State University.

Bannan, B., Cook, J., & Pachler, N. (2016). Reconceptualizing design research in the age of mobile learning. *Interactive Learning Environments*, *24*(5), 938–953. doi:10.1080/10494820.2015.1018911

Barbe, W. B., Milone, M. N., & Swassing, R. H. (1979). *Teaching Through Modality Strengths: Concepts and Practices*. Zaner-Bloser.

Bhattacharyya, O., Mossman, K., Ginther, J., Hayden, L., Sohal, R., Cha, J., . . . Mitchell, W. (2019). 6. Assessing Health Program Performance in Low-and Middle-Income Countries: Building a Feasible, Credible, and Comprehensive Framework. In Private Sector Entrepreneurship in Global Health (pp. 129-163). University of Toronto Press.

Benkert, C., & Dam, N. (2015). *Experiential learning: What's missing in most change programs.* Retrieved from https://www.mckinsey.com/business-functions/operations/our-insights/experiential-learning-whats-missing-in-most-change-programs

Bennett, C. C. (2012). *The role of the body in leading and learning: A case study of a somatic leadership development program* (Doctoral dissertation). Teachers College, Columbia University.

Bereiter, C. (2002). Design research for sustained innovation. *Cognitive Studies*, *9*(3), 321–327.

Blandford, A., Wesson, J., Amalberti, R., AlHazme, R., & Allwihan, R. (2020). Opportunities and challenges for telehealth within, and beyond, a pandemic. *Lancet*, *8*, e1364–e1365. PMID:32791119

Bloom, B. S., Krathwohl, D. R., & Masia, B. B. (1984). *Bloom taxonomy of educational objectives*. Allyn and Bacon.

Bower, M., Howe, C., McCredie, N., Robinson, A., & Grover, D. (2014). Augmented Reality in education–cases, places and potentials. *Educational Media International*, *51*(1), 1–15. doi:10.1080/09523987.2014.889400

Boud, D., Keogh, R., & Walker, D. (Eds.). (2013). *Reflection: Turning experience into learning*. Routledge. doi:10.4324/9781315059051

Boud, D., Keogh, R., & Walker, D. (1985). Promoting reflection in learning: A model. *Reflection: Turning experience into learning*, 18-40.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. doi:10.1191/1478088706qp063oa

Buckingham, D. (2013). *Beyond technology: Children's learning in the age of digital culture*. John Wiley & Sons.

CCNMTL. (2013, June 25). *Design Research at CCNMTL | About Design Research at CCNMTL*. Retrieved August 05, 2017, from https://ccnmtl.columbia.edu/dr/about/

Chen, O., Woolcott, G., & Sweller, J. (2017). Using cognitive load theory to structure computer-based learning including MOOCs. *Journal of Computer Assisted Learning*, *33*(4), 293–305. doi:10.1111/jcal.12188

Chiauzzi, E., Clayton, A., & Huh-Yoo, J. (2020). Videoconferencing-Based Telemental Health: Important Questions for the COVID-19 Era From Clinical and Patient-Centered Perspectives. *JMIR Mental Health*, *7*(12), e24021. doi:10.2196/24021 PMID:33180739

Chitungo, I., Mhango, M., Mbunge, E., Dzobo, M., Musuka, G., & Dzinamarira, T. (2021). Utility of telemedicine in sub-Saharan Africa during the COVID-19 pandemic. A rapid review. *Human Behavior and Emerging Technologies*.

Custer, O., Deutscher, P., & Haddad, S. (Eds.). (2016). *Foucault/Derrida Fifty Years Later: The Futures of Genealogy, Deconstruction, and Politics*. Columbia University Press. doi:10.7312/cust17194

Dahlgren, R. L. (2017). Education and Popular Culture Narratives. In *From Martyrs to Murderers* (pp. 13–30). SensePublishers. doi:10.1007/978-94-6300-965-2_2

Dewey, J. (1938). *Experience and Education*. Collier Books.

Dorsey, E. R., & Topol, E. J. (2016). State of Telehealth. *The New England Journal of Medicine*, *375*(2), 154–161. doi:10.1056/NEJMra1601705 PMID:27410924

Edelson, D. C. (2002). Design research: What we learn when we engage in design. *Journal of the Learning Sciences*, *11*(1), 105–121. doi:10.1207/S15327809JLS1101_4

Epelboin, Y. (2017). MOOCs: A Viable Business Model? In *Open Education: from OERs to MOOCs* (pp. 241–259). Springer Berlin Heidelberg. doi:10.1007/978-3-662-52925-6_13

Elias, J. L., & Merriam, S. B. (1995). *Philosophical foundations of adult education*. Krieger Publishing.

Gaebel, M. (2014). *MOOCs: Massive open online courses*. EUA.

Great School Partnership. (2014, March 5). *Bloom's Taxonomy Definition by the glossary of education reform*. Retrieved March 06, 2018, from https://www.edglossary.org/blooms-taxonomy/

Goran, S. F. (2020). Chapter Twenty-One The Telehealth Nurse: Yesterday, Today And In The Future Susan Flewelling Goran, MSN, RN. *The Many Roles of the Registered Nurse*, 217.

Gumzej, R. (2021). E-Health. In *Intelligent Logistics Systems for Smart Cities and Communities* (pp. 45–51). Springer. doi:10.1007/978-3-030-81203-4_5

Feijt, M. (2017). *Perceived drivers and barriers to the adoption of online counseling by psychologists: the construction of the levels of adoption of online counseling model.* Master Thesis.

Felicia, P. (Ed.). (2011). *Handbook of Research on Improving Learning and Motivation through Educational Games: Multidisciplinary Approaches: Multidisciplinary Approaches*. IGI Global. doi:10.4018/978-1-60960-495-0

Fernros, L., Furhoff, A. K., & Wändell, P. E. (2008). Improving quality of life using compound mind-body therapies: Evaluation of a course intervention with body movement and breath therapy, guided imagery, chakra experiencing and mindfulness meditation. *Quality of Life Research: An International Journal of Quality of Life Aspects of Treatment, Care and Rehabilitation*, *17*(3), 367–376. doi:10.100711136-008-9321-x PMID:18324479

Friesen, N. (2012). *Report: Defining blended learning*. http://learningspaces. org/papers/Defining_ Blended_Learnin g_NF. pdf

Heifetz, R. A. (1994). *Leadership without easy answers* (Vol. 465). Harvard University Press. doi:10.4159/9780674038479

Heifetz, R. A., & Linsky, M. (2014). *Adaptive Leadership: The Heifetz Collection (3 Items)*. Harvard Business Review Press.

Kabat-Zinn, J. (2003). Mindfulness-based interventions in context: Past, present, and future. *Clinical Psychology: Science and Practice*, *10*(2), 144–156. doi:10.1093/clipsy.bpg016

Kaplan Andreas, M., & Michael, H. (2016). Higher education and the digital revolution: About MOOCs, SPOCs, social media, and the Cookie Monster. *Business Horizon, 59*.

Kasworm, C. E., Rose, A. D., & Ross-Gordon, J. M. (Eds.). (2010). *Handbook of adult and continuing education*. Sage.

Kegan, R., & Lahey, L. L. (2009). *Immunity to change: How to overcome it and unlock potential in yourself and your organization*. Harvard Business Press.

Khoury, B., Sharma, M., Rush, S. E., & Fournier, C. (2015). Mindfulness-based stress reduction for healthy individuals: A meta-analysis. *Journal of Psychosomatic Research*, *78*(6), 519–528. doi:10.1016/j. jpsychores.2015.03.009 PMID:25818837

Kisicki, A., Becker, S., Chaple, M., Gustafson, D. H., Hartzler, B., Jacobson, N., ... Molfenter, T. (2021). *Behavioral Healthcare Providers' Experiences Related to use of Telehealth as a Result of the COVID-19 Pandemic: An Exploratory Study*. Academic Press.

Ko, S., & Rossen, S. (2017). *Teaching online: A practical guide*. Taylor & Francis. doi:10.4324/9780203427354

Kolb, D. A. (1984). *Experience as the source of learning and development Prentice-Hall*.

Kolb, A. Y., & Kolb, D. A. (2012). Experiential learning theory. In Encyclopedia of the Sciences of Learning (pp. 1215-1219). Springer US. doi:10.1007/978-1-4419-1428-6_227

Kolb, D. A. (2014). *Experiential learning: Experience as the source of learning and development*. FT Press.

Krygier, J. R., Heathers, J. A., Shahrestani, S., Abbott, M., Gross, J. J., & Kemp, A. H. (2013). Mindfulness meditation, well-being, and heart rate variability: A preliminary investigation into the impact of intensive Vipassana meditation. *International Journal of Psychophysiology*, *89*(3), 305–313. doi:10.1016/j.ijpsycho.2013.06.017 PMID:23797150

Lazaroiu, G., Popescu, G. H., & Nica, E. (2016, July). Democratizing education: the potential of EdX in revolutionizing learning. In *The International Scientific Conference eLearning and Software for Education* (*Vol. 3*, p. 34). "Carol I" National Defence University.

Li, C., & Lalani, F. (2020, April 29). T*he COVID-19 pandemic has changed education forever. This is how*. Retrieved December 30, 2021, from https://www.weforum.org/agenda/2020/04/coronavirus-education-global-covid19-online-digital-learning/

Lin, C. C. C., Dievler, A., Robbins, C., Sripipatana, A., Quinn, M., & Nair, S. (2018). Telehealth in health centers: Key adoption factors, barriers, and opportunities. *Health Affairs*, *37*(12), 1967–1974. doi:10.1377/hlthaff.2018.05125 PMID:30633683

Lukoff, K., Lyngs, U., Gueorguieva, S., Dillman, E. S., Hiniker, A., & Munson, S. A. (2020, July). From ancient contemplative practice to the app store: Designing a digital container for mindfulness. In *Proceedings of the 2020 ACM Designing Interactive Systems Conference* (pp. 1551-1564). 10.1145/3357236.3395444

Lynch, M. (2020). E-Learning during a global pandemic. *Asian Journal of Distance Education*, *15*(1), 189–195.

Malanga, D. F. (2017). Implementation of Mobile Health Initiatives in Malawi: Current Status, Issues, and Challenges. *Health Information Systems and the Advancement of Medical Practice in Developing Countries*, 115-128.

Mentor, D. (Ed.). (2019). Advancing Mobile Learning in Contemporary Educational Spaces. IGI Global, Information Science Reference. doi:10.4018/978-1-5225-9351-5

Mentor, D. (2018). mClass Planet of the Apps: The Rise of Mobile Learning. In Computer-Mediated Learning for Workforce Development (pp. 196-215). IGI Global.

Mentor, D. (2018). Micro to Macro Social Connectedness Through Mobile Phone Engagement. In *Encyclopedia of Information Science and Technology* (4th ed., pp. 6184–6194). IGI Global.

Mentor, D. (2017, April 25). Cultivating Digital TLC – Teaching and Learning Communities. In *ModSim World 2017*. Retrieved July 23, 2017, from http://www.modsimworld.org/2017/documents/Working-Agenda-17-April.pdf

Mentor, D. (2016). EMxC3= e&mLearning Cultivating Connected Communities: Sustainable Workforce Talent Development. Handbook of Research on Mobile Learning in Contemporary Classrooms, 240-259.

Mentor, D. J. (2011) *Exploring social connectedness via mobile phone texting* (Ph.D. thesis). Teachers College, Columbia University. Retrieved December 25, 2017 from https://www.learntechlib.org/p/117314/

Merchant, Z., Goetz, E. T., Cifuentes, L., Keeney-Kennicutt, W., & Davis, T. J. (2014). Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis. *Computers & Education*, *70*, 29–40. doi:10.1016/j.compedu.2013.07.033

Merriam, S. B., Caffarella, R. S., & Baumgartner, L. M. (2012). *Learning in adulthood: A comprehensive guide*. John Wiley & Sons.

Mezirow, J. (2000). Learning as Transformation: Critical Perspectives on a Theory in Progress. The Jossey-Bass Higher and Adult Education Series. Jossey-Bass Publishers.

Mitchell, W. (2019). 6 Assessing Health Program Performance in Low-and Middle-Income Countries: Building a Feasible, Credible, and Comprehensive Framework. *Private Sector Entrepreneurship in Global Health: Innovation, Scale, and Sustainability*, 129.

Mrazek, A. J., Mrazek, M. D., Cherolini, C. M., Cloughesy, J. N., Cynman, D. J., Gougis, L. J., Landry, A. P., Reese, J. V., & Schooler, J. W. (2019). The future of mindfulness training is digital, and the future is now. *Current Opinion in Psychology*, *28*, 81–86. doi:10.1016/j.copsyc.2018.11.012 PMID:30529975

Naismith, L., Sharples, M., Vavoula, G., & Lonsdale, P. (2004). *Literature review in mobile technologies and learning*. Academic Press.

Obrenović, Ž. (2011). Design-based research: What we learn when we engage in design of interactive systems. *Interactions, 18*(5), 56-59.

Okan, Z. (2003). Edutainment: Is learning at risk? *British Journal of Educational Technology*, *34*(3), 255–264. doi:10.1111/1467-8535.00325

Omboni, S. (2019). Connected health in hypertension management. *Frontiers in Cardiovascular Medicine*, *6*, 76. doi:10.3389/fcvm.2019.00076 PMID:31263703

OrthoLive. (2018, October 11). *Five Ways Telehealth Helps Sports Doctors Improve Their Practice*. Retrieved December 31, 2021, from https://www.ortholive.com/blog/five-ways-telehealth-helps-sports-doctors-improve-their-practice/

Ospina, M. B., Bond, K., Karkhaneh, M., Buscemi, N., Dryden, D. M., Barnes, V., & Shannahoff Khalsa, D. (2008). Clinical trials of meditation practices in health care: Characteristics and quality. *Journal of Alternative and Complementary Medicine (New York, N.Y.)*, *14*(10), 1199–1213. doi:10.1089/acm.2008.0307 PMID:19123875

Pask, G. (1976). *Conversation theory: Applications in education and epistemology*. Elsevier Publishing Company.

Peters, M. A. (2016). The postcolonial university. *Linguistic and Philosophical Investigations*, *15*, 77.

Plass, J. L., Moreno, R., & Brünken, R. (2010). *Cognitive load theory*. Cambridge University Press. doi:10.1017/CBO9780511844744

Plaza, I., Demarzo, M. M. P., Herrera-Mercadal, P., & García-Campayo, J. (2013). Mindfulness based mobile applications: Literature review and analysis of current features. *JMIR mHealth and uHealth*, *1*(2), e24. doi:10.2196/mhealth.2733 PMID:25099314

Pelster, B., Haims, J., Stempel, J., & Vyver, B. (2016). Learning: Employees take charge. Global Human Capital Trends 2016. *The new organization: Different by design*. Retrieved from https://www2.deloitte.com/us/en/pages/human-capital/articles/introduction-human-capital-trends-2016.html

Pereira, F., & Fife, E. (2021). *Tele-health in theory versus practice: A comparative look at the United States and Singapore*. Academic Press.

Ralph, T. W. (1949). Basic principles of curriculum and instruction. Syllabus for Education.

Richards, R. (2012). Exploring Formative Assessment with a Project Using Mobile Phones.*Ubiquitous Learning*. *International Journal (Toronto, Ont.)*, *4*(2).

Rogers, E. M. (2010). *Diffusion of innovations*. Simon and Schuster.

Savino, D. M. (2014). The impact of MOOCs on human resource training and development. *Journal of Higher Education Theory and Practice*, *14*(3), 59.

Selwyn, N. (2016). *Education and technology: Key issues and debates*. Bloomsbury Publishing.

Shah, D. (2016, December 25). *By the numbers: MOOCS in 2016*. Retrieved from https://www.class-central.com/report/mooc-stats-2016/

Shah, D. (2020, December 7). *EdX's 2020: Year in Review - Class Central*. Retrieved November 30, 2021, from https://www.classcentral.com/report/edx-2020-review/

Shah, K., & Tomljenovic-Berube, A. (2021). A New Dimension of Health Care: The Benefits, Limitations and Implications of Virtual Medicine. *Journal of Undergraduate Life Sciences*, *15*(1), 10–10. doi:10.33137/juls.v15i1.37034

Sharples, M., Taylor, J., & Vavoula, G. (2007). A Theory of Learning for the Mobile Age. In R. Andrews & C. Haythornthwaite (Eds.), *The Sage Handbook of Elearning Research* (pp. 221–247). Sage. doi:10.4135/9781848607859.n10

Srivastava, S. (2021, September 21). *Unhooking the Drama: Meditation App Statistics To Know in 2021*. Retrieved December 31, 2021, from https://appinventiv.com/blog/latest-meditation-app-statistics/

Stankov, U., Filimonau, V., Gretzel, U., & Vujičić, M. D. (2020). E-mindfulness–the growing importance of facilitating tourists' connections to the present moment. *Journal of Tourism Futures*.

Täuscher, K., & Kietzmann, J. (2017). Learning from Failures in the Sharing Economy. *MIS Quarterly Executive*, *16*(4).

Taylor, E. W., & Cranton, P. (2012). *The handbook of transformative learning: Theory, research, and practice*. John Wiley & Sons.

Toresdahl, B. G., Young, W. K., Quijano, B., & Scott, D. A. (2021). A systematic review of telehealth and sport-related concussion: Baseline testing, diagnosis, and management. *HSS Journal*, *17*(1), 18–24. doi:10.1177/1556331620975856 PMID:33967637

Traxler, J. (2007). Defining, Discussing and Evaluating Mobile Learning: The moving finger writes and having writ..... *The International Review of Research in Open and Distributed Learning*, *8*(2). Advance online publication. doi:10.19173/irrodl.v8i2.346

UNICEF Annual Report 2009. (2010). United Nations Children's Fund (UNICEF).

Van der Stappen, E., & Zitter, I. (2016). Exploring Design Principles for Technology-Enhanced Workplace Learning. In Bled eConference (p. 14). Academic Press.

Verger, A., Lubienski, C., & Steiner-Khamsi, G. (2016). The emergence and structuring of the global education industry: Towards an analytical framework. In A. Verger, C. Lubienski, & G. Steiner-Khamsi (Eds.), *World Yearbook of Education 2016: The Global Education Industry*. Routledge. doi:10.4324/9781315720357

Wahbeh, H., Elsas, S.-M., & Oken, B. S. (2008). Mind–body interventions: Applications in neurology. *Neurology*, *70*(24), 2321–2328. doi:10.1212/01.wnl.0000314667.16386.5e PMID:18541886

Watkins, K. E., Marsick, V. J., & Faller, P. G. (2012). Transformative learning in the workplace: Leading learning for self and organizational change. The handbook of transformative learning, 373-387.

Watkins, K. E., & Marsick, V. J. (2014). Adult education & human resource development: Overlapping and disparate fields. *New Horizons in Adult Education and Human Resource Development*, *26*(1), 42–54. doi:10.1002/nha3.20052

Weekly, T., Walker, N., Beck, J., Akers, S., & Weaver, M. (2018). A review of apps for calming, relaxation, and mindfulness interventions for pediatric palliative care patients. *Children (Basel, Switzerland)*, *5*(2), 16. doi:10.3390/children5020016 PMID:29373515

Wielgosz, J., Schuyler, B. S., Lutz, A., & Davidson, R. J. (2016). Long-term mindfulness training is associated with reliable differences in resting respiration rate. *Scientific Reports*, *6*(1), 6. doi:10.1038rep27533 PMID:27272738

Wildi-Yune, J., & Cordero, C. (2015). *Corporate Digital Learning: How to Get It "Right"*. IMD-2015-1. Retrieved from https://www.imd.org/globalassets/publications/working-papers/docs/working-paper_corporate-digital-learning-final--05-05-15.pdf

Yuan, L., Powell, S., & Cetis, J. (2013). *MOOCs and open education: Implications for higher education*. Academic Press.

Yusif, S., Hafeez-Baig, A., & Soar, J. (2017). e-Health readiness assessment factors and measuring tools: A systematic review. *International Journal of Medical Informatics*, *107*, 56–64. doi:10.1016/j.ijmedinf.2017.08.006 PMID:29029692

## KEY TERMS AND DEFINITIONS

**Allied Health:** Allied health are professionals who work to prevent, diagnose, as well as treat diseases and illnesses, while also applying scientific principles and evidence-based practices, they provide a range of diagnostic, technical, therapeutic, support services, management, and administration skills to assist patients as well as health care systems.

**Biokinetics:** Is an allied health discipline, like physiotherapy and occupational therapy, that is focused on using scientifically prescribed and supervised exercise for preventative, curative, and rehabilitative health care.

**E-Learning:** Conventionally refers to learning through online platforms and computers. Could be a tethered computer to a desk or un-tethered in the form of a laptop.

**Experiential Learning Cycle:** Developed by David Kolb, an American educational theorist credited with a popular model of learning through experience and learning styles.

**Instrumental Learning:** Also called Technical Learning. Refers to learning leading to getting information that helps carry out tasks in a pre-defined manner using a set of instructions and skills.

**Learning Style:** Refers to the idea that learners differ from each other in the way they prefer to learn or learn better. There are quite a few conceptualizations of learning styles and preferences including Kolb's Learning styles.

**M-Learning:** Learning offered via mobile devices and/or learning happening for a mobile learner.

**Mindfulness:** The phenomenon of being present to ones here and now thoughts, feelings, sensations and actions.

**Telehealth, Telemedicine, or M-Health:** Are terms used interchangeably, as a subset of e-health, and refer to the use of technology to provide health care through the internet or telecommunications by using a variety of telecommunication devices, including computers, telephones, smartphones, and mobile wireless devices, with or without a video connection.

**Transformative Learning:** Learning that requires going beyond information and knowledge as well as challenging the assumptions based on which knowledge is based leading to new perspectives and approaches.

# Chapter 15
# Libraries Creating Opportunities Before and During Crises:
## The Evolving Role of Libraries Before and During the COVID-19 Pandemic Around the World

**Jason D. Reid**
*Teachers College, Columbia University, USA*

## ABSTRACT

*The onset of the COVID-19 pandemic created a source of disruption for libraries around the world with regards to the delivery of their services. Throughout the pandemic, many libraries were forced by their respective governing bodies to reduce their in-person operating hours. As a result, a greater integration of technology became an imperative for libraries to continue to deliver relevant content to patrons. Many libraries were successful at implementing further innovative technologies into their organizational processes. However, several challenges remain with respect to the delivery of resources in an equitable manner, especially in developing nations. This chapter addresses the myriad ways libraries across the world adapted to the changing demands by regulators and patrons. This chapter also offers a literature review on the subject and provides recommendations on how libraries can continue to adapt to the rapidly evolving digital landscape catalyzed by the COVID-19 pandemic.*

## INTRODUCTION

This chapter explores how the COVID-19 pandemic has proved itself to be a source of crisis for libraries around the globe and how several libraries have capitalized on the emergent opportunities from the aforementioned crisis by adopting innovative technologies such as Social Networking Sites, Web and Mobile Applications, and Interactive Media Game Design into their operating procedures to continue to deliver relevant content and services to their patrons. Additionally, the present chapter outlines a few examples of the challenges facing the greater adoption of technological innovation by libraries, especially

DOI: 10.4018/978-1-6684-3996-8.ch015

in developing nations. Finally, the chapter provides recommendations for how libraries should proceed to continue to meet the evolving demands of library patrons and how future researchers might be able to further investigate the phenomenon of Information and Communication Technology (ICT) adoption by libraries across the world.

## BACKGROUND

The distressing fear of adverse health consequences associated with COVID-19 through direct person-to-person interaction has brought and held the world to a standstill (Annune et al. 2020). Commonplace activities that served connective roles to our social fabric such as shaking hands, attending school or workplaces, shopping at public marketplaces, visiting libraries and attending public religious ceremonies have all become feared sources of viral transmission (Annune et al. 2020; CDC, 2021). As a result, libraries, which are institutions that have traditionally operated through direct person-to-person interactions between library staff and patrons, have also become feared sources of contagion (Ifijeh & Yusuf, 2020).

Upon hearing about the health consequences of SARS-CoV-2, the virus responsible for the COVID-19 Pandemic, the initial response for many policymakers was to close the library indefinitely to avoid the further risk of viral transmission (Baker & Ellis, 2021). However, it has been argued in previous literature that "during situations of crisis, libraries should be endeavored to provide consistent services to the clients or users, without any fluctuations or delays" due to their relevant functional nature in society for promoting education and research (Deol & Brar, 2021, p. 4). Specifically, libraries play an important role in the intellectual development of individuals as well as the total development of a society (Annune et al., 2020). To date, libraries are the most enduring and flexible agency for learning and have been in existence for over two millennia, transcending even the first academic universities (Annune et al., 2020; Bundy, 2004). Furthermore, University libraries have long been recognized for their central importance to academic institutions; for example, Charles Eliot, President of Harvard University from 1834 to 1926, once proclaimed that "The Library is the heart of the University" (Simpson, 2016, p. 503).

Moreover, academic libraries, which are established in colleges and universities, have proven to be the core sources of information for students, researchers, and teachers (Deol & Brar, 2021). Information seekers at academic institutions across the world fundamentally rely on academic libraries to obtain the most appropriate and most reliable sources of information (Deol & Brar, 2021). Consistent with the concept of libraries being the "heart" of academic institutions, previous empirical research has confirmed the relationship between students' "Sense of Belonging" and academic outcomes, such as retention or persistence with study (Scoulas, 2021). Offering students, a sense of belonging, and an academic social connectedness (Mentor, 2018) to their peers in the library, their learning journeys, and their pursuit of academic success. There are numerous examples of research which show that students' Sense of Belonging has an impact not only on their academic outcomes but also on their psychological well-being (Scoulas, 2021). For example, students who have a greater sense of belonging are more likely to remain in university because they feel accepted and valued by their peers and universities, whereas students who lack a sense of belonging are more likely to experience feelings of both loneliness and depression (Scoulas, 2021). With respect to non-academic libraries, prior to the COVID-19 pandemic, many community public libraries often served key roles in educating the community and mitigating health disparities through the delivery of informational health programs and services (Lenstra, 2017; Rubenstein, 2018; Whiteman et al., 2018). For example, some of the health programs and services offered by certain community libraries included community gardens, educational classes, and health screenings (Flaherty & Miller, 2016; Lenstra, 2018a, 2018b; Lenstra & D'Arpa, 2019; Rubenstein et al., 2021). Furthermore, many veterans and senior citizens rely upon library computer resources to refill prescriptions and update wills. Additionally, library staff members often assist unemployed community members file for unemployment benefits (Santos, 2020) and host or help with unemployment skill building workshops (Mentor, 2019).

To combat the transmission of SARS-CoV-2, many libraries around the world had to convert their services to online interfaces and limit their person-to-person interaction with patrons (Ahmad et al., 2020; Annune et al. 2020; Baker & Ellis, 2021; Scoulas, 2021). As a result, what scholars have described as traditional face-to-face librarianship thus became impossible, forcing many library staff members to become more responsible for delivering distance-learning programs, which can be defined as "the function of delivering educational content directly to students' homes" (Mehrotra et al., 2001, p. 3). This presented a significant challenge to libraries with regards to adequate delivery of services because prior to the COVID-19 pandemic, most libraries are considered as an in-person social space and worked primarily in-person with library patrons to facilitate not only research and scholarship for students and researchers, but also for members of the community with which they serve (Wheeler & Kyprianou-Chavda, 2021). Many libraries across the world used the COVID-19 pandemic as an opportunity to further integrate technical solutions into their operations. The following section of the present chapter addresses some of the opportunities presented by the pandemic and how many innovative libraries were able to transition from in-person delivery of services to an effective virtual resource delivery strategy.

## LIBRARY OPPORTUNITIES FOR TECHNOLOGICAL INNOVATION

Library and Information Science (LIS) scholars have generally agreed that to form an information literate society, librarians and information science professionals must possess Information and Communication Technology (ICT) skills and competencies (Bukari et al. 2011; Shastri & Chudasma, 2021). Traditionally, library professionals had not been recognized specifically for their ICT knowledge and applications, but primarily for their principal roles as librarians, lecturers, and/or research scholars (Shastri & Chudasma, 2021). In a recently published journal article, Shastri and Chudasma (2021) argue that recent developments in the status of librarianship have caused fundamental changes to the urgency of recognizing library staff's ICT skills, and adoption by library professionals. These scholars argue that the traditional librarian's role was centered around taking care of the library's resources and its records (Shastri & Chudasma, 2021; Ifijeh & Yusuf, 2020) which has become more and more digitized. Furthermore, the authors find that the traditional skills of librarians are still relevant to date, but that professional survival of many librarians is only possible by adapting to the fundamental changes that have occurred to the role of librarianship in the digital age and more so since the outbreak of the COVID-19 pandemic (Shastri & Chudasma, 2021). Citing the work of other scholars in the discipline of LIS, Shastri & Chudasma (2021) perceived that the traditional library model would not be replaced by a virtual one, but that the model would undergo significant changes that would increase the demand by patrons with respect to accessing information from outside the library walls (Rubin, 2004; Abraham & Mohanan, 2021). To summarize, it has now become the duty of library professionals to educate library users to access various information through present and forthcoming technologies (Shastri & Chudasma, 2021). However, prior to the COVID-19 Pandemic, many libraries across the world had already and were working towards a digital integration of the libraries' services (Martzoukou, 2021). Martzoukou (2021) also argued that predating the COVID-19 situation, there existed a greater push in libraries towards the adoption of technology and online tools usage as in teaching, scholarship and research activities across universities (Martzoukou, 2021). He expands on this theme by stating:

*When the global pandemic hit, the provision of online teaching, learning and assessment were not a new undiscovered territory for universities across the globe. [Many libraries] had already been developing significant pockets of expertise on the use of diverse online technologies and the provision of a range of online resources and activities (e.g. digitized learning material, lecture capture content, synchronous and asynchronous online teaching and communication sessions, 'how-to' video tutorials and overview sessions, flipped classrooms, e-tutoring opportunities, audio and video feedback, screen capture demonstrations, online quizzes and multimedia demos, and virtual reality simulations) (Martzoukou, 2021, p. 3).*

Thus, the COVID-19 pandemic proved not to be the sole impetus for advancing towards greater adoption of technological interfaces with which to serve and deliver content, but it provided a further catalyst in the transition, due to forced library closures and social distancing mandates (Martzoukou, 2021). Many libraries around the world were able to adapt to these changes with relative success (Bangani, 2021; Ifijeh & Yusuf, 2020; Kretz et al, 2021; Martzoukou, 2021; Santos, 2020; Shastri & Chudasma, 2021). To illustrate, examples are provided of how several libraries were able to incorporate ICTs into their operations to continue to serve key roles and functions to their communities. A few of the ICTs used are as follows: Social Networking Sites, Web and Mobile Applications, and Interactive Media Game Design.

## SOCIAL NETWORKING SITES

Social Networking Sites (SNS) are currently the largest platform where "real-time information can be shared among users from highly personal to academic needs" (Abraham & Mohanan, 2021, p. 1). Boyd and Ellison defined SNS as web-based services that allow individuals to construct a public or semi-public profile within a bounded system, compile a list of other users with whom they share a connection, and view their list of connections as well as the connections made by others within the system (Boyd & Ellison, 2008, p. 211). Currently, SNS are growing rapidly as channels of communication and interaction among organizations and individuals (Ifijeh & Yusuf, 2020). One of the advantages of social media networks are their ability to establish and build relationships through social interaction, thus, helping libraries to connect with the information needs of users (Ifijeh & Yusuf, 2020). Social Networking Sites help library patrons to acquire interconnections with library staff and access the library services and products in a wider way (Abraham & Mohanan, 2021). More specifically, SNS such as Facebook, Instagram, LinkedIn, WhatsApp, Twitter, Blogs, and Snapchat have been used to erect relationships, build connections, and promote knowledge sharing with user groups. (Abraham & Mohanan, 2021; Ifijeh & Yusuf, 2020). Social Networking Sites are some of the modern digital tools that library staff have employed to create library networks, market library services, and digitally connect with patrons in a relational orientation.

### Facebook Live Example

An example from the United States of successful integration of SNS for the purposes of libraries can be found in Michelle Chan Santos' Libraries Respond to COVID-19, first published in the *Texas Library*

*Journal* (2020). In this article, Santos (2020) details how many libraries in the state of Texas were able to integrate SNS into their delivery of services. For example, Kerol Harrod at the Denton Public Library has been able to incorporate Facebook Live to broadcast virtual story times to their children's audience, which would traditionally be held in-person (Santos, 2020). Harrod states the following about using Facebook Live to connect with youth patrons:

*I love creating live virtual programs for families. I believe the live aspect is particularly important since it allows for real-time interaction. In one of our Facebook Live story times, for example, viewers were able to vote throughout the program for their favorite foods; at the end of the story time, the food with the most votes (which happened to be spaghetti) was woven into a song. That's an opportunity to interact and feel more connected, not just with one's own family, but with other families who participate. Story times are meant to be interactive, and preserving some of those important dialogic qualities gives children a sense of something that's familiar and meaningful. It shows them that the library has not gone away, and that they can still show up and be included. Facilitating that kind of connection when we so desperately need it is rewarding for everyone involved. (Santos, 2020, p. 67).*

## Web and Mobile Applications

In the current COVID-19 pandemic, users are unable to access the library physically. Therefore, the library has to reach out to users frequently to fulfill patron demands. Different technological strategies have been used for this specific purpose where both web and mobile application technologies have proven to be some of the most instrumental tools for the achievement of this aim. Some of these web and mobile applications include the library's website, the library's online digital catalog, the library's dedicated mobile app, and particularly in developing nations, messaging and chat platforms such as WhatsApp (Shastri & Chudasma, 2021). To demonstrate how this has become a commonplace phenomenon used to engage library patrons and get them excited about using the library's resources, a few LIS scholars have conducted surveys on web and mobile application usage in the United States (Becker, 2020). These surveys have revealed that nearly half (46%) of all urban libraries have both mobile websites and mobile apps (Becker, 2020, Guo et al. 2018). Additionally, according to the same survey, around 95% of libraries have at least one mobile website, mobile catalog, or mobile app (Becker, 2020; Guo et al., 2018).

Many libraries have also found value in the adoption of proprietary web and mobile applications (Santos, 2020). For example, in public libraries across Texas during COVID-19 lockdown, "book club members learned how to use Zoom [teleconferencing software]" (Santos, 2020, p. 66). Additionally, to further fulfill patron demands in Texas, librarians worked harder than ever as thousands of readers across the state signed up for virtual subscriptions and learned how to check out books and other materials with web applications such as Libby, Overdrive, Hoopla and other apps (Santos, 2020). Additionally, library staff working from home (WFH) have used proprietary web and mobile applications to continue to conduct library operations and meet with other library staff virtually, which has often prevented the full closure of libraries across the US (Santos, 2020). In another example from Texas, six staff librarians at East View High School reported that through the pandemic, they have met regularly for a video conference every week. Furthermore, proprietary software has also allowed these same librarians to share ideas and resources by collaborating on several Google docs, Google sites, as well as newer applications such as Flipgrid, Peardeck, and Sora (Santos, 2020). These applications have, likewise, proven beneficial for providing library staff the increased opportunity to work with and help teachers who are less acquainted with the library staff and resources through setting up meetings to speak via teleconferencing software, such as Microsoft Teams and Zoom (Santos, 2020). These examples demonstrate how web and mobile applications can be used not only for bolstering previously established relationships, but also helping to foster new ones originally formed via the internet (Santos, 2020).

## Fighting Covid-19 Misinformation via Web Applications

While several web and mobile applications have provided rapid real-time information sharing between individuals, not all of the information shared via the web is particularly truthful (Naeem & Bhatti, 2020). The spreading of misinformation via the web has been demonstrated to have potentially harmful consequences to society, particularly within the public health domain (Naeem & Bhatti, 2020). During the COVID-19 pandemic, many people across the globe have been exposed to misinformation regarding COVID-19 that has constituted the status of an "infodemic" by the World Health Organization (WHO) (Naeem & Bhatti, 2020; WHO, 2020). Naeem and Bhatti (2020, p. 233) define an infodemic as an excessive amount of information concerning a problem where the public finds it difficult to distinguish between evidence-based information and inaccurate misinformation.

Since the onset of the COVID-19 pandemic, many social networking sites such as Twitter, Facebook, WhatsApp, Instagram and WeChat have become some of the major sources of information sharing and retrieval due to their ubiquitous digital presence in people lives via their mobile and other computer devices (Naeem & Bhatti, 2020). While these social networking sites have allowed members of the general public to become more informed about the pandemic, much of the information shared on these platforms has not been authored by credible and reliable sources, leading members of the public to develop false perceptions and beliefs regarding the virus (Bangani, 2021; Naeem & Bhatti, 2020). For example, research by the Bruno Kessler Foundation in Italy showed that in March 2020 there was an average of 46,000 new posts each day on Twitter that were linked to misleading information about the pandemic (Hollowood & Mostrous, 2020; Lupi, 2020). Additionally, a recent Ofcom survey (2020) in the United Kingdom (UK) indicated that 46% of UK adults reported that they had been exposed to misleading information online about the pandemic. Furthermore, 40% of adults in the UK also reported that they are experiencing difficulty ascertaining what is true or false about the virus (Ofcom, 2020). The current infodemic surrounding the COVID-19 pandemic has highlighted the need for credible and reliable information sources regarding the virus to be more readily available in the public domain. The role of academic librarians now includes countering misinformation and providing credible information to both healthcare workers and the public (Yuvaraj, 2020).

Many libraries have been able to employ their respective library websites as well as proprietary web applications, such as LibGuides, to combat the spread of misinformation. Specifically, in South Africa, the false information propagated through social networking sites was further exacerbated by the high levels of functional illiteracy (Bangani, 2021). Previous LIS research on misinformation demonstrates how the promotion of Information Literacy (IL) skills can help combat misinformation (Bangani, 2021). In a recent study, Bangani (2021) observed the websites of all 26 South African public university libraries between July and August 2020 (Bangani, 2021) to further understand the extent to which academic libraries were adopting tactics to combat COVID-19 misinformation. The author's study demonstrated that many academic libraries in South Africa have relied on several strategies to battle COVID-19 misinformation including the provision of credible information, Information and Media Literacy instruction, and public awareness campaigns about "fake news" (Bangani, 2021). For example, the university websites of Limpopo Library, Mpumalanga Library, Nelson Mandela Library, Pretoria Library, Rhodes Library, Witwatersrand Library, and Zululand Library all included links to free, credible COVID-19 resources in their homepages. Some of the content included in these links provided access to zero rated databases, free electronic books, and library e-resources concerning COVID-19 (Bangani, 2021). Additionally, many public academic library websites in South Africa provided useful links to university LibGuides. LibGuides are useful web tools that are used to curate knowledge and share information (Springshare). Many of the LibGuides posted to South African libraries' websites provide links to external websites that contain anti-fake news information, evaluation of websites using various tools, COVID-19 anti-fake news websites, and the International Federation of Library Associations and Institutions (IFLA) "how to spot fake news" tool (IFLA, 2017). The results of this study reflect how public city, provincial and academic libraries in South Africa were able to provide high-quality information to counter the negative effects of COVID-19 misinformation through dissemination of credible and reliable information via the libraries' website and LibGuides (Bangani, 2021).

Libraries have always been seats that hold change agent status. However, with the pandemic, they were presented with more opportunities to become change agents with respect to how individuals interact with online information (Martzoukou, 2020). Through utilizing the libraries' website and credible information sharing applications such as LibGuides, many libraries in South Africa were able to combat against the spread of harmful misinformation regarding COVID-19.

## Interactive Media Game Design

As a result of the COVID-19 Pandemic, some libraries have found ways to incorporate interactive media forms, such as game design, into their content delivery strategy (Kretz et al, 2021). In January 2020, Stony Brook University Libraries began planning a more engaging in-person program to welcome new students to the libraries. Envisioned as a series of activities within the library building, the event was scheduled to take place during the first week of the Autumn 2020 semester (Kretz et al, 2021). However, the COVID-19 outbreak put the plan for an in-person event on hold. When it became clear over the summer term that the pandemic would require the Autumn 2020 semester at Stony Brook University to be conducted through nearly all-virtual instruction, library staff made the decisive move to shift to an innovative virtual event (Kretz et al, 2021). What had been conceived as a series of games and challenges at different service points spread throughout the physical building was thus radically redesigned (Kretz et al, 2021). In an attempt to retain the core concept of a fun and engaging introduction to the Stony Brook University Libraries, the libraries staff shifted to the development of a totally online experience (Kretz et al, 2021). The Stonybrook Library created a Research Guide for a Study Room Time Machine (SRTM) that "created a virtual library escape game during COVID" (C. Kretz et al., 2021). This experience consisted of a series of virtual escape rooms built around a cohesive fictional narrative called the Study Room Time Machine (SRTM) (Kretz et al, 2021). Taking advantage of the digital canvas provided by the Stony Brook University Libraries' virtual spaces, librarians and university staff incorporated multiple facets of the Stony Brook University Libraries' resources and history into the game design (Kretz et al, 2021). This game proved to build a positive association with the library for new students, despite not being physically present in the library walls (Kretz et al, 2021). The organizers of this event measured the game's success via the feedback form provided upon the game's completion (Kretz et al, 2021). Of the respondents who completed the game, their responses were "overwhelmingly positive" (Kretz et al, 2021, p. 16). Additional anecdotal feedback from Stony Brook University students included: "well designed and thought out"; "it was incredibly fun and I'd love to do more of these"' and "please make more" (Kretz et al, 2021, p. 16).

## Challenges Facing Widespread ICT Adoption around the World

While many libraries and library patrons were able to successfully connect through ICT means throughout the COVID-19 pandemic, gaps in knowledge and research still remain with regards to certain library populations. The financial burden on certain communities presents unique challenges to ensure that all community members would have equal access to library services. In three separate examples of international research, the following section demonstrates how although the COVID-19 pandemic presented the opportunity for library and library patrons to establish and maintain digital relationships, certain populations are left behind due to structural inequalities that still exist in the larger societal realm. When ICTs have been adopted by libraries in these populations, they have been found to be beneficial for supplanting learning and scholarship; however, certain challenges still remain in ensuring that all persons have access to a credible knowledge base, as demonstrated in Figure 1.

*Figure 1. Challenges facing libraries' greater ICT adoption around the world*

## Denmark

In a recent journal article published in *Research in Social Stratification & Mobility* titled Inequality in Learning Opportunities During Covid-19: Evidence from Library Takeout, Jaeger & Blaabaek (2020) investigate inequality in a single dimension of learning opportunities during COVID-19: families' daily take out or borrowing of digital children's books from libraries in Denmark (Jaeger & Blaabaek, 2020). Through their data analysis, the authors found strong evidence that inequality increased during the COVID-19 Pandemic (Jaeger & Blaabaek, 2020). From their data, the researchers observed that High Socioeconomic status (SES) families took out more digital and physical children's books before the COVID-19 lockdown than low-SES families (Jaeger & Blaabaek, 2020). Similarly, during the pandemic, the baseline SES gradient increased: high-SES families consistently took out more digital children's books than low-SES families in each of the three phases of the Covid-19 lockdown (Jaeger & Blaabaek, 2020). The researchers also found that the SES gradient was different in immigrant compared to the numbers in native families. With a stronger gradient in families that had recent experience in taking out digital materials from the library, as well as in families with children in the early stages of elementary school. Whereas the educational gradient in borrowing of digital children's books was much smaller in immigrant families than in native families, both in the first and second lockdown phase of the pandemic (Jaeger & Blaabaek, 2020). The authors maintained that their study results are in line with other research that documents inequality in home schooling activities during the COVID-19 pandemic (Sevilla et al., 2020; Bol, 2020; Jaeger & Blaabaek, 2020).

## Nigeria

The situation becomes more pressing in Nigeria. In a paper recently published in the *Journal of Academic Librarianship*, Ifijeh and Yusuf (2020) outline how Nigerian academic libraries currently experience unique challenges transitioning to a full digital landscape, primarily dependent upon a more advanced ICT infrastructure system. In most Nigerian Universities, subject/course departments and lecturers are seen as the major stakeholders in the University community, while the roles of libraries and librarians as well as other non-teaching units and staff are often viewed as 'supportive'" (Ifijeh & Yusuf, 2020, p. 5).This presents an issue to Nigerian academic libraries as the Nigerian University management often provides more resources to the aforementioned major stakeholders, while libraries and other non-teaching units have become less prioritized (Ifijeh & Yusuf, 2020). The authors argue that libraries are consistently relegated to the background with respect to funding and that they only become relevant during accreditations by regulatory bodies (Ifijeh & Yusuf, 2020). Despite their importance to regulatory bodies, academic libraries in Nigeria continue to remain underfunded (Ifijeh & Yusuf, 2020). Furthermore, Daniel (2013) demonstrates how lack of funds is the major reason for the underdevelopment of libraries in Nigeria. Currently, University libraries in Nigeria receive their funding mainly from the 10% recurrent budgetary allocation of their parent institutions as stipulated by the government which Ifijeh & Yusuf (2020) argue are barely enough to cover recurrent expenditure (p. 5), making investments in ICT library infrastructure increasingly more difficult.

This lack of investment funds does not proportionately reflect the level of awareness of the benefits of ICTs by many academic librarians in Nigeria, as they are described to be very receptive to the concept of integrating ICTs into their traditional services (Ifijeh & Yusuf, 2020). In fact, many professionals in Nigeria believe that library services can better support teaching and learning by leveraging the benefits of ICT skills (Ifijeh & Yusuf, 2020). This awareness has prompted libraries to propose several ICT implementation projects; however, technological infrastructure challenges seem to be the major barriers to execution of such projects (Ifijeh & Yusuf, 2020). As several scholars have observed, technological infrastructure projects that could facilitate greater ICT adoption in Nigeria and other developing countries have not yet received the required financial support from relevant authorities (Davies et al. 2019; Ifijeh & Yusuf, 2020). Additionally, Ifijeh & Yusuf (2020) argue that Nigerian technological infrastructure suffers from poor management, theft, low electricity supply, poor manpower engagement, and general neglect. As a result, the inadequacy of technological infrastructure has stalled the deployment of innovative library initiatives that could have potentially led to a higher quality of service delivery in support of virtual teaching and learning (Ifijeh & Yusuf, 2020).

Libraries now operate beyond the walls of their buildings tilting more towards the virtual environment (Thanuskodi, 2015). The need for librarians in Nigeria to improve their ICT skills with the urgency it deserves has been identified by several LIS researchers in Nigeria (Ifijeh & Yusuf, 2020). No matter the level of sophistication of ICT infrastructure deployment, librarians must possess relevant ICT skills to be able to maximize their use in meeting the dynamic information needs of users and to contribute meaningfully to the emerging change in teaching methodologies (Ifijeh & Yusuf, 2020). As libraries now operate in an environment of constant change, if governing bodies and library staff do not adapt to these changes, Ifijeh & Yusuf (2020) argue that the future relevance of Nigerian libraries may fall into a state of jeopardy.

## PAKISTAN

The context of libraries in Pakistan is also concerning, where during the COVID-19 pandemic, all educational institutions were closed and shifted to online modes of learning (Shoaib et al., 2021). Similar to in Nigeria, the university libraries in Pakistan face a number of social, financial, and technical challenges (Rafiq et al., 2021). The lack of wide-scale technological applications, off-campus access to subscribed resources, large scale digital initiatives, institutional repositories, and collaborative projects have been sources of concern in university libraries in Pakistan (Rafiq et al., 2021). Additionally, low internet penetration and mobile broadband access in small towns have greatly affected the ability of students to efficiently access online classes and information resources (Baloch & Musyani, 2020; Nakhoda, 2020; Rafiq et al., 2021).

However, as the COVID-19 pandemic physically closed academic libraries in Pakistan for patrons, Rafiq, Batool, Ali, and Ullah (2021), demonstrate that despite the halting of in-person operations, academic libraries in Pakistan were still "very much engaged" with users (Rafiq et al., 2021, p. 9). While few university libraries were offering print lending material, mainly to the faculty living on the university campus, certain libraries revamped their web pages, reassigned resources, and adopted online offerings (Rafiq et al., 2021) to adapt to the changing demands. Mostly, libraries were able to communicate with patrons virtually through phone, WhatsApp, and email to conduct virtual operations with patrons (Rafiq et al., 2021).

Similarly, in a cross-sectional study conducted by Ahmad, Ahmad, Shoaib, and Shaukat (2021), the researchers collected a sample of 2,378 library patrons at public universities in Pakistan. A structured questionnaire was administered via Google Forms to collect information from the students, teachers, and library users of public universities in Pakistan (Ahmad et al., 2021). The survey was constructed to observe several key variables relevant to the libraries' functioning, including: socio-demographic characteristics, variables resulting from the COVID-19 outbreak, the fear of infection, the element of social distancing, the accessibility of manuscripts, the accessibility of periodicals, the accessibility of books, and online library resources (Ahmad et al., 2021). The survey revealed that many public libraries at higher education institutions capitalized on the opportunity to further incorporate ICTs into their operational procedure by providing online resources to facilitate educational instruction throughout the COVID-19 pandemic (Ahmad et al., 2021; Ali & Gatiti, 2020). Through their data analysis, the researchers found that by connecting with patrons virtually, public libraries in Pakistan improved in quality at all educational institutions more broadly (Ahmad et al., 2021). Although, internet access problems were initially reported as a major barrier facing library staff and patrons, as library staff continued to develop innovative solutions to these challenges, the availability of online library resources improved over time (Ahmad et al. 2021).

## SOLUTIONS AND RECOMMENDATIONS

Several ICTs such as Social Networking Sites, Web and Mobile Applications, and Interactive Media Game Design technologies have demonstrated their potential viability as solutions for meeting the evolving demands of library patrons. The author recommends for the greater adoption of ICTs by libraries around the world through further adaptive ICT skills and infrastructure development to continue to deliver library services in innovative ways and connect with library patrons beyond library walls. Additionally, it is recommended that future research be directed at understanding the wider impact of ICTs in libraries on student's perceived Sense of Belongingness at academic institutions. Furthermore, future research is warranted with respect to the extent to which library ICTs are being equally accessed by persons from varying SES in countries with high degrees of income inequality. Therefore, funding for the development of ICT skills and infrastructure development should be prioritized by government and universities in both low SES communities and developing nations. Finally, additional research on library resource access should be conducted in more developing nations to ensure global equality of credible and reliable information access and promote global competitiveness in terms of the intellectual, societal, and academic achievements of developing nations.

## CONCLUSION

Social Networking Sites, Web and Mobile Applications, and Interactive Media Game Design are some of the few ways in which libraries have captured the opportunity to deliver reliable and credible content in novel ways to patrons virtually. These digital tools can be used to help libraries to create awareness and promote new information material to form a more information literate society (Bangani, 2021; Ifijeh & Yusuf, 2020; Kretz et al, 2021; Martzoukou, 2021; Santos, 2020; Shastri & Chudasma, 2021). Though the physical presence of the end-user, the library patron, was, and in many places still is, limited due to COVID-19 social distancing mandates. However, as show in this chapter, through dedicated librarian's practices of integrating ICTs into libraries' operations, libraries can maintain persistent relations with library patrons. Through the digital integrations, libraries continued to remain more than relevant, and rather continued to maintain its status as a central hub of information and support to its communities.

Libraries continued to provide services that their users embraced, particularly when they were unable to physically access materials and services, librarians have been very creative by offering regular virtual interaction through ICT tools, digitized the curation of resources prior to and during the pandemic lock downs, and provided digital instruction opportunities for their patrons (Becker, 2020, Guo et al. 2018). Additionally, while the COVID-19 Pandemic has presented governments and civic structures with many opportunities to invest in libraries' ICTs, librarians have and will continue to find novel ways to connect with their patrons. While these opportunities have not been able to be fully extrapolated by various populations, especially by those residing in lower SES communities and developing nations, this chapter serves as part of an information sharing effort in this regard. Furthermore, when ICTs have been implemented by libraries in these populations, they have often demonstrated their utility in connecting library staff and patrons as well as combating misinformation. However, several obstacles still remain in ensuring equitable access to credible information resources globally. The investment of funds by governing bodies to further support wide-scale library ICT infrastructure projects has been identified as the most critical potential solution to the challenge of providing equitable access to library resources in under resourced communities around the world.

## ACKNOWLEDGMENT

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

## REFERENCES

Abraham, P., & Mohanan, N. (2021). Efficacy of social networking sites in library services at the time of social distancing due to COVID- 19 lockdown: A study among the library professionals and students in India. *Library Philosophy and Practice*, 1-12. http://ezproxy.cul.columbia.edu/login?url=https://www.proquest.com/scholarly-journals/efficacy-social-networking-sites-library-services/docview/2552127263/se-2

Ahmad, J., Ahmad, A., Shoaib, M., & Shaukat, B. (2021). Public Library Online Information Resources to Library Patrons during COVID-19 Pandemic: A Case of Higher Education Institutions. *Library Philosophy and Practice*, 1-14. http://ezproxy.cul.columbia.edu/login?url=https://www.proquest.com/scholarly-journals/public-library-online-information-resources/docview/2582231515/se-2

Ali, M. Y., & Gatiti, P. (2020). The Covid-19 (coronavirus) pandemic: Reflections on the roles of Librarians and Information Professionals. *Health Information and Libraries Journal*, *37*(2), 158–162. doi:10.1111/hir.12307 PMID:32251543

Annune, A. E. P., Agoh, J. A., Annune, D. F., & Ihongo, D. A. (2020). Sensitization and Awareness Creation as Tools for Curbing Perceived Effects of COVID- 19 Pandemic on University Library Users in Nigeria. *Library Philosophy and Practice*, 1-18. http://ezproxy.cul.columbia.edu/login?url=https://www.proquest.com/scholarly-journals/sensitization-awareness-creation-as-tools-curbing/docview/2447004970/se-2

Baker, D., & Ellis, L. (2021). Libraries, digital information, and covid: Practical applications and approaches to challenge and change. *Libraries, Digital Information, and COVID*, 1–12. doi:10.1016/B978-0-323-88493-8.00010-0

Baloch, S. M., & Musyani, Z. (2020, July 8). Pakistan's great digital divide. Retrieved from. *The Diplomat*. https://thediplomat.com/2020/07/pakistans-great-digita l-divide/

Bangani, S. (2021). The fake news wave: Academic libraries' battle against misinformation during COVID-19. *Journal of Academic Librarianship*, *47*(5), 102390. doi:10.1016/j.acalib.2021.102390

Becker, D. A. (2020). Creating online teaching resources and suggesting mobile apps in the time of COVID 19. *Journal of Electronic Resources in Medical Libraries*, *17*(3-4), 105–112. doi:10.1080/15424065.2020.1829233

Bol, T. (2020). Inequality in homeschooling during the Corona Crisis in the Netherlands. First results from the Liss Panel. doi:10.31235/osf.io/hf32qosf.io/hf32q

boyd, d. m., &; Ellison, N. B. (2007). Social network sites: Definition, history, and scholarship. *Journal of Computer-Mediated Communication*, *13*(1), 210–230. doi:10.1111/j.1083-6101.2007.00393.x

Buarki, H., Hepworth, M., & Murray, I. (2011). ICT skills and employability needs at the LIS programme kuwait: A literature review. *New Library World*, *112*(11), 499–512. https://dx.doi.org/10.1108/03074801111190392

Bundy, A. (2004). *Beyond Information: The academic library as educational change agent. Paper presented at the 7th International Bielefeld Conference Germany.* Retrieved January 17, 2022, from http://conference.ub.uni-bielefeld.de/2004/proceedings/bundy_rev.pdf

Daniel, J. (2013). *Lack of funds hampers library development in Nigeria Premium Times*. Nigeria Premium Times.

Davies, I. E. E., Nwankwo, C. O., Olofinnade, O. M., & Michaels, T. A. (2019). Insight review on impact of infrastructural development in driving the SDGs in developing nations: A case study of Nigeria. In 1st International conference on sustainable infrastructural development. IOP Publishing. https://doi.org/10.1088/1757-899X/640/1/012112.

Deol, N. K., & Brar, K. S. (2021). The pandemic of COVID 19 and Role of Academic Libraries. *Library Philosophy and Practice*, 1-10. http://ezproxy.cul.columbia.edu/login?url=https://www.proquest.com/scholarly-journals/pandemic-covid-19-role-academic-libraries/docview/2561526465/se-2

Flaherty, M., & Miller, D. (2016). Rural Public Libraries as Community Change Agents: Opportunities for Health Promotion. *Journal of Education for Library and Information Science Online*, *57*(2), 143–150. https://doi.org/10.12783/issn.2328-2967/57/2/6

Guo, Y. J., Liu, Y. Q., & Bielefield, A. (2018). The provision of mobile services in US Urban Libraries. *Information Technology and Libraries*, *37*(2), 78–93. https://doi.org/10.6017/ital.v37i2.10170

Hollowood, E., & Mostrous, A. (2020, March 23). *Fake news in the time of C-19.* Tortoise. Retrieved March 15, 2022, from https://www.tortoisemedia.com/2020/03/23/the-infodemic-fake-news-coronavirus/

Ifijeh, G., & Yusuf, F. (2020). Covid – 19 pandemic and the Future of Nigeria's University System: The quest for libraries' relevance. *Journal of Academic Librarianship*, *46*(6), 102226. https://doi.org/10.1016/j.acalib.2020.102226

IFLA (International Federation of Library Associations and Institutions). (2017). *How To Spot Fake News*. Retrieved March 15, 2022, from https://www.ifla.org/publications/node/11174

Jæger, M. M., & Blaabæk, E. H. (2020). Inequality in learning opportunities during covid-19: Evidence from library takeout. *Research in Social Stratification and Mobility*, *68*, 100524. https://doi.org/10.1016/j.rssm.2020.100524

Kretz, C., Payne, C., & Reijerkerk, D. (2021). Study room time machine: Creating a Virtual Library escape game during COVID. *College & Undergraduate Libraries*, 1–23. doi:10.1080/10691316.2021.1975341

Lenstra, N. (2017). Let's move! fitness programming in public libraries. *Public Library Quarterly*, *37*(1), 61–80. https://doi.org/10.1080/01616846.2017.1316150

Lenstra, N. (2018). The experiences of Public Library staff developing programs with physical activities: An exploratory study in North Carolina. *The Library Quarterly*, *88*(2), 142–159. https://doi.org/10.1086/696580

Lenstra, N., & D'Arpa, C. (2019). Food justice in the Public Library: Information, resources, and meals. *The International Journal of Information, Diversity, & Inclusion, 3*(4). doi:10.33137/ijidi.v3i4.33010

Lupi, V. (2020, March 10). *Covid-19 and fake news in the social media*. FBK. Retrieved March 15, 2022, from https://www.fbk.eu/en/press-releases/covid-19-and-fake-news-in-the-social-media/

Martzoukou, K. (2020). Academic libraries in covid-19: A renewed mission for Digital Literacy. *Library Management*, *42*(4/5), 266–276. https://doi.org/10.1108/lm-09-2020-0131

Mehrotra, C., Hollister, C. D., & McGahey, L. (2001). *Distance learning: Principles for effective design, delivery, and evaluation*. Sage Publications.

Mentor, D. (2018). Micro to macro social connectedness through mobile phone engagement. In *Encyclopedia of Information Science and Technology* (4th ed., pp. 6184–6194). IGI Global.

Mentor, D. (2019). Electronic and Mobile Learning for Workforce Development. In *Advancing Mobile Learning in Contemporary Educational Spaces* (pp. 181–208). IGI Global.

Naeem, S. B., & Bhatti, R. (2020). The Covid-19 'infodemic': A new front for information professionals. *Health Information and Libraries Journal*, *37*(3), 233–239. https://doi.org/10.1111/hir.12311

Nakhoda, A. (2020, June 29). Bridging Digital Divide in Pakistan. *The Express Tribune*. Retrieved January 17, 2022, from https://tribune.com.pk/story/2252437/bridging-digital-divide-in-pakistan

Ofcom. (2020, April 9). *Covid-19 news and information: Consumption and attitudes*. Results from week one of Ofcom's online survey. Retrieved March 16, 2022, from https://www.ofcom.org.uk/__data/assets/pdf_file/0031/194377/covid-19-news-consumption-weeks-one-to-three-findings.pdf

Rafiq, M., Batool, S. H., Ali, A. F., & Ullah, M. (2021). University libraries response to COVID-19 pandemic: A developing country perspective. *Journal of Academic Librarianship*, *47*(1), 102280. https://doi.org/10.1016/j.acalib.2020.102280

Rubenstein, E. L., Burke, S. K., D'Arpa, C., & Lenstra, N. (2021). Health equity and small and rural public libraries during COVID -19. *Proceedings of the Association for Information Science and Technology*, *58*(1), 827–829. https://doi.org/10.1002/pra2.577

Santos, M. C. (2020). Libraries respond to COVID-19. *Texas Library Journal, 96*(2), 64-70, 72-73. http://ezproxy.cul.columbia.edu/login?url=https://www.proquest.com/scholarly-journals/libraries-respond-covid-19/docview/2418802935/se-2?accountid=10226

Scoulas, J. M. (2021). College students' perceptions on sense of belonging and inclusion at the academic library during COVID-19. *Journal of Academic Librarianship*, *47*(6), 102460. https://doi.org/10.1016/j.acalib.2021.102460

Sevilla, A., Phimister, A., Krutikova, S., Kraftman, L., Farquharson, C., Costa Dias, M., Cattan, S., & Andrew, A. (2020). *Learning during the lockdown: Real-time data on children's experiences during home learning*. doi:10.1920/bn.ifs.2020.bn0288

Shastri, D. K., & Chudasma, P. (2021). The perception of ICT skills and challenges of usage of technologies among the library professionals of the Gujarat state during the COVID 19: A comprehensive study. *Quality & Quantity*. doi:10.1007/s11135-021-01167-x

Shoaib, M., Rasool, D., & Anwar, D. (2021). Evaluating Research Support Facilities to University Students during COVID-19. *Library Philosophy and Practice*, *4953*(1), 1–18.

Simpson, J. (2016). The heart of the university: Library link location on doctoral granting institutions webpages and correlation with research output. *Journal of Academic Librarianship*, *42*(5), 503–508. https://doi.org/10.1016/j.acalib.2016.06.011

Springshare. (n.d.). *Libguides*. Retrieved March 15, 2022, from https://www.springshare.com/libguides/

Thanuskodi, S. (2015). ICT skills among library professionals. *Advances in Library and Information Science*, 1–20. doi:10.4018/978-1-4666-8178-1.ch001

Wheeler, A., & Kyprianou-Chavda, V. (2021). "We are all distance learners now": How distance learning informed a library team's response to the COVID-19 pandemic. *Journal of Library & Information Services in Distance Learning*, *15*(2), 84–98. https://doi.org/10.1080/1533290x.2021.1938788

Whiteman, E. D., Dupuis, R., Morgan, A. U., D'Alonzo, B., Epstein, C., Klusaritz, H., & Cannuscio, C. C. (2018). Public libraries as partners for Health. *Preventing Chronic Disease, 15*. doi:10.5888/pcd15.170392

World Health Organization. (2020). *Munich Security Conference*. Director-General, Tedros Adhanom Ghebreyesus. Available at: https://www.who.int/dg/speeches/detail/munich-security-conference

Yuvaraj, M. (2020). Global responses of health science librarians to the COVID-19 (Corona virus) pandemic: A desktop analysis. *Health Information and Libraries Journal*, *37*(4), 337–342. https://doi.org/10.1111/hir.12321

## ADDITIONAL READING

Ahlfeld, K. (2021). Covid Diary Fall 2020: A day in the life of a hybrid school librarian. *Journal of Library Administration*, *61*(2), 244–251. doi:10.1080/01930826.2020.1853474

Akello, J. A., Lutwama-Rukundo, E., & Musiimenta, P. (2017). Functional adult literacy. *Adult Education Quarterly*, *67*(2), 79–96. doi:10.1177/0741713616685143

Amanda Markovic, A. I. A., & Zachary Zettler, A. I. A. (2020). Designing resilient libraries for a post-covid world. *Building Design & Construction*. http://ezproxy.cul.columbia.edu/login?url=https://www.proquest.com/trade-journals/designing-resilient-libraries-post-covid-world/docview/2401867155/se-2?accountid=10226

Condic, K. (2021). Examination of Academic Library websites regarding covid-19 responsiveness. *Journal of Web Librarianship*, *15*(1), 32–45. doi:10.1080/19322909.2021.1906823

Kathuria, S. (2021). Library support in times of crisis: An analysis of chat transcripts during COVID. *Internet Reference Services Quarterly*, *25*(3), 107–119. doi:10.1080/10875301.2021.1960669

Nichols, E. (2021). School age programs and services committee: Act boldly! working to combat covid slide. *Children & Libraries*. Advance online publication. doi:10.5860/cal.19.4.39

Rashid, S., & Yadav, S. S. (2020). Impact of covid-19 pandemic on Higher Education and research. *Indian Journal of Human Development*, *14*(2), 340–343. doi:10.1177/0973703020946700

## KEY TERMS AND DEFINITIONS

**Distance Learning:** The function of delivering educational content directly to students' homes (Mehotra et al, 2001, p.3).

**Functional Literacy:** The ability of an individual is able to improve on his or her quality of life, make informed decisions, and continue learning in all those activities for which literacy skills are required (Akello et al. 2017, p. 80).

**Infodemic:** An excessive amount of information concerning a problem such that the public finds it difficult to distinguish between evidence-based information and inaccurate misinformation (Naeem & Bhatti, 2020, p. 233).

**Information Communication Technology Skills (ICT Skills):** The skills needed to access, evaluate, communicate information, and to produce documents electronically by the use of computers and communication technologies (Bukari et al., 2011, p .499-500).

**Social Networking Sites (SNS):** Web-based services that allow individuals to construct a public or semi-public profile within a bounded system, articulate a list of other users with whom they share a connection, and view and traverse their list of connections and those made by system others within the system (Boyd & Ellison, 2008, p. 211).

# Chapter 16
# Mobile Assessment Applications and Training for Professional Examinations:
## The Case of Project Management Certifications

**Fusun Sahin**
*American Institutes for Research, USA*

**Dominic Mentor**
*Teachers College, Columbia University, USA*

## ABSTRACT

*Mobile-assessment applications provide various conveniences to working professionals who prepare for a certification exam. The purposes of this chapter are highlighting the usefulness of m-assessment apps to learners and informing the field about the needs in this area. The chapter focuses on the m-assessment apps in terms of preparing for project management certification examinations. The authors developed nine criteria based on learning theories and literature on m-assessment. These criteria organized important features of m-apps under three categories: 1) general user experience, 2) learning experience, and 3) practice test-experience. The authors also evaluate the features of m-assessment apps found in the app spaces using the criteria. Results communicate how the examined apps perform against the criteria and emphasize different ways that these features can help learners. The chapter concludes with future directions based on the updated requirements of the project management certification exam and the need for more apps that implement theoretically supported features.*

DOI: 10.4018/978-1-6684-3996-8.ch016

## BACKGROUND AND GOAL

Receiving a professional credential is a common pursuit of professionals who want to prove and upgrade their capabilities. Some credentials are mandatory to perform professionally, such as medical certifications, whereas others are optional, such as a photography certification. In any certification process, candidates must pass at least one assessment to receive certification. Yet, many professionals find it challenging to prepare for credentialing assessments while working full time. Mobile learning (hereafter, m-learning) and mobile assessment (hereafter, m-assessment) tools (i.e., tools that enable learning and assessment on mobile devices) alleviate this challenge for working professionals. To exemplify how m-learning and m-assessment tools can provide unique convenience to candidates, the study team picked an internationally recognized project management certification program. The Project Management Professional (PMP)®[1] is a highly respected certification program in the area of project management. Receiving this certification requires passing an exam. The study team applied lenses from m-learning theories, andragogy, and m-assessment measurement perspectives to build criteria taxonomy to help elucidate interrogation of the mobile apps (hereafter, m- apps), which focus practicing for the PMP examination.

### M-assessment Apps for Practice Tests

M-assessments provide the convenience to take tests anywhere, anytime, and by anyone (Sahin & Mentor, 2019). People preparing for professional examinations are among those who feel the need to crunch study and practice as much as possible. Many commuters, for example, productively use their commute time by learning on the go (Mentor, 2016).

In addition to convenience, other benefits of m-apps include being personal; the ability to pick up where you left off via a login on multidevice access (if well designed); immediate feedback on performance; and stimulation with multimodal accommodations, which aid memorization, retention, and critical thinking. The multimodal elements also aid higher order thinking because the m-assessments are delivered through technology-enhanced question types, such as drag-and-drop, ordering, matching, and screen interactive hot-spots. The user's hypermedia interaction with these rich multimodal assessments have cognitive importance because they leverage, albeit on a small but impactful level, learning by doing principles. The interactive engagement aids learning, thinking, and comprehension. M-assessments also enhance drill-and-practice elements at a higher level because they mimic the actual operational summative tests that candidates take and help learners improve their learning through immediate feedback from practice tests. These are good examples of behaviorist, scaffolding and cognitive load learning theories to name but a few, applied in practical ways to help learners, manage their learning, keep them engaged and stimulated, and work toward their goals.

## THEORETICAL FRAMEWORK

The application of m-learning theories to the certificate and compliance training review process applied in this chapter allowed the study team to more closely look at m-assessments in various contexts. The team divided the practical use of the theoretical lenses into two categories: individual use and group use. The team demarcated the theoretical lenses into these two categories because (a) not all m-learning apps need to or cater for both uses, (b) the individual ultimately owns all learning, and (c) not all individuals want to connect with others when engaging in m-learning. Some learners desire to forge their own individual learning with an m-learning app, so the collaborative aspect could be a distraction or a source of negative competition, not the strength and support to tap into for m-learning benefit. The study team applied the learning theories as follows:

- Individual uses
    - **Cognitive Load.** Applies to both individual and group interaction in terms of how the app caters for either use
    - **Element Interactivity.** A sub-branch of cognitive load in terms of digital device input and output elements
    - **Constructivist Learning.** Building on existing knowledge and experience (Parsons & MacCallum, 2020)
    - **Behaviorist learning** through the m-learning environment (Slavkovic & Savic, 2015)
- Group uses
    - **Sociocultural theory of human learning**
    - **Collaborative learning**
    - **Communities of practice**

M-app designers should address cognitive load and element interactivity for the user upfront. The design of the user interface helps the user have a positive user experience. Cognitive load and element interactivity help the user make quick sense of how to navigate the app, where to get what for which purpose, and interact with the app environment seamlessly. In addition, but also separately, mobile responsive designs can accommodate element interactivity as the app adjusts to the user's device of access.

Mobile responsiveness refers to how the content is accommodating to the user when accessing the app on a tablet, a desktop computer, a laptop computer, or a multitude of mobile phone screens. Moreover, users typically live multiscreen lives; therefore, accommodating mobile and multiscreen responsiveness is a staple of mobile and web app designs. Adult learners might learn while commuting and/or might switch between a bigger desktop, a laptop, or a tablet screen, thus cognitive load considerations during the design stage are aided by built-in device or mobile responsiveness.

Device responsiveness adjusts to the user's device for both output to the user and potential input from a user for interactive content, such as formative practice quizzes or summative quiz assessments. Users may switch between a touch screen keyboard, a stylus, or a physically connected keyboard as well as use a variety of different screen sizes. A preplanned, well-designed responsive user interface can prevent unnecessary or excessive scrolling, automatically managing text that might appear too large on a small screen, or input fields that might be too big or too small for a user to properly interact with when using the app on multiple devices. Furthermore, the dynamic lives of adults also require user preferences to switch back and forth depending on their contexts and their needs—the narrow or more expansive ways that m-learning can be defined in the multi-context, multidevice ownership of many people. M-learning concepts have been highlighted in a multitude of literature reviews (Kumar & Mohite, 2018; Naismith, 2004; Sönmez, Göçmez, Uygun & Ataizi, 2018; Nikou & Economides, 2018).

The pioneering Naismith mobile learning literature review (2004) placed laptops in an m-learning quadrant, including examples of why that was and still is the case. That opinion may conflict with some academics using a very strict lens, claiming element interactivity on the mobile device and screen real estate input and output. However, Naismith's designation of placing laptops in the m-learning category can still be true today because of not only their portability but also element interactivity.

Furthermore, it is important to discuss element interactivity from both a cognitive load and a physical form factor perspective with a practical example. In "mClass Planet of the Apps" (Mentor, 2018), the author discussed the need to both differentiate and include laptops from m-learning depending on the context. This need occurred within a U.S.-based national talent development organization that ran a 6-month intensive training regimen with daily and weekly assessment requirements. The 12-year-old organization was still operating with paper-based training. The concepts of e-learning and blended learning were introduced as part of a digital transformation process of educational engagement. Within that context, the national academic director was driving a series of connected digital educational initiatives to transform the national training organization. The organization was preparing young adult talent for internship positions with major U.S.-based national and multinational corporations from various industries, ranging from financial, technology, civic, and state government to a host of other industries. The national academic director had to include m-learning into the digital transformation processes because many young adult trainees, who came from impoverished backgrounds in major U.S. cities, did not own computers or have internet access in their homes. These trainees highly relied on mobile phones to engage with the training material, which they could now do after the introduction of blended learning, m-learning, and e-learning. Some trainees also invested in cheaper laptops and digital notebooks, but they still relied on the mobile devices for internet accessibility. In this context, hosting the digital notebooks and cheaper, smaller laptops in the m-learning and e-learning categories were important. Researchers often saw students switch between their own mobile devices, smaller notebooks and laptops, and the company's desktop computers at the training facilities, based on the availability of the desktops, as well as the required training tasks they needed to engage with and complete.

The input and output real estate of a laptop versus a mobile phone also came into play. It became apparent that form factors and element interactivity influenced those trainees' decisions on how they engaged with, consumed, and interacted with the training material and assessments. The study team also observed how form factors and element interactivity influenced the trainees' choices of what to do on a laptop or a mobile device when they could choose from either device. The trainees also made demands of one another to switch between devices depending on what task they needed to do as related to the type of content, the length and duration of readings, assessments, and technical bandwidth. These factors all spoke to the physical form factors of the devices that influenced the trainees' decisions to switch between devices, as well as the cognitive element interactivity considerations that influenced the demands and preferences for interacting with content or assessments based on the affordances of different input and outputs per device.

What some people call the form factors of technology about the input and output of devices, element interactivity better captures the user cognitively interacting with the element (device). From an element interactivity perspective, input and output considerations tie in with physiological conditions, ranging from eyestrain on small screen sizes to thumb tendonitis on small screens or keyboards, which also influence assessment participation and the results. Why is this important to consider from an m-learning, cognition, and handheld device perspective? It will help you, the progenitor in many contexts (i.e., the facilitator of m-learning) consider where and how the receiver or the dynamic active learner agent will interact with the learning and assessment pieces from an element interactivity perspective.

Other practical examples of the theory of element interactivity apply to museums. Many teachers and trainers take their young and adult learners to museums for training, including assessments as part of the learning objectives. The museum app examples also add to element interactivity, with the following examples resonating with embodied cognition. The Asia Society in New York City hosted an exhibit on Arabic calligraphy in which mobile phones were used to great effect (Everson, 2011). Visitors could access the audio accompaniment via their own mobile phones instead of the complex, rote, heavy, and archaic museum audio tour equipment. By allowing visitors to use their own mobile device, they were immediately catered for with a familiar element of interactivity. Offering personal element interactivity with which they are familiar enhanced the museum visit experience and any m-assessment required in this context. Othman et al. (2015) also spoke of the need to reexamine museum visitors' experiences that showed art exhibits on their smartphone and reported these as overwhelmingly positive experiences.

As another example, the International Center of Photography in New York City used a tablet device to enhance the linear, mapped out exhibit along a timeline, bringing an interactive experience to the historical struggle of apartheid in South Africa, offering visitors opportunities to interact with photographs and videos of anti-apartheid protests and peaceful political negotiation (Cheers, 2013. The multimodal opportunities to interact with the exhibits via tablet devices allowed visitors to zoom in on photographs and posed questions that allowed them to become users and make connections to contemporary civic protests and struggles. The ability to transfer knowledge was further aided by the interactive engagement offered via the tablet devices, which allowed these museum visitors to construct new knowledge and add to their existing knowledge and thinking processes.

For more personalized and individualized training, such as in courses required for professional development, incorporating the concept of constructivist learning into the app's design can help tailor content for the learner through prior knowledge assessment checks as well as formative and summative assessments. Depending on how well the back-end data algorithms are built for an app, prior knowledge checks, as well as formative and summative assessments, can help position a learner at an appropriate level to aid their learning gaps or needs. Based on the quality of the back-end data algorithms, and how they interact with the learner's input regarding prior knowledge and formative or summative practice assessments, the learner could be offered authentic learning paths to pursue based on needs identified from those assessments. Ament and Edwards (2018) said that tapping into constructivism in this way with mobile responsive learning apps works toward personalized learning journeys. Amidst personalized m-learning, offering behaviorist positive reinforcement would not only help reinforce the learning but also aid learning motivation.

Behaviorist theory is very much prevalent in quiz-type games, as well as in mobile-assisted language learning (MALL) and social-responsive mobile engagement contexts. Within the practical use of behaviorist theory in computer-assisted language learning (CALL) and MALL, a hybridized practical application of theories within m-learning apps can offer a wide impact on a learner's agency, inclusion, and livelihood. For example, CALL and MALL—with or without a sophisticated, personalized assessment—can offer access, status, buy-in, and inclusion in many forms for the m-learning user. Access to work and promotion opportunities are examples of this case.

From the behaviorist perspective, it would add value to the positive reinforcement within CALL and MALL multimedia educational initiatives and assessments. Applying behaviorism principles in CALL and MALL, as well as other learning applications, have become a regular part of educational software apps, such that developers do not necessarily see the value of a user turning on, returning, or not switching off from an educational computer or a mobile software app. You also see it in badges and the gamification aspects of today's computer and mobile software apps. However, does all learning require behavioral theory positive reinforcement for basic needs or material gain? What other possibilities offer valuable intangible rewards, as well as pre- and post-assessment and monitoring of learning motivation, or confidence in a particular learning context?

John Dewey has been interpreted as saying that users need not only an industrialized approach but also a personal learning environment and approach applied in many educational contexts. The personalized learning journey and environment is still valid and applicable in the modern era of m-learning app contexts. With the personalized learning journey served by behaviorist principles to maintain engagement and offer positive feedback, even for incorrect answers, there is still room to apply social and collaborative learning principles to computer and m-learning apps to further advance and promote learning engagement. The room for collaborative and social learning can be crucial. If the m-app is well designed, it could develop into a supportive community of practice.

The sociocultural theory of human learning, as posited by Vygotsky (Prahani, et al., 2020), still applies in the modern age of m-learning. The design of the m-learning app can lend itself to that in a multitude of ways. Passively, a learner's score could be posted to a leader scoreboard to see where the learner fits or for incentivized learning for those who thrive on a competitive element. Social learning also can develop into synchronous or asynchronous collaborative learning with others in an ad hoc or as needed and informal manner. A more formal community of practice could be developed depending on the access to other users that one might have through the multiscreen m-learning app. The idea of collaborative and social learning as well as communities of practice, even in virtual communities facilitated through computers and m-apps, can offer learners the feeling that they are not studying alone (Ghamrawi, 2022; Pimmer et al., 2019; Yang & Fu, 2021). The idea of not being in "it" alone plays off the engendering and facilitation of practical applications of connected and co-presence theories.

The importance of connected presence and co-presence and how those feed into interplays between virtual, physical, cognitive, and emotional connected matrices should not be understated (Ament & Edwards, 2018; Angelone et al., 2020; Clauzel et al., 2020; Glavas & Schuster, 2020). Hosting and applying the concepts of connected presence and co-presence in multiscreen computer or mobile-assisted apps can be powerful tools and offer virtual aspects that can be leveraged—even in remote or mobile educational engagement contexts. Furthermore, adding and using social connectedness as part of the connected and co-presence concepts, from a personal micro or macro stance, can offer shared transformative learning experiences. Tapping into seamless interchanges between the physical and virtual realms through m-learning apps can offer fluidity and simultaneously or near-synchronously allow learners to move between virtual, physical, cognitive, and emotionally connected realms. Mobile or computer apps that support or engender social connectedness can feed the co-presence and the connected presence even further, which can aid cognition or be used cognitively in educational and other contexts. Co-presence and connected presence can be further facilitated through collaborative engagement (Mentor, 2019). Even though in-person collaborative learning can easily be monitored in-person, special care is necessary during the design phase to design the computer and m-app collaborative learning spaces as conducive spaces.

In well-designed computer and m-learning apps, the value of collaborative learning also could stretch into collaborative teaching. Based on personal learner data, algorithms could help group learners in collaborative teaching and learning groups as communities of practice based on zones of proximal development or in co-teaching partnerships or groups. By using the hybridized theoretical approach, a computer and m-learning app could group advanced users with medium- or upper-level learners. In addition to collaborative learning, a mobile app could host co-teaching models. Co-teaching, even in the virtual space, has many advantages when done well, including multiple perspectives, energy, and extra attention offered to participant learners. If collaborative learning brings out the best in students, would collaborative teaching, with cloud-based apps via mobile devices, benefit the educational process and the learner?

Although cognitive load, element interactivity, and constructivist learning are crucial for the individual and how they interact with and leverage the app, the study team also added the concept of social connectedness to the theoretical lenses. People learn better when they feel a sense of affiliation with others going through a similar experience as them (Mentor, 2011, 2017). Hence, when m-learning apps cater for social connectedness, in which learners can connect with others synchronously through a live chat or an automated bot, for example, learners feel that they are not alone and gain a sense of affiliation and a sense of belonging. Social connectedness can be engendered asynchronously through, for example, delayed chat responses, delayed messaging, or feedback with relevant resources from another user on a question posted by a learner.

Although social connectedness helps the learner feel as if they are not walking this learning journey alone, other social elements apply from a constructivist learning perspective. As learners pose questions, or communicate with one another a/synchronously, they also gauge and either place or rank themselves in a zone of proximal development and see which chat groups to latch onto for general or specific areas of the learning material. Depending on the learning analytics that a user could receive from the m-app, they also can be supplied with their own level according to pre-established benchmarks of progress, benchmarks of ranking within a global user base, or a time-framed cohort. These benchmarks then could affirm being on track or provide motivational encouragement to make appropriate learning adjustments according to the learner's goals and allow learners to establish a social constructivist framework.

Social learning theories applied through a well-designed m-learning app will aid the learner in not only being in this together with others but also placing themselves in their own zones of proximal development. Leveraging the latter, learners could see who to connect with in terms of specific aspects or areas of the required learning, latching onto other expert learners for confirmation of work or for help on identified areas posing difficulty. A learner can apply these theoretical lenses to ascertain whether a particular learning app, among a plethora of m-learning apps for a particular subject, would be worth their investment to download and use the app.

A hybrid consideration of theories is definitely a good approach from the design, testing, use, and response areas. Considering a combination of theories caters to differentiated instruction and different learning styles, which would then allow catering to the majority and minority as well as the marginalized tech user/student/learner. A hybrid theoretical approach for teaching or training in various contexts caters to contexts that differ, ranging from levels of the target audience's knowledge and skills, proclivities, subject matter expertise, and preferences of learning methods. An important point to note is that theories are not static because contexts and people are dynamic with constantly changing technology and needs, which require revisiting for every context, as well as when introducing changes into a context.

These theoretical lenses can form part of a criteria matrix for a teacher or an adult learner to determine whether an m-learning app will meet learning needs. Behaviorist theory still brings positive reinforcement reward factors and promotes app engagement and learning when included in computer- and/or mobile-mediated learning and language acquisition. Hosting a hybrid of theories, especially given different contexts, goals, objectives, target audiences, and levels, will aid mobile-mediated learning.

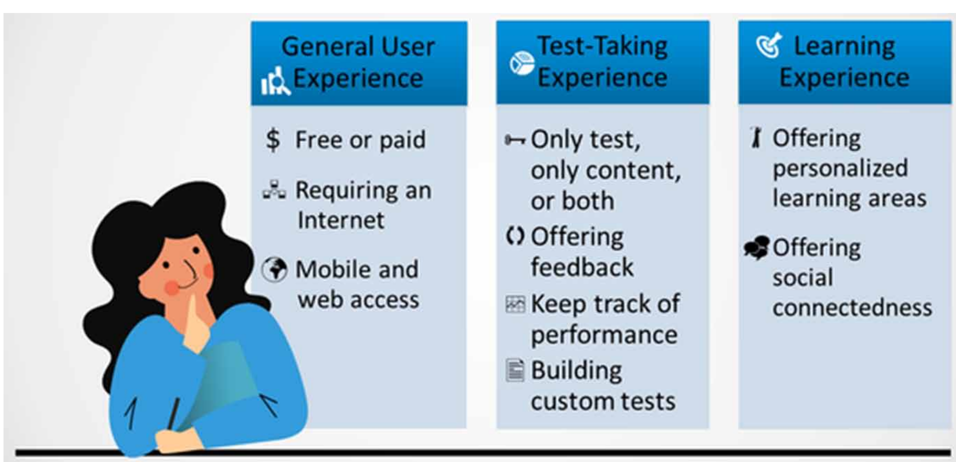
## METHODOLOGY

This study's methodology included searching for m-apps geared toward preparing for PMP exams. The criteria included searching the keywords ("project management professional exam"). The study team included only those apps geared toward test preparation and content revision, excluding those focused on managing projects. We searched the Google Play store for devices using the Android operating system and the Apple App Store for devices using the iOS operating system. We then investigated these apps based on a criteria matrix of multiple features and capabilities to aid learning and test practice. The search uncovered more than 2,000 apps, which is too many to report here, so the study team selected the top 24 apps and summarized the results in this section. We searched for apps in the website version of the app stores, namely the education category. We completed the search in December 2021.

### Criteria

The study authors used carefully curated criteria to examine the features of the apps. The criteria included a list of features considered to elevate users' learning, benefit, and experience. Specifically, we compiled a list of features under three broad categories: general user experience, test experience, and learning experience. For features related to usability, we included three general app features: (a) Is the app is free or paid? (b) Does the app require an internet connection? (c) Does the app allow both mobile and web access from another device? For features related to test delivery, we examined four features: Does the app (a) offer only test questions, only content review, or both test questions and content; (b) offer feedback to the user based on the user's performance; (c) keep track of users' scores; and (d) allow the user to build custom tests geared toward their needs? For features related to the learning experience, we examined whether the app offers personalized learning areas of improvement and allows opportunities for a social connection with teachers or peers. These criteria are in Figure 1. Each criterion is essential for the user experience. The following subsections describe in depth how each feature benefits the user.

*Figure 1. Organization of the criteria used for evaluating the m-assessment apps*



## Importance of App Features for General User Experience

*Free or Paid.* Whether an app is free or paid is a deciding factor whether a learner installs the app. Even though making an app free would increase the number of potential users, much effort goes into making an app. For the Apple App Store, hosting the app in the store also is not free. To combat these competing interests, many apps use the freemium model: The basic app is free to install, but the premium version requires a purchase.

*Requiring an Internet Connection.* An app that does not require an internet connection would enable using the app more smoothly. Not requiring an internet connection would allow users to use it on the subway, train, bus, plane, or whenever the app does not receive a reception signal, or no Wi-Fi is accessible. For some consumers with restrained budgets, apps not requiring connection to the internet also means saving on their mobile carrier's data plan. Apps that do not require an internet connection to work download the app's content upon installation, and the learner's actions do not necessarily trigger a web-based reaction. For example, feedback to an incorrect response to a question is not pulled from a web-based query; rather, it is an automated calling of content within the app. However, an app that requires an internet connection has many benefits. By signing in with their credentials, users of such apps can have their progress saved and continue using the app from where they left off. Also, some customized test building and feedback gathering can use web-based solvers in the background, which would not work when the app does not have an internet connection.

*Mobile and Web Access.* Because many people have multidevice and multiscreen lives (Mentor, 2017), switching between native and website apps can be quite helpful. Apps native to the mobile device and apps with corresponding website apps allow users to seamlessly switch from using their apps via their mobile devices to a browser on a computer or a tablet. These apps require an internet connection and a sign-in credential. The look and feel of the app (i.e., user interface and user experience) is the same across devices and browser interfaces. This feature provides more flexibility and device agnosticism to users. For example, a user can use the app while traveling, but when returning home, the user may want to benefit from a larger screen size and continue progress on their home computer.

## Importance of App Features for Test-Taking Experience

*Only Test, Only Content, or Both.* Learners can prepare for a test by studying content and solving practice questions. Apps may specialize in delivering only the content of a test. Apps that focus only on content allow users to learn or review the subject. The content of the PMP certification examination is heavily related to the sixth edition of the Project Management Body of Knowledge (*PMBOK*®[2]; Project Management Institute [PMI], 2017), which is available on the PMI website where PMI members can freely download. The *PMBOK*® is secured with password protection, and distributing these materials is illegal. At the time of writing, the authors are not aware of an m-app that was endorsed by PMI. The content in the m-apps can come in many formats, such as text, audio, and video format, or in a multimodal way in which the app supports more than one mode, including both video and a transcription of the video in the app. Such affordances allow learners to choose between modalities based on their preference or combine different sources of stimulus, which can enhance the retention of information.

In preparing for an examination, learners may need to practice test questions rather than focus on the content. They can familiarize themselves with the questions and improve on their testing strategies. Thus, choosing an app that focuses only on the actual test can cater to these learners' needs. One requirement for registering for the PMP examination is taking at least 35 hours of project management training from an accredited provider. Many users who prepare for PMP certification may receive education or training from a vendor as a course, a bootcamp, online synchronous, asynchronous, and individual or group sessions. In addition to registering for a course via an accredited provider, users can find a plethora of content from sources such as LinkedIn Learning, YouTube, and other platforms. Moreover, some of this content is from accredited content providers for the PMP examination.

*Offering Feedback.* Providing immediate, specific, and detailed feedback is an integral part of formative assessment. This kind of feedback improves learning and achievement. Certification examinations are summative assessments; the examination measures the accumulation of a learner's proficiency on the subject. Practice examinations are formative assessments, in which learners learn from their mistakes on the test with the help of feedback. Therefore, m-assessment apps providing feedback to users on their performance is crucial in helping them succeed in the certification examination.

Feedback from practice tests can take multiple forms. One form is explaining correct answers. For example, in a practice test with multiple-choice, single-select questions, the feedback might explain why the response option the user selected is wrong and why the keyed answer is the correct answer.

Another vital piece of information in feedback is explaining what the question asks and the knowledge area or examination content to which the question relates. According to the PMP examination content outline (PMI, 2021), the PMP certification examination measures content in three domains: people, processes, and business environment. Moreover, the examination draws content from both predictive (waterfall) project management approaches, and agile or a hybrid of agile and predictive approaches. Each question is in the structure of a domain, representing one of the three high-level domains; a task, which represents the underlying responsibilities of a project manager; and some enablers, which are illustrative examples of the work associated with the task. In addition, *PMBOK*® suggests 10 knowledge areas of project management such as project schedule management, project cost management, and project quality management. Feedback on the practice questions can help learners identify which domain or task the question addresses, given the enablers or the context of the question. Another form of feedback is guiding the learner to appropriate resources for review. For example, feedback can link the part of the domain or task to the presented scenario in the question.

*Keeping Track of Performance.* Offering feedback on learners' overall performance in test preparation is as important as providing feedback on individual questions. Users seeing their growth in a dashboard or a similar interface will see their progress and which areas they lack ideal performance at a general scope. These interfaces display metrics such as the number of tests attempted or in progress, the time spent on each test, and the percentage of questions answered correctly. More detailed information can include the percentage of correct responses broken down by the domains or project management approaches. As a side note, even though the percentage of correct scores in a test is a frequently used metric for test performance, PMI does not require a fixed percentage of correct responses to pass the PMP examination. PMP examination, as many large-scale high-stakes examinations, is likely based on a psychometric model, in which more difficult questions contribute more to one's test performance score than easier questions. For this reason, two test takers who had the same percentage of correct scores may not receive identical scores on the test. Therefore, overall percentage of correct scores on practice tests may not necessarily relate to performance on the actual exam. However, users receiving information on their percentage of correct scores broken down by test content can provide more actionable feedback to learners.

*Building Custom Tests.* One action that learners can take based on feedback received in a test or a series of tests is focusing on the areas in which they need improvement. Receiving feedback and using resources for improvement is part of self-regulated learning. Detailed feedback on the topics/questions that learners missed allow them to review content and solve more questions on these topics. As mentioned earlier, learners can use resources for in-app content, such as links to in-app content provided in the feedback or outside resources. However, practicing test questions on the missed content requires more elaborate infrastructure than providing a link. M-apps enabling users to build custom tests allow them to build tests on areas that need more practice. For example, learners can select a test that includes only the people domain or agile approaches if this is an area they missed the most. Another scenario involves a custom test-building feature to aid in timing. For example, a user may want to have a quick test experience during their 30-minute commute. The user can set up a test with only 20 questions, take the test, and receive feedback on their performance during this time. This feature allows taking action based on feedback and provides additional flexibility to the user.

## Importance of App Features for Learning Experience

*Offering Personalized Learning Areas of Improvement.* Effective feedback is personal, specific, and actionable. M-assessment apps need to incorporate some features to make feedback personal and specific to the learner. Offering personalized feedback improves the quality of feedback that an m-assessment app gives. Most m-assessment apps offer feedback on individual question performance by providing explanations of answers that are saved in the system. Even though this kind of feedback is specific, it is not personalized. Feedback can be more personalized by aggregating question-level information to the learner's level and making suggestions based on past performance.

In addition to making feedback personal, feedback should be specific. Most m-apps include a dashboard that conveys the user's percentage of correct scores in each test taken in the app. Contrary to prerecorded feedback on individual items, feedback based on information in a dashboard is personal but not specific enough to enable learners to act on it. An example of personal, specific, and actionable feedback would be providing the success rate of the learner in a test by people, process, and business areas of the PMP test. Such feedback would give the learner input on what to focus on next for improving their performance.

*Offering social connectedness.* Creating social connectedness in, and through an m-learning app offer many positives that include enhanced social connectedness, which offers learners a sense of connectedness with other learners. That sense of connectedness can also be represented by or gained from a scoring leaderboard, or synchronous and asynchronous communication offered with the learning app. The connectedness can be cultivated and maintained through communication with other learners and/or with an automated bot giving a user feedback. While there is the risk of the social connection elements of social connectedness being distracting, a lack of social presence can also adversely affect some learners who crave social connections while using an app. Furthermore, given the mobility of mobile devices and for those learners who feed off social connections through the cultivation and maintenance of social connectedness, learning on the go also offer learners of an app portable communities. These portable communities extend the co-presence and connected presence of m-learning app users as well as the idea that they are not studying alone, but is part of a learning community (Mentor 2011, 2017).

Mobile learning apps that tap into social connectedness in their design can also encourage participants to experience social connectedness within a learning community. Social connectedness can aid learners using a m-learning app to connect with their portable community through cognitive and socio-emotional processes. These processes simultaneously could foster and maintain social connectedness through diverse communication or engagement channels built into the app. That synergy can also fuel the building and affiliation of a learning community and can so within or without temporal bounds as well as spur competitive zones of proximal development or motivation to do as well or better than one's mobile app learning peers.

## RESULTS

This section describes how many of the top 24 apps found in the study's search fitted the criteria. Sometimes, there were differences between apps in how they implement a feature. This section also will highlight such differences between the apps.

### General App Features

*Free or Paid.* Among the apps examined, six apps were free to install and use, three apps were paid, and 15 apps were free to install with pay for premium service options (i.e., freemium; see Table 1). The freemium services mostly provided access to additional content, questions, or tests rather than additional features. The payment required for paid apps ranged from \$0.99 to \$4.99.

*Table 1. Distribution of the number of PMP preparation apps as free or paid*

| Free or paid | Number of apps |
|---|---|
| Free | 6 |
| Free + in-app purchase | 15 |
| Paid | 3 |
| Total | 24 |

*Requiring an Internet Connection.* Among the apps examined, 22 apps required an Internet connection, and two apps did not require an Internet connection (see Table 2). One app that does not require an Internet connection—*PMP Handbook – PMBOK 6th Edition"*—focuses on only test content based on sections of the *PMBOK®*. The other app that does not require an Internet connection—*PMP Test - PMP Certification Exam Prep App*—focuses on only test content. This difference suggests that the content of the app does not directly relate to whether the app requires an internet connection.

*Table 2. Distribution of the number of PMP preparation apps that require an internet connection*

| Requires an internet connection | Number of apps |
|---|---|
| Yes | 22 |
| No | 2 |
| Total | 24 |

*Mobile and Web Access.* Among the 24 apps, only one app—*PMP Exam Prep Questions & Videos*—allowed access to the app from both mobile phones and the web (see Table 3). This app delivered both content and practice tests and allowed tracking of the learning journey via multiscreen access on a desktop web browser or a mobile phone.

*Table 3. Distribution of the number of PMP preparation apps offering both mobile and web access*

| Mobile and web access | Number of apps |
|---|---|
| Yes | 1 |
| No | 23 |
| Total | 24 |

## Features for the Learning Experience

*Offering Only Test, Only Content, or Both.* Among the 24 apps, 15 apps offered only practice tests, three apps delivered only content preparing for the PMP examination, and six apps offered both content and practice tests (see Table 4). This distribution suggests that the PMP test preparation app space is heavier on the test than on content.

*Table 4. Distribution of the number of PMP preparation apps offering only test, only content, or both*

| Test or content | Number of apps |
|---|---|
| Content only | 3 |
| Test only | 15 |
| Both content and test | 6 |
| Total | 24 |

Among the 15 apps that delivered only tests, only two apps were free; all others were either paid or offered as an in-app purchase. Nearly all the apps that delivered only tests (13 apps) had features to provide feedback to the questions. Among the apps that offered both content and test (six apps), two apps did not provide feedback to the test questions. While keeping in mind that the sample sizes in this study were quite small, the study team speculated that providing feedback to test questions is a more emphasized function for apps that focus on only practice tests.

*Offering Feedback.* Twenty-one of the 24 apps offered tests. Because feedback is not available for apps that offer only content, the analysis did not include those three apps (see Table 5). Some apps that offered tests offered solely tests, and some apps offered tests along with some study content. Among these 21 apps, 16 apps offered feedback, and five apps did not offer any form of feedback. The most common form of feedback was giving explanations of why the keyed response is the correct answer and why the response alternatives (i.e., distractors) cannot be the correct response. Another area to provide feedback to learners is about their time on the test. For example, the app –*PMP Exam Prep 2022* – provides the average time a user took to solve a test.

*Table 5. Distribution of the number of PMP preparation apps providing feedback*

| Providing feedback | Number of apps |
|---|---|
| Yes | 16 |
| No | 5 |
| N/A | 3 |
| Total | 24 |

*Keeping Track of Scores.* For the 21 of 24 apps that offered a test, 12 apps kept track of learners' scores, and nine apps did not track scores (see Table 6). The most common form of keeping track of scores was in a dashboard listing historically each test the learner took and the percentage of correct scores in each test. Very few apps provided performance data beyond overall test correctness. The app –*PMP Certification Exam 2020* – provided a percentage of correct scores on questions in each knowledge area. This feature can help users focus on the areas in which they do not perform well. This app also provided a breakdown of the percentage of scores on tests by the last test, the last five tests, the last 10 tests, the last 20 tests, and all tests taken by that time. Similarly, the –*PMI PMP Certification Prep 2021 Exam Update* – app provides the percentage of scores broken down by the exam content (i.e., business, processes, and people).

*Table 6. Distribution of the number of PMP preparation apps keeping track of scores*

| Keeping track of scores | Number of apps |
|---|---|
| Yes | 12 |
| No | 9 |
| N/A | 3 |
| Total | 24 |

*Custom Test Builder.* Building custom tests is possible only for those apps that offer a test. Among the 21 apps that offer a test, 14 apps offered the ability to build a custom test for the user, and seven apps did not offer custom-built tests (see Table 7).

The apps used different customizations for the practice tests. PMP preparation apps provide a customized test experience in the following ways:

- Allow users to change only the number of questions. Three apps have this feature. Some apps allow users to enter the number of questions they want to prepare, and some apps offer users to select tests from pre-made practice tests of varying lengths (e.g., 10, 20, 100 questions).

*Table 7. Distribution of the number of PMP preparation apps with custom test building*

| Custom test builder | Number of apps |
|---|---|
| Yes | 14 |
| No | 7 |
| N/A | 3 |
| Total | 24 |

- Allow users to change only knowledge areas. Two apps have this feature. Users select from pre-made tests, each focusing on a different knowledge area.
- Allow users to change both the total number of questions and the total time. Two apps offer this feature. One app –PMP Test - PMP Certification Exam Prep App – allows users to manually enter a time limit (in minutes) and number of questions in the same dashboard. The other app, – PMP Certification Exam 2021 – allows separate clickable areas for changing time and changing number of questions. Learners can change these settings only two times.
- Allow users to change knowledge areas or process groups. In the PMP examination, a process can correspond to both a knowledge area and a process group. One app has this feature. Based on the user's selection, the questions related to both the selected knowledge area and the process would come up for the user.
- For the automated selection of practice test areas based on previous performance, allow users to select the number of questions and the time limit. One app has this feature combination. The app keeps track of the user's performance and automates the selection of content from questions that the user did not answer correctly. In addition, the user can select the number of questions in each practice test and adjust the time limit for that practice test.
- Allow users to select the test difficulty and domain. One app has this feature. Users select whether they want an easy, medium, or difficult test and select one of the business, processes, or people domains of the PMP examination.
- Allow users to select both the domain and the number of questions. One app allows users to select one of the three domains and the number of questions they would like to practice.
- Embedded quiz builder for creating and customizing the quizzes the user wants. This is a premium feature in one app, but it is not clear what aspects of the test the user can customize.
- Allow users to select content area. One app has this feature. However, this is a premium feature, and it is not clear how the content areas are organized for user selection.

*Offering Personalized Learning Areas for Improvement.* Five of the 24 apps offer personalized learning areas to users (see Table 8). Two apps (one free version and one paid version of the same app) automate a learning program based on evaluation test results. Users of this app start with an evaluation test, and the app offers a roadmap based on the user's performance on this test. One app claims to provide a study plan that sets up a studying schedule for the user. However, it is not clear how this feature works. Similarly, another app also benefits from automation and creates practice tests based on performance on previous practice exams. Another app uses a fully humanized approach and asks the user to contact the founder/instructor who will offer a personalized map for the user. This feature is available to only premium users of the app.

*Table 8. Distribution of the number of PMP preparation apps that offering personalized learning areas for improvement*

| Personalized learning areas of improvement | Number of apps |
|---|---|
| Yes | 5 |
| No | 19 |
| Total | 24 |

*Offering a Social Connection.* Six apps allow some sort of social communication and connection (see Table 9). Each app offers a different way of incorporating a social aspect to their app. The social connection features were as follows:

- Competing with others by leaderboard function
- Messaging with the founder/instructor (*PMP Exam Prep Questions & Videos* was branded with the founder, who also is the instructor for the app. All users can email the founder/instructor, and paid users can receive personalized learning areas of improvement.)
- In-app messaging with experts and offering 30 free bonus questions through social media
- Commenting and liking posts
- Competing with others in a leaderboard and in-app messaging with the app's expert team
- Having discussion forums to communicate with experts

*Table 9. Distribution of number of PMP preparation apps offering a social connection*

| Offering a social connection | Number of apps |
|---|---|
| Yes | 6 |
| No | 18 |
| Total | 24 |

## RECOMMENDATIONS

In addition to the features examined in the 24 apps, the study team suggests including certain features to make the apps even more useful based on learning theories and best practices. Five features can enhance learners' experience and benefit from the app: (a) crowdsourcing with peers, (b) tracking one's learning journey across different web and physical outlets, (c) helping users manage testing time better, (d) including more question types, (e) including updated test content.

### Crowdsourcing with Peers

The current features of apps for social connection allow users to either compete with peers with the leaderboard function or connect with an expert. One untapped potential of social learning is peer learning. In an app environment, peer learning can look like a place where users share their questions and tips with other users who also are preparing for the test. Such communication can happen in a discussion forum or cohort group in which there is a cultivating and supportive environment among learners.

## Tracking Learning Journey across Different Web and Physical Outlets

Among the 24 apps, only one app offered a user experience that is interchangeable between the web and the mobile device. The study team suggests that more apps be flexible in terms of the device used and offer an uninterrupted learning experience to users. Consistent with this suggestion, track user performance on both the mobile and web apps in the same dashboard so that there is uninterrupted performance monitoring. In addition, features should allow users to share their results on the web, such as their social networking sites; engage in private messages, such as their WhatsApp groups; and print or download physical media.

## Helping Users Manage Testing Time Better

The PMP examination is a high-stakes, timed examination. Test takers should manage their testing time to perform well on the test. While taking practice tests, it would be helpful to offer a time spent or time remaining sign on the screen. A few apps shared information on the average time spent on the tests as a point for feedback and allowing users to adjust testing time for practice tests. The study team suggests that more apps emphasize testing time.

## Including More Question Types

Almost all 24 apps use only multiple-choice, single-select question types in the practice tests. However, the PMP examination has introduced different question types to the examination since the exam was first offered digitally. Digital examinations allow the administration of more innovative question types. Some new question types that PMI uses are drag-and-drop and hot-spot (for prototype questions used in certification exams offered by PMI see their website PMI, n.d). In drag-and-drop questions, test takers take draggable objects (i.e., sources) to some areas (i.e., target). In hot-spot questions, test takers see a visual image and select areas in that image based on what the question asks. Apps should include more question types similar to the ones used in the PMP certification examinations.

## Updating Test Content

The PMP examination content changed for examinations effective in January 2021. The PMP examination has 180 questions (previously, it was 200 questions) with a time limit of 230 minutes (PMI, 2021). Many apps offer practice tests that claim to mimic the full PMP examination. However, these tests are based on content for the previous examination. App designers should update their practice tests, content, and settings for building custom tests to follow changes in the actual PMP examination.

## FUTURE DIRECTIONS

The capabilities of the internet, mobile phones, and apps continually increase, which result in advancements in preparing for the PMP examination. Future apps can benefit more from automation in ways that will enhance users' experience and benefit from the practice apps. One area in which advancements will play a vital role is individualizing content, practice tests, and feedback. Automation features and embedding more capable algorithms can enable providing users content aligned with where they are in their learning progressions and individualized feedback for their current performance. Another area in which automation can help is providing individualized roadmaps for each learner based on their goals.

## REFERENCES

Ament, V., & Edwards, R. (2018). *Better teaching and more learning in mobile learning courses: Towards a model of personable learning*. International Association for Development of the Information Society. https://eric.ed.gov/?id=ED590379

Angelone, L., Warner, Z., & Zydney, J. M. (2020). Optimizing the technological design of a blended synchronous learning environment. *Online Learning, 24*(3), 222–240. https://eric.ed.gov/?id=EJ1271880

Cheers, D. M. (2013). A remembrance of Mangaliso Dukuza Alf Kumalo of South Africa. *Visual Communication Quarterly*, *20*(4), 220–231. doi:10.1080/15551393.2013.849993

Clauzel, A., Riché, C., Le Hegarat, B., & Zerbib, R. (2020). Co-presence and mobile apps: Technology's impact on being with others. *Canadian Journal of Administrative Sciences/Revue Canadienne des Sciences de l'Administration, 37*(1), 30–44. doi:10.1002/cjas.1553

Everson, M. E. (2011). Best practices in teaching logographic and non-Roman writing systems to L2 learners. *Annual Review of Applied Linguistics*, *31*, 249–274. doi:10.1017/S0267190511000171

Ghamrawi, N. (2022). Teachers' virtual communities of practice: A strong response in times of crisis or just another fad? *Education and Information Technologies*. Advance online publication. doi:10.100710639-021-10857-w PMID:35095322

Glavas, C., & Schuster, L. (2020). Design principles for electronic work integrated learning (eWIL). *The Internet and Higher Education*, *47*, 100760. Advance online publication. doi:10.1016/j.iheduc.2020.100760

Kumar, B. A., & Mohite, P. (2018). Usability of mobile learning applications: A systematic literature review. *Journal of Computers in Education,* 1-17.

Mentor, D. (2016). The commuter's learning journey: field observations informing mobile learning initiatives. In *Handbook of Research on Mobile Learning in Contemporary Classrooms* (pp. 315–335). IGI Global.

Mentor, D. (2018). TLC for MOOCS: Teaching and Learning Communities for Computer Programming. In Computer-Mediated Learning for Workforce Development (pp. 93-110). IGI Global.

Mentor, D. (2018). mClass planet of the apps: The rise of mobile learning. In Computer-mediated learning for workforce development (pp. 196–215). IGI Global. doi:10.4018/978-1-5225-4111-0.ch010

Mentor, D. (Ed.). (2019). Advancing Mobile Learning in Contemporary Educational Spaces. IGI Global, Information Science Reference. doi:10.4018/978-1-5225-9351-5

Mentor, D. J. (2011). *Exploring social connectedness via mobile phone texting* (Doctoral dissertation). Teachers College, Columbia University.

Naismith, L., Lonsdale, P., Vavoula, G., & Sharples, M. (2004). *Literature Review in Mobile Technologies and Learning: Report 11*. Futurelab.

Nikou, S. A., & Economides, A. A. (2018). Mobile-based assessment: A literature review of publications in major referred journals from 2009 to 2018. *Computers & Education*, *125*, 101–119. doi:10.1016/j.compedu.2018.06.006

Othman, M. K., Nogoibaeva, A., Leong, L. S., & Barawi, M. H. (2021). Usability evaluation of a virtual reality smartphone app for a living museum. *Universal Access in the Information Society*, 1–18. doi:10.100710209-021-00820-4

Parsons, D., & MacCallum, K. (2020). A learning theory rubric for evaluating mobile learning activities. In *Mobile devices in education: Breakthroughs in research and practice* (pp. 983–998). IGI Global. doi:10.4018/978-1-7998-1757-4.ch056

Pimmer, C., Brühlmann, F., Odetola, T. D., Oluwasola, D. O., Dipeolu, O., & Ajuwon, A. J. (2019). Facilitating professional mobile learning communities with instant messaging. *Computers & Education*, *128*, 102–112. doi:10.1016/j.compedu.2018.09.005

Prahani, B., Jatmiko, B., Hariadi, B., Sunarto, D., Sagirani, T., Amelia, T., & Lemantara, J. (2020). Blended Web Mobile Learning (BWML) model to improve students' higher order thinking skills. *International Journal of Emerging Technologies in Learning*, *15*(11), 42–55. doi:10.3991/ijet.v15i11.12853

Project Management Institute. (2017). *A Guide to the Project Management Body of Knowledge (PMBOK)* (6th ed.). Project Management Institute.

Project Management Institute. (2021). *Project Management Professional (PMP)® examination content outline: January 2021 exam update*. https://www.pmi.org/-/media/pmi/documents/public/pdf/certifications/pmp-examination-content-outline.pdf?v=ef41743a-9156-4137-a9a6-fd31e19a9668&sc_lang_temp=en

Project Management Institute. (n.d.). *New item types*. https://www.pmi.org/-/media/pmi/documents/public/pdf/certifications/prototype-exam-questions.pdf?v=5ce972c2-1f02-49d9-aaff-c23c1ebb43f6

Şahin, F., & Mentor, D. (2017). Creating teaching and learning accountabilities through data analytic feedback loops. *Proceedings of the MODSIM World Conference & Expo*.

Şahin, F., & Mentor, D. (2019). Mobile Phones for Assessment: Anywhere, Anytime, by Anyone. In Advancing Mobile Learning in Contemporary Educational Spaces (pp. 128-159). IGI Global.

Slavkovic, N., & Savic, A. (2015). The usage of m learning for adult education in Serbia. *Procedia: Social and Behavioral Sciences*, *174*, 2806–2812. doi:10.1016/j.sbspro.2015.01.971

Sönmez, A., Göçmez, L., Uygun, D., & Ataizi, M. (2018). A review of current studies of mobile learning. *Journal of Educational Technology and Online Learning*, *1*(1), 12–27. doi:10.31681/jetol.378241

Yang, H. C., & Fu, Y. C. (2021). From teachers' professional learning communities to mobile networked learning communities: An additional path to the integration of gender education into medical education. *Journal of Educational Practice and Research*, *34*(3), 165–204.

## KEY TERMS AND DEFINITIONS

**Cognitive Load:** Amount of information that working memory can hold at one time.

**Computer-Assisted Language Learning (CALL):** Employing computers in the teaching and learning of a language.

**Device Agnosticism:** Being able to access the same digital data and platforms regardless of the device type used.

**Device Responsiveness:** Refers to adjusting the user's device for both output to the user and potential input from a user for interactive content such as user's responses to quizzes and seeing results.

**Mobile Assessment (M-Assessment):** Mobile assessment stands for assessing learners via mobile devices.

**Mobile Responsiveness:** Refers to how the content is accommodating to the user when accessing the app on a tablet, a desktop computer, a laptop computer, or a multitude of mobile phone screens.

**Mobile-Assisted Language Learning (MALL):** Language learning that is assisted or enhanced through the use of a handheld mobile device.

**Psychometrics:** Field of study concerned with the theory and techniques of measurement applied to testing, measurement, assessment, and related activities.

**Social Connectedness:** A sense of affiliation with others in a similar community, and a sense of belonging.

**Summative Tests:** The assessment of a test taker's knowledge and skills at the completion of a program of learning.

## ENDNOTES

1. The Project Management Professional (PMP) is a registered mark of the Project Management Institute, Inc.
2. The Project Management Body of Knowledge (PMBOK) is a registered mark of the Project Management Institute, Inc.

# APPENDIX. EXAMINATION OF THE APPS

*Table 10. Individual Categorization of the Apps Based on Criteria*

| App | Free/paid | Test/ content | Providing feedback | Keeping track of score | Custom test builder | Social connection | Require internet connection | Personalized learning areas of improvement | Mobile and web |
|---|---|---|---|---|---|---|---|---|---|
| PMP Handbook – PMBOK 6th Edition | Free | Content | N/A | N/A | N/A | No | No | No | No |
| PMP Exam Prep Free | Free | Test | Yes | Yes | Yes; only number of questions | No | Yes | No | No |
| PMP Exam Smart Prep | Free | Test | Yes | No | Yes; only number of questions | No | Yes | Yes; automated based on evaluation test | No |
| Study Hall | Free | Content | N/A | N/A | N/A | No | Yes | No | No |
| PMP,RMP,SP Exam Prep 2020 | Free | Both | Yes | No | Y- knowledge areas and process groups | No | Yes | No | No |
| myPMI | Free | Content | N/A | N/A | N/A | Comments and likes on the posts | Yes | No | No |
| PMI PMP Exam Prep | Free + In-app subscription | Test | Yes | Yes | No | No | Yes | No | No |
| PMP Exam Prep 2022 | Free + In-app upgrade | Test | Yes | No | Yes; selecting easy, medium, difficult tests; and option to select tests from three domains | No | Yes | Yes; sets up a specific schedule | No |
| PMP Certification Exam 2020* | Free + In-app upgrade | Test | Yes | Yes | No | No | Yes | No | No |
| PMI PMP Certification Prep 2021 Exam Update | Free + In-app upgrade | Both | Yes | Yes | Yes; selecting questions from three test domains and number of questions | No | Yes | No | No |
| PMP Exam Now - Project Management Simulation | Free + In-app upgrade | Both | No | No | Yes; knowledge areas and process groups | Compete with others by leaderboard function | Yes | No | No |
| PMP Pocket Prep | Free + In-app upgrade | Test | No | Yes | Yes; not clear what is being selected | In-app messaging with experts; 30 free bonus questions through social media | Yes | No | No |
| PMP Exam Prep 2022: 100% Pass! | Free + In-app upgrade | Test | Yes | Yes | No | No | Yes | No | No |

*continues on following page*

*Table 10. Continued*

| App | Free/paid | Test/ content | Providing feedback | Keeping track of score | Custom test builder | Social connection | Require internet connection | Personalized learning areas of improvement | Mobile and web |
|---|---|---|---|---|---|---|---|---|---|
| PMP Exam Prep | Free + In-app upgrade | Test | Yes | Yes | Yes; number of questions, time limit, automated selection of practice test areas based on previous performance | No | Yes | Yes; test areas are created by performance on previous exams | No |
| PMP Exam Prep 2022 | Free + In-app upgrade | Both | Yes | Yes | Yes; Quiz Builder: create & customize the quiz the way you like | Leaderboard: Check your rank and compare with other users globally; in-app messaging with experts | Yes | No | No |
| PMP Certification Exam 2021 | Free + In-app upgrade | Test | Yes | Yes | Yes; change total number of questions, total time | Yes; discussion forums to communicate with experts | Yes | No | No |
| PMP Exam Free - Oliver Lehmann | Free + In-app upgrade | Test | Yes | No | No | No | Yes | No | No |
| PMP Test - PMP Certification Exam Prep App | Free + In-app upgrade | Test | No | Yes | Yes; change total number of questions, total time | No | No | No | No |
| PMP Exam Simulator | Free + In-app upgrade | Test | Yes | Yes | Yes; only by knowledge areas | No | Yes | No | No |
| PMP Certification Mastery | Free + In-app upgrade | Test | Yes | Yes | No | No | Yes | No | No |
| PMP Handbook Pro – PMBOK 6th Edition | Paid ($4.49) | Both | No | No | No | No | Yes | No | No |
| PMP Certification | Paid ($0.99) | Test | Yes | No | Yes; only by knowledge areas | No | Yes | No | No |
| PMP Exam Smart Prep + | Paid ($3.99) | Test | Yes | No | Yes; only number of questions | No | Yes | Yes; automated based on evaluation test | No |
| PMP Exam Prep Questions & Videos | Free + In-app upgrade | Both | No | No | No | Can message with the founder/ instructor | Yes | Yes; the founder/ instructor will do it for the user with premium | Yes |

* Note: The PMP Certification Exam 2020 app was taken off the app store before publishing of this chapter.

# Compilation of References


Abraham, P., & Mohanan, N. (2021). Efficacy of social networking sites in library services at the time of social distancing due to COVID- 19 lockdown: A study among the library professionals and students in India. *Library Philosophy and Practice*, 1-12. http://ezproxy.cul.columbia.edu/login?url=https://www.proquest.com/scholarly-journals/efficacy-social-networking-sites-library-services/docview/2552127263/se-2

Acharya, U. R., Joseph, K. P., Kannathal, N., Lim, C. M., & Suri, J. S. (2006). Heart rate variability: A review. *Medical & Biological Engineering & Computing*, *44*(12), 1031–1051. doi:10.100711517-006-0119-0 PMID:17111118

Acquaro, P. E. (2017). *Investigation of the selection, implementation, and support of online learning tools in higher education* (Unpublished doctoral dissertation). Teachers College, Columbia University, New York, NY. Retrieved January 15, 2022 from: https://www.edtechdecisionmakinginhighered.org/edtech-research-papers

Acquaro, P. E. (2018). Investigation Into the Selection of Online Learning Platforms and Tools in Higher Education. In D. Mentor (Ed.), *Computer-Mediated Learning for Workforce Development* (pp. 150–167). IGI Global. doi:10.4018/978-1-5225-4111-0.ch008

Acquaro, P. E. (2020). Structuring and Scaffolding the Online Course. *International Journal of Online Graduate Education*, *3*(1), 1–16.

Acquatella, F. (2016). Le COOC, un autre visage du MOOC. *Distances et médiations des savoirs,* (14). doi:10.4000/dms.1386

Adam, T., Kaye, T., & Haßler, B. (2020). *The Maldives and Sri Lanka: Question & Answer Session* (No. 18). EdTech Hub.

Addison, S., Wright, A., & Milner, R. (2009). Using clickers to improve student engagement and performance in an introductory biochemistry class. *Biochemistry and Molecular Biology Education*, *37*(2), 84–91. doi:10.1002/bmb.20264 PMID:21567711

Adisa, T. A., Aiyenitaju, O., & Adekoya, O. D. (2021). The work–family balance of British working women during the COVID-19 pandemic. *Journal of Work-Applied Management*, *13*(2), 241–260. doi:10.1108/JWAM-07-2020-0036

Adzovie, D. E., Jibril, A. B., Adzovie, R. H., & Nyieku, I. E. (2020, July). E-Learning resulting from Covid-19 pandemic: A conceptual study from a developing country perspective. In *7th European Conference on Social Media ECSM 2020* (p. 19). Academic Press.

Ahamad, F. (2019). Impact of word-of-mouth, job attributes and relationship strength on employer attractiveness. *Management Research Review*, *42*(6), 721–739. doi:10.1108/MRR-11-2017-0382

Ahmad, J., Ahmad, A., Shoaib, M., & Shaukat, B. (2021). Public Library Online Information Resources to Library Patrons during COVID-19 Pandemic: A Case of Higher Education Institutions. *Library Philosophy and Practice*, 1-14. http://ezproxy.cul.columbia.edu/login?url=https://www.proquest.com/scholarly-journals/public-library-online-information-resources/docview/2582231515/se-2

Airila, A., Hakanen, J., Punakallio, A., Lusa, S., & Luukkonen, R. (2012). Is work engagement related to work ability beyond working conditions and lifestyle factors? *International Archives of Occupational and Environmental Health*, *85*(8), 915–925. doi:10.100700420-012-0732-1 PMID:22270385

Akbiyik, C. (2010). Can affective computing lead to more effective use of ICT in education? *Review of Education*, *352*(4), 181–185.

Akkermans, J., Richardson, J., & Kraimer, M. (2020). The Covid-19 crisis as a career shock: Implications for careers and vocational behavior. *Journal of Vocational Behavior, 119*(1) 103434. doi: https://doi.org/10.1016/j.jvb.2020.103434

Al Mamun, M. A., Lawrie, G., & Wright, T. (2020). Instructional design of scaffolded online learning modules for self-directed and inquiry-based learning environments. *Computers & Education*, *144*, 103695. doi:10.1016/j.compedu.2019.103695

Aldahadha, B. (2021). Metacognition, mindfulness attention awareness, and their relationships with depression and anxiety. *Journal of Rational-Emotive & Cognitive-Behavior Therapy*, *39*(2), 183–200. doi:10.100710942-020-00367-y

Alhumaid, K., Ali, S., Waheed, A., Zahid, E., & Habes, M. (2020). COVID-19 & Elearning: Perceptions & Attitudes Of Teachers Towards E-Learning Acceptancein The Developing Countries. *Multicultural Education*, *6*(2), 100–115.

Ali, M. Y., & Gatiti, P. (2020). The Covid-19 (coronavirus) pandemic: Reflections on the roles of Librarians and Information Professionals. *Health Information and Libraries Journal*, *37*(2), 158–162. doi:10.1111/hir.12307 PMID:32251543

Ali, S., Kabajaasi, O., Kawooya, M. G., Byamugisha, J., Zakus, D., Papageorghiou, A. T., Grobusch, K. K., & Rijken, M. J. (2021). Antenatal Doppler Ultrasound Implementation in a Rural Sub - Saharan African Setting : Exploring the Perspectives of Women and Healthcare Providers. *Reproductive Health*, *18*(1), 1–12. doi:10.118612978-021-01233-5 PMID:34620186

Allen, I. E., Seaman, J., Straut, T. T., & Poulin, R. (2016). *Online Report Card: Tracking Online Eucation in the United States*. Retrieved January 15, 2022 from: http://onlinelearningsurvey.com/reports/onlinereportcard.pdf

Allen, L., Cobiac, L., & Townsend, N. (2017). Quantifying the Global Distribution of Premature Mortality from Non-Communicable Diseases. *Journal of Public Health (United Kingdom)*, *39*(4), 698–703. doi:10.1093/pubmed/fdx008 PMID:28184435

Almanthari, A., Maulina, S., & Bruce, S. (2020). Secondary school mathematics teachers' views on e-learning implementation barriers during the COVID-19 pandemic: The case of Indonesia. *Eurasia Journal of Mathematics, Science and Technology Education*, *16*(7), em1860. doi:10.29333/ejmste/8240

Almeida-Santos, M. A., Barreto-Filho, J. A., Oliveira, J. L. M., Reis, F. P., da Cunha Oliveira, C. C., & Sousa, A. C. S. (2016). Aging, heart rate variability and patterns of autonomic regulation of the heart. *Archives of Gerontology and Geriatrics*, *63*, 1–8. doi:10.1016/j.archger.2015.11.011 PMID:26791165

Almubark, B. M., Majrashi, N., Alghusun, N., Alhammad, M., Alhthifi, F., & Alyahya, R. S. (2021). Telehealth Clinical Practice Guide for Occupational Therapy, Physical Therapy, and Speech and Language Pathology: A Saudi and Middle Eastern Guide. *Telemedicine Journal and e-Health*, tmj.2021.0021. doi:10.1089/tmj.2021.0021 PMID:34529497

Almusharraf, A., & Almusharraf, N. (2021). Socio-interactive practices and personality within an EFL online learning environments. *Education and Information Technologies*, *26*(4), 3974–3966. doi:10.100710639-021-10449-8 PMID:33584118

Al-Nuaimi, M. N., Al-Kabi, M. N., & Al-Emran, M. (2021). Digitizing Learning During the Outbreak of COVID-19 Pandemic: Lessons Learned from the Most Infected Countries. In *Emerging Technologies During the Era of COVID-19 Pandemic* (pp. 291–303). Springer. doi:10.1007/978-3-030-67716-9_18

Alsaghir, L., Abdallah, N., & Bazan, S. B. (2020). Optimizing Recruitment Online: The Critical Importance of Using the Right Channels. *International Journal of E-Business Research*, *16*(4), 18–33. doi:10.4018/IJEBR.2020100102

Al-Sudani, S. (2019, October). The Impact of In-Class Mobile Learning on Students' Engagement and Performance. In *European Conference on Games Based Learning* (pp. 13-XII). Academic Conferences International Limited.

Al-Zaiti, S. S., & Carey, M. G. (2015). The prevalence of clinical and electrocardiographic risk factors of cardiovascular death among on-duty professional firefighters. *The Journal of Cardiovascular Nursing*, *30*(5), 440–446. doi:10.1097/JCN.0000000000000165 PMID:24874885

Al-Zaiti, S., Rittenberger, J. C., Reis, S. E., & Hostler, D. (2015). Electrocardiographic Responses during Fire Suppression and Recovery among Experienced Firefighters. *Journal of Occupational and Environmental Medicine*, *57*(9), 938–942. doi:10.1097/JOM.0000000000000507 PMID:26340281

Ament, V., & Edwards, R. (2018). *Better teaching and more learning in mobile learning courses: Towards a model of personable learning*. International Association for Development of the Information Society. https://eric.ed.gov/?id=ED590379

American Academy of Child and Adolescent Psychiatry. (2020, February). *Screen time and children*. https://www.aacap.org/AACAP/Families_and_Youth/Facts_for_Families/FFF-Guide/Children-And-Watching-TV-054.aspx

American Academy of Pediatrics. (2020, March 17). *AAP: Finding ways to keep children occupied and during these challenging times*. https://www.aap.org/en/news-room/news-releases/aap/2020/aap-finding-ways-to-keep-children-occupied-during-these-challenging-times/

Andersen, M. H. G., Saber, A. T., Pedersen, P. B., Loft, S., Hansen, Å. M., Koponen, I. K., Møller, P. (2017). Cardiovascular health effects following exposure of human volunteers during fire extinction exercises. *Environmental Health: A Global Access Science Source, 16*(1), 1–9. doi:10.1186/s12940-017-0303-8

Andersen, L., Boud, D., & Cohen, R. (2000). Experience-based learning. In G. Foley (Ed.), *Understanding adult education and training* (2nd ed., pp. 225–239). Allen & Unwin.

Anderson, J. R. (2015). *Cognitive psychology and its implications*. Worth Publishers.

Anderson, V., & Tomlinson, M. (2021). Signaling standout graduate employability: The employer perspective. *Human Resource Management Journal*, *31*(3), 675–693. doi:10.1111/1748-8583.12334

Andrews, K. L. (2019). *Technologies, Pedagogies, and Ecologies: First-Year Writing Faculty's Attitudes toward Technology and Technological Uptake in the Composition Classroom*. North Carolina State University.

Andriessen, J., Baker, M., & Suthers, D. (Eds.). (2013). *Arguing to learn: Confronting cognitions in computer-supported collaborative learning environments* (Vol. 1). Springer Science & Business Media.

Angelone, L., Warner, Z., & Zydney, J. M. (2020). Optimizing the technological design of a blended synchronous learning environment. *Online Learning, 24*(3), 222–240. https://eric.ed.gov/?id=EJ1271880

Annune, A. E. P., Agoh, J. A., Annune, D. F., & Ihongo, D. A. (2020). Sensitization and Awareness Creation as Tools for Curbing Perceived Effects of COVID- 19 Pandemic on University Library Users in Nigeria. *Library Philosophy and Practice*, 1-18. http://ezproxy.cul.columbia.edu/login?url=https://www.proquest.com/scholarly-journals/sensitization-awareness-creation-as-tools-curbing/docview/2447004970/se-2

Anthis, K. (2011). Is it the clicker, or is it the question? Untangling the effects of student response use. *Technology Teacher*, *38*(3), 189–193. doi:10.1177/0098628311411895

Aoki, K. (2015). MOOCs and open education in Japan: The case of the Open University of Japan. In *MOOCs and open education around the world* (pp. 21–29). Routledge. doi:10.4324/9781315751108-4

Arenas, N., & Silver-Malyska, T. (2021). Imagining the unimaginable: Best practices for returning to work post-COVID-19. *Benefits Quarterly*, *37*(1), 45–57.

Arnett, D. K., Blumenthal, R. S., Albert, M. A., Buroker, A. B., Goldberger, Z. D., Hahn, E. J., Himmelfarb, C. D., Khera, A., Lloyd-Jones, D., McEvoy, J. W., Michos, E. D., Miedema, M. D., Muñoz, D., Smith, S. C., Virani, S. S., Williams, K. A., Yeboah, J., & Ziaeian, B. (2019). 2019 ACC/AHA Guideline on the Primary Prevention of Cardiovascular Disease. A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines.

Astatke, Y., Ladeji-Osias, J. O., James, P., Moazzami, F., Scott, C., Connor, K., & Saka, A. (2016). Improving and Expanding Engineering Education in the Middle East and Africa Using Mobile Learning Technology and Innovative Pedagogy. In *Advances in Engineering Education in the Middle East and North Africa* (pp. 235–260). Springer International Publishing.

AT&T and Udacity to Offer Scholarships to Underserved Students for New Online Tech Training Program. (n.d.). Retrieved December 10, 2017, from http://about.att.com/content/csr/home/blog/2014/09/at_t_and_udacityto.html#sthash.U0r03eEW.dpuf

AT&T Aspire. (n.d.). Retrieved December 10, 2017, from http://about.att.com/content/csr/home/people/at-t-aspire.html

AT&T. (2014, September 14). *Att_and_MOOC service provider_launch_online_training_program_nanodegree*. Retrieved from http://about.att.com/story/att_and_MOOC service provider _launch_online_training_program_nanodegree.html

Baber, C. (2003). *Cognition and tool use*. Taylor & Francis.

Baker, D., & Ellis, L. (2021). Libraries, digital information, and covid: Practical applications and approaches to challenge and change. *Libraries, Digital Information, and COVID*, 1–12. doi:10.1016/B978-0-323-88493-8.00010-0

Baloch, S. M., & Musyani, Z. (2020, July 8). Pakistan's great digital divide. Retrieved from. *The Diplomat*. https://thediplomat.com/2020/07/pakistans-great-digita l-divide/

Banamara, F., Taboada, M., & Mathieu, Y. (2016). Evaluative language beyond bags of words: Linguistic insights and computational applications. *Computational Linguistics, 43*(1), 201-264. doi: a 00278 doi:10.1162/COLI

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Prentice Hall.

Bandyopadhyay, C., & Srivastava, K. B. L. (2021). HR signals in the context of HRM-firm performance relationship: Development of a conceptual framework. *International Journal of Productivity and Performance Management*, *70*(2), 376–390. doi:10.1108/IJPPM-03-2019-0141

Bangani, S. (2021). The fake news wave: Academic libraries' battle against misinformation during COVID-19. *Journal of Academic Librarianship*, *47*(5), 102390. doi:10.1016/j.acalib.2021.102390

Bannan, B., Cook, J., & Pachler, N. (2016). Reconceptualizing design research in the age of mobile learning. *Interactive Learning Environments*, *24*(5), 938–953. doi:10.1080/10494820.2015.1018911

Barbe, W. B., Milone, M. N., & Swassing, R. H. (1979). *Teaching Through Modality Strengths: Concepts and Practices*. Zaner-Bloser.

Barnett, J. (2006). Implementation of personal response units in very large lecture classes: Student perceptions. *Australasian Journal of Educational Technology*, *22*(4), 474–494. doi:10.14742/ajet.1281

Bartan, M. (2020). Preschool Teachers' Informal Learning Behaviors. *Journal of Education and Future*, (18), 17–27.

Baur, D M, Leiba, A., Christophi, C. A., & Kales, S. N. (2012). Low fitness is associated with exercise abnormalities among asymptomatic firefighters. Occupational Medicine. doi:10.1093/occmed/kqs112

Baur, D. M., Christophi, C. A., Tsismenakis, A. J., Cook, E. F., & Kales, S. N. (2011). *Cardiorespiratory Fitness Predicts Cardiovascular Risk Profiles in Career Firefighters. 53*(10), 1155–1160. doi:10.1097/JOM.0b013e31822c9e47

Baur, D. M., Christophi, C. A., Cook, E. F., & Kales, S. N. (2012). Age-related decline in cardiorespiratory fitness among career firefighters: Modification by physical activity and adiposity. *Journal of Obesity*, *2012*, 1–6. Advance online publication. doi:10.1155/2012/710903 PMID:22666557

Baym, N. (2010). *Personal Connections in the Digital Age*. Polity Press.

Beaudouin-Lafon, M., & Mackay, M. (2000). Research directions in situated computing. In *CHI'00 Extended Abstracts on Human Factors in Computing Systems* (pp. 369–369). ACM. doi:10.1145/633292.633516

Becker, D. A. (2020). Creating online teaching resources and suggesting mobile apps in the time of COVID 19. *Journal of Electronic Resources in Medical Libraries*, *17*(3-4), 105–112. doi:10.1080/15424065.2020.1829233

Beetham, H., & Sharpe, R. (2013). *Rethinking pedagogy for a digital age: Designing for 21st century learning*. Routledge.

Bell, B., & Federman, J. (2013). E-learning in postsecondary education. *The Future of Children*, *23*(1), 165–185. doi:10.1353/foc.2013.0007 PMID:25522650

Benkert, C., & Dam, N. (2015). *Experiential learning: What's missing in most change programs.* Retrieved from https://www.mckinsey.com/business-functions/operations/our-insights/experiential-learning-whats-missing-in-most-change-programs

Bennett, C. C. (2012). *The role of the body in leading and learning: A case study of a somatic leadership development program* (Doctoral dissertation). Teachers College, Columbia University.

Bereiter, C. (2002). Design research for sustained innovation. *Cognitive Studies*, *9*(3), 321–327.

Bevan, B. (2017). The promise and the promises of making in science education. *Studies in Science Education*, *53*(1), 75–103. doi:10.1080/03057267.2016.1275380

Bezovski, Z., Temjanovski, R., & Sofijanova, E. (2021). Telecommuting best practices prior and during the COVID-19 pandemic. *Journal of Economics*, *6*, 85–100. doi:10.46763/JOE2160085b

Bhati, P., & Kumar, I. (2020). Role of library professionals in a pandemic situation like COVID-19. *International Journal of Library and Information Studies*, *10*(2), 33–48.

Bhattacharyya, O., Mossman, K., Ginther, J., Hayden, L., Sohal, R., Cha, J., . . . Mitchell, W. (2019). 6. Assessing Health Program Performance in Low-and Middle-Income Countries: Building a Feasible, Credible, and Comprehensive Framework. In Private Sector Entrepreneurship in Global Health (pp. 129-163). University of Toronto Press.

Biéchy, J. P., Charissou, C., Gobert, S., Verdier, J. C., Castel-Lacanal, E., Amarantini, D., & Fautrelle, L. (2021). The combination of deep breathing and mental imagery promotes cardiovascular recovery in firefighters. *Ergonomics*, *64*(10), 1231–1242. doi:10.1080/00140139.2021.1916606 PMID:33899680

Billman, G. E., Huikuri, H., Sacha, J., & Trimmel, K. (2015). An introduction to heart rate variability: Methodological considerations and clinical applications. *Frontiers in Physiology*, *6*(February), 2013–2015. doi:10.3389/fphys.2015.00055 PMID:25762937

Bissonnette, S., & Gauthier, C. (2012). Faire la classe à l'endroit ou à l'envers? *Formation Profession*, *20*(1), 23–28.

Blandford, A., Wesson, J., Amalberti, R., AlHazme, R., & Allwihan, R. (2020). Opportunities and challenges for telehealth within, and beyond, a pandemic. *Lancet*, *8*, e1364–e1365. PMID:32791119

Blankstein, A. M., Noguera, P., & Kelly, L. (2016). *Excellence through Equity*. ASCD.

Blasco-Arcas, L., Buil, I., Hernandez-Ortega, B., & Sese, F. J. (2013). Using clickers in class. The role of interactivity, active collaborative learning, and engagement in learning performance. *Computers & Education*, *32*, 102–110. doi:10.1016/j.compedu.2012.10.019

Blood, E., & Neel, R. (2008). Using student response systems in lecture-based instruction: Does it change student engagement and learning? *Journal of Technology and Teacher Education*, *16*(3), 375–383.

Bloom, B. S., Krathwohl, D. R., & Masia, B. B. (1984). *Bloom taxonomy of educational objectives*. Allyn and Bacon.

Boardman, K. L., Vargas, S. A., Cotler, J. L., & Burshteyn, D. (2021). Effects of Emergency Online Learning during COVID-19 Pandemic on Student Performance and Connectedness. *Information Systems Education Journal*, *19*(4), 23–36.

Bol, T. (2020). Inequality in homeschooling during the Corona Crisis in the Netherlands. First results from the Liss Panel. doi:10.31235/osf.io/hf32qosf.io/hf32q

Bolter, J. D. (2007). Remediation and the language of new media. *Northern Lights: Film & Media Studies Yearbook*, *5*(1), 25–37. doi:10.1386/nl.5.1.25_1

Bonaiuti, G., Calvani, A., & Piazza, D. (2015). Increasing classroom engagement and student comprehension through the use of clickers: An Italian secondary school experience. *Research on Education and Media*, *5*(1), 95–108.

Bonet, R., Capelli, P., & Hamori, M. (2013). Labour market intermediaries and the new paradigm for human resources. *The Academy of Management Annals*, *7*(1), 341–392. doi:10.5465/19416520.2013.774213

Bonk, C. J., & Lee, M. M. (2017). Motivations, achievements, and challenges of self-directed informal learners in open educational environments and MOOCs. *Journal of Learning for Development*, *4*(1), 36–57.

Bonnell, E., Huggins, C., Huggins, C., McCaffrey, T., Palermo, C., & Bonham, M. (2017). Influences on Dietary Choices during Day versus Night Shift in Shift Workers: A Mixed Methods Study. *Nutrients*, *9*(3), 193. doi:10.3390/nu9030193 PMID:28245625

Boud, D., Keogh, R., & Walker, D. (1985). Promoting reflection in learning: A model. *Reflection: Turning experience into learning*, 18-40.

Boud, D., Keogh, R., & Walker, D. (Eds.). (2013). *Reflection: Turning experience into learning*. Routledge. doi:10.4324/9781315059051

Bower, M., Howe, C., McCredie, N., Robinson, A., & Grover, D. (2014). Augmented Reality in education–cases, places and potentials. *Educational Media International*, *51*(1), 1–15. doi:10.1080/09523987.2014.889400 boyd, d. m., &; Ellison, N. B. (2007). Social network sites: Definition, history, and scholarship. *Journal of Computer-Mediated Communication*, *13*(1), 210–230. doi:10.1111/j.1083-6101.2007.00393.x

Boykin, W. A., & Noguera, P. (2011). *Creating the opportunity to learn moving from research to practice to close the achievement gap*. ASCD.

Boyle, J. T., & Nicol, D. J. (2003). Using classroom communication systems to support interaction and discussion in large class settings. *Association of Learning Technology Journal*, *11*(3), 43–57. doi:10.3402/rlt.v11i3.11284

Bradley, A., Beevers-Cowling, F., Norton, C., Hill, C., Pelopida, B., & Quigley, M. (2021). Falling at the first hurdle: Undergraduate students' readiness to navigate the graduate recruitment process. *Studies in Higher Education*, *46*(9), 1827–1838. doi:10.1080/03075079.2019.1709164

Brame, C. J. (2016). Effective Educational Videos: Principles and Guidelines for Maximizing Student Learning from Video Content. *CBE Life Sciences Education*, *15*(4), es6. Advance online publication. doi:10.1187/cbe.16-03-0125 PMID:27789532

Brammer, S., & Clark, T. (2020). COVID-19 and Management Education: Reflections on Challenges, Opportunities, and Potential Futures. *British Journal of Management*, *31*(3), 453–456. doi:10.1111/1467-8551.12425

Brandi, U., & Thomassen, M. L. (2021). Sustainable organizational learning and corporate entrepreneurship: A conceptual model of sustainability practices in organizations. *Journal of Workplace Learning*, *33*(3), 212–228. doi:10.1108/JWL-05-2020-0084

Bransford, J. D., & Schwartz, D. L. (1999). Rethinking transfer: A simple proposal with multiple implications. *Review of Research in Education*, *24*(1), 61–100. doi:10.3102/0091732X024001061

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. doi:10.1191/1478088706qp063oa

Bravo, E., Amante, B., Simo, P., Enache, M., & Fernandez, V. (2011). Video as a new teaching tool to increase student motivation. In *2011 IEEE Global Engineering Education Conference (EDUCON)*. IEEE. 10.1109/EDUCON.2011.5773205

Brenčič, V. (2014). Search online: Evidence from acquisition of information on online job boards and resume banks. *Journal of Economic Psychology*, *42*(1), 112–125. doi:10.1016/j.joep.2014.02.003

Breslin, M., & Buchanan, R. (2008). On the case study method of research and teaching in design. *Design Issues*, *24*(1), 36–40. doi:10.1162/desi.2008.24.1.36

Bridgstock, R., & Jackson, D. (2019). Strategic institutional approaches to graduate employability: Navigating meanings, measurements and what really matters. *Journal of Higher Education Policy and Management*, *41*(2), 1–17. doi:10.1080/1360080X.2019.1646378

Bright Network. (2020). *What do graduates want? 2020/21. Data Insights from the future workforce*. https://www.brightnetwork.co.uk/employers/bright-network-research-report

Britton, N., Miller, M. A., Safadi, S., Siegel, A., Levine, A. R., & Mccurdy, M. T. (2019). Tele-Ultrasound in Resource-Limited Settings. *Systematic Reviews*, *7*(September), 244. Advance online publication. doi:10.3389/fpubh.2019.00244 PMID:31552212

Briz-Ponce, L., Juanes-Mendez, J. A., & García-Peñalvo, F. J. (Eds.). (2016). *Handbook of Research on Mobile Devices and Applications in Higher Education Settings*. IGI Global.

Brown, E. (2019, April 28). *Americans spend far more time on their smartphones than they think*. Retrieved December 19, 2021, from https://www.zdnet.com/article/americans-spend-far-more-time-on-their-smartphones-than-they-think/

Bruns, A. (2009). *Blogs, Wikipedia, second life and beyond: From production to produsage*. Peter Lang.

Buarki, H., Hepworth, M., & Murray, I. (2011). ICT skills and employability needs at the LIS programme kuwait: A literature review. *New Library World*, *112*(11), 499–512. https://dx.doi.org/10.1108/03074801111190392

Bucala, M., & Sweet, E. (2019). Obesity in the fire service: An inside look at the perceptions of firefighters towards obesity and other health issues. Research Square., doi:10.21203/rs.2.15518/v1

Buckingham, D. (2003, Fall). Media Education and the End of the Critical Consumer. *Harvard Educational Review*, *73*(3), 309–327. doi:10.17763/haer.73.3.c149w3g81t381p67

Buckingham, D. (2013). *Beyond technology: Children's learning in the age of digital culture*. John Wiley & Sons.

Bugajska, J., Zużewicz, K., Szmauz-Dybko, M., & Konarska, M. (2007). Cardiovascular stress, energy expenditure and subjective perceived ratings of fire fighters during typical fire suppression and rescue tasks. *International Journal of Occupational Safety and Ergonomics*, *13*(3), 323–331. doi:10.1080/10803548.2007.11076730 PMID:17888240

Buheji, M., & Ahmed, D. (2020). Optimising Empathy in Dealing with Complex Problems during Challenging Times-The Case of Mariam & Empathetic Parenting. *International Journal of Management*, *11*(11).

Buil, I., Catalan, S., & Martinez, E. (2016). Do clickers enhance learning? A control-value theory approach. *Computers & Education*, *103*, 170–182. doi:10.1016/j.compedu.2016.10.009

Buil, I., Catalan, S., & Martinez, E. (2019). The influence of flow on learning outcomes: An empirical study on the use of clickers. *British Journal of Educational Technology*, *50*(1), 428–439. doi:10.1111/bjet.12561

Bundy, A. (2004). *Beyond Information: The academic library as educational change agent. Paper presented at the 7th International Bielefeld Conference Germany.* Retrieved January 17, 2022, from http://conference.ub.uni-bielefeld.de/2004/proceedings/bundy_rev.pdf

Buraphadeja, V., & Dawson, K. (2008, July). Content Analysis in Computer-Mediated Communication: Analyzing Models for Assessing Critical Thinking Through the Lens of Social Constructivism. *American Journal of Distance Education*, *22*(3), 130–145. doi:10.1080/08923640802224568

Burbach, M., Matkin, G., & Fritz, S. (2004). Teaching critical thinking in an introductory leadership course utilizing active learning strategies: A confirmatory study. *College Student Journal*, *38*(3), 482–493.

Cabañero, L., Hervás, R., González, I., Fontecha, J., Mondéjar, T., & Bravo, J. (2020). Characterisation of mobile-device tasks by their associated cognitive load through EEG data processing. *Future Generation Computer Systems*, *113*, 380–390.

Caldwell, J. E. (2007). Clickers in the large classroom: Current research and best-practice tips. *Life Sciences Education*, *6*(1), 9–20. doi:10.1187/cbe.06-12-0205 PMID:17339389

Caminal, P., Sola, F., Gomis, P., Guasch, E., Perera, A., Soriano, N., & Mont, L. (2018). Validity of the Polar V800 monitor for measuring heart rate variability in mountain running route conditions. *European Journal of Applied Physiology*, *118*(3), 669–677. doi:10.100700421-018-3808-0 PMID:29356949

Candy, P. C. (2004). *Linking thinking: Self-directed learning in the digital age*. Department of Education, Science and Training.

Cannon, C. P. (2007). Cardiovascular Disease and Modifiable Cardiometabolic Risk Factors. *Clinical Cornerstone*, *8*(3), 11–28. doi:10.1016/S1098-3597(07)80025-1 PMID:18452839

Carey, M. G., Al-Zaiti, S. S., Dean, G. E., Sessanna, L., & Finnell, D. S. (2011). Sleep problems, depression, substance use, social bonding, and quality of life in professional firefighters. *Journal of Occupational and Environmental Medicine*, *53*(8), 928–933. doi:10.1097/JOM.0b013e318225898f PMID:21785370

Carlén, A., Nylander, E., Åström Aneq, M., & Gustafsson, M. (2019). ST/HR variables in firefighter exercise ECG – relation to ischemic heart disease. *Physiological Reports*, *7*(2), 1–10. doi:10.14814/phy2.13968 PMID:30688031

Carliner, S. (2017). Informal learning. In R. A. Reiser & J. V. Dempsey (Eds.), *Trends and Issues in Instructional Design and Technology* (pp. 142–151). Pearson.

Carnaghan, C., Edmonds, T. P., Lechner, T. A., & Olds, P. R. (2011). Using student response systems in the accounting classroom: Strengths, strategies, and limitations. *Journal of Accounting Education*, *29*(4), 265–283. doi:10.1016/j.jaccedu.2012.05.002

Caro-López, H. (2010). *Ecuadorians in New York City 1990—2008.* Center for Latin American, Caribbean & Latino Studies. Retrieved from https://clacls.gc.cuny.edu/files/2013/10/Ecuadorians-in-New-York-1990-2008.pdf

Carpenter, G. S. J., Carpenter, T. P., Kimbrel, N. A., Flynn, E. J., Pennington, M. L., Cammarata, C., Zimering, R. T., Kamholz, B. W., & Gulliver, S. B. (2015). Social support, stress, and suicidal ideation in professional firefighters. *American Journal of Health Behavior*, *39*(2), 191–196. doi:10.5993/AJHB.39.2.5 PMID:25564831

Carter, T. J., & Adkins, B. (2017). Situated learning, communities of practice, and the social construction of knowledge. *Theory and Practice of Adult and Higher Education*, 113.

Carter, R. A. Jr, Rice, M., Yang, S., & Jackson, H. A. (2020). Self-regulated learning in online learning environments: Strategies for remote learning. *Information and Learning Science*, *121*(5–6), 311–319. doi:10.1108/ILS-04-2020-0114

Casillas, R., Morán, A. L., & Meza-Kubo, V. (2017, November). Evaluation of a multisensory stimulation tool: effect of auditory, olfactory and visual stimuli for scenario identification and memory evocation. In *International Conference on Ubiquitous Computing and Ambient Intelligence* (pp. 330-339). Springer. 10.1007/978-3-319-67585-5_35

Castillo, N. M., Lee, J., Zahra, F. T., & Wagner, D. A. (2015). MOOCS for development: Trends, challenges, and opportunities. *Information Technologies and International Development*, *11*(2), 35.

CCNMTL. (2013, June 25). *Design Research at CCNMTL | About Design Research at CCNMTL.* Retrieved August 05, 2017, from https://ccnmtl.columbia.edu/dr/about/

Celermajer, D. S., Sorensen, K. E., Gooch, V. M., Spiegelhalter, D. J., Miller, O. I., Sullivan, I. D., Lloyd, J. K., & Deanfield, J. E. (1992). Non-Invasive Detection of Endothelial Dysfunction in Children and Adults at Risk of Atherosclerosis. *Lancet*, *340*(8828), 1111–1115. doi:10.1016/0140-6736(92)93147-F PMID:1359209

Centers for Disease Control and Prevention. (2019). *Basics of COVID-19*. U.S. Department of Health and Human Services. Retrieved from https://www.cdc.gov/coronavirus/2019-ncov/your-health/about-covid-19/basics-covid-19.html

Centers for Disease Control. (2021a, August 2). *COVID-19 Risks and Vaccine Information for Older Adults*. https://www.cdc.gov/aging/covid19/covid19-older-adults.html

Centers for Disease Control. (2021b, December 13). *COVID-19 Vaccines for Children and Teens*. https://www.cdc.gov/coronavirus/2019-ncov/vaccines/recommendations/children-teens.html

Chaffey, D. (2021, March 30). *Mobile marketing statistics compilation*. Retrieved December 18, 2021, from https://www.smartinsights.com/mobile-marketing/mobile-marketing-analytics/mobile-marketing-statistics

Chandel, R. S., Sharma, S., Kaur, S., Singh, S., & Kumar, R. (2021). Smart watches: A review of evolution in bio-medical sector. *Materials Today: Proceedings*.

Chan, S. C. H., & Ko, S. (2019). Personal response systems and learning performance: The mediating role of learners' engagement. *Journal of Education for Business*, *94*(4), 234–242. doi:10.1080/08832323.2018.1520684

Chan, S. C. H., & Ko, S. (2020). The dark side of personal response systems (PRSs): Boredom, feedback, perceived learning, learning satisfaction. *Journal of Education for Business*, *96*(7), 435–444. doi:10.1080/08832323.2020.1848769

Chan, S. C. H., Wan, C. L. J., & Ko, S. (2019). Interactivity, active collaborative learning, and learning performance: The moderating role of perceived fun by using personal response systems. *International Journal of Management Education*, *17*(1), 94–102. doi:10.1016/j.ijme.2018.12.004

Chan, S. C., & Ko, S. (2018). The Impact of Personal Response Systems on Students' Learning Performance: Research Implications and Future Research Directions. In *Computer-Mediated Learning for Workforce Development* (pp. 234–250). IGI Global.

Chappel, S. E., Aisbett, B., Vincent, G. E., & Ridgers, N. D. (2016). Firefighters' Physical Activity across Multiple Shifts of Planned Burn Work. *International Journal of Environmental Research and Public Health*, *13*(10), 973. Advance online publication. doi:10.3390/ijerph13100973 PMID:27706057

Cheers, D. M. (2013). A remembrance of Mangaliso Dukuza Alf Kumalo of South Africa. *Visual Communication Quarterly*, *20*(4), 220–231. doi:10.1080/15551393.2013.849993

Cheng, K. S., Croarkin, P. E., & Lee, P. F. (2019). Heart rate variability of various video-aided mindful deep breathing durations and its impact on depression, anxiety, and stress symptom severity. *Mindfulness*, *10*(10), 2082–2094. doi:10.100712671-019-01178-8

Cheng, L. T. W., & Wang, J. W. (2019). Enhancing learning performance through classroom response systems: The effect of knowledge type and social presence. *International Journal of Management Education*, *17*(1), 103–118. doi:10.1016/j.ijme.2019.01.001

Chen, J. C., Whittinghill, D. C., & Kadlowec, J. A. (2010). Classes that click: Fast, rich feedback to enhance students' learning and satisfaction. *Journal of Engineering Education*, *99*(2), 158–169. doi:10.1002/j.2168-9830.2010.tb01052.x

Chen, O., Woolcott, G., & Sweller, J. (2017). Using cognitive load theory to structure computer-based learning including MOOCs. *Journal of Computer Assisted Learning*, *33*(4), 293–305. doi:10.1111/jcal.12188

Chiauzzi, E., Clayton, A., & Huh-Yoo, J. (2020). Videoconferencing-Based Telemental Health: Important Questions for the COVID-19 Era From Clinical and Patient-Centered Perspectives. *JMIR Mental Health*, *7*(12), e24021. doi:10.2196/24021 PMID:33180739

Chien, Y. T., Chang, Y. H., & Chang, C. Y. (2016). Do we click in the right way? A meta-analytic review of clicker-integrated instruction. *Educational Research Review*, *17*, 1–18. doi:10.1016/j.edurev.2015.10.003

Chitungo, I., Mhango, M., Mbunge, E., Dzobo, M., Musuka, G., & Dzinamarira, T. (2021). Utility of telemedicine in sub-Saharan Africa during the COVID-19 pandemic. A rapid review. *Human Behavior and Emerging Technologies*.

Choi, B., Ko, S., & Kojaku, S. (2017). Resting heart rate, heart rate reserve, and metabolic syndrome in professional firefighters: A cross-sectional study. *American Journal of Industrial Medicine*, *60*(10), 900–910. doi:10.1002/ajim.22752 PMID:28869309

Choi, D. H., Kim, J., & Kim, S. H. (2007). ERP training with a web-based electronic learning system: The flow theory perspective. *International Journal of Human-Computer Studies*, *65*(3), 223–243. doi:10.1016/j.ijhcs.2006.10.002

Choy, S. C., & Cheah, P. K. (2009). Teacher Perceptions of Critical Thinking Among Students and its Influence on Higher Education. *International Journal on Teaching and Learning in Higher Education*, *20*(2), 198–206.

Chuang, C., Chung, W., Shu, C., & Chen, M. (2007). Pain Assessment in Musculoskeletal Pain Patients by Heart Rate Variability. Journal of Musculoskeletal Pain. doi:10.1300/J094v15n04

Chung, G., Chan, X., Lanier, P., & Ju, P. W. Y. (2020, June 25). Associations between work-family balance, parenting stress, and marital conflicts during COVID-19 pandemic in singapore. doi:10.31219/osf.io/nz9s8osf.io/nz9s8

Cilhoroz, B., Zaleski, A., Taylor, B., Fernhall, B., Chen, M., Thompson, P., & Pescatello, L. (2021). The ambulatory blood pressure and heart rate variability responses following sudden vigorous physical exertion among firefighters with hypertension [Hipertansiyonlu itfaiyeciler arasında ani yü ksek şiddetli fiziksel efor sonrası ambulatuvar kan basıncı]. *Turkish Journal of Sports Medicine*, *56*(3), 98–105. doi:10.47447/tjsm.0492

Cisel, M., & Bruillard, É. (2013). *Chronique des MOOC. STICEF*. Sciences et Technologies de l'Information et de la Communication pour l'Éducation et la Formation.

Clancey, W. J. (1995). *A tutorial on situated learning*. In J. Self (Ed.), *Proceedings of the International Conference on Computers and Education* (pp. 49-70). Charlottesville, VA: AACE.

Clarke, V., & Braun, V. (2013). Teaching thematic analysis: Overcoming challenges and developing strategies for effective learning. *The Psychologist*, *26*(2), 120–123.

Clauzel, A., Riché, C., Le Hegarat, B., & Zerbib, R. (2020). Co-presence and mobile apps: Technology's impact on being with others. *Canadian Journal of Administrative Sciences/Revue Canadienne des Sciences de l'Administration, 37*(1), 30–44. doi:10.1002/cjas.1553

Cleland-Huang, J. (2015). Mining Domain Knowledge. *IEEE Software*, *32*(3), 16–19. doi:10.1109/MS.2015.67

Clemens, B., & Bakstran, L. (2010). A framework of theoretical lenses and strategic purposes to describe relationships among firm environmental strategy, firm performance, and environmental performance. *Management Research Review*, *33*(4), 393–405. doi:10.1108/01409171011030480

Clifford, R. M. S., Jung, S., Hoerrnann, S., Billinqhurst, M., & Lindeman, R. W. (2019). Creating a stressful decision making environment for aerial firefighter training in virtual reality. *26th IEEE Conference on Virtual Reality and 3D User Interfaces, VR 2019 - Proceedings*, 181–189. 10.1109/VR.2019.8797889

Coaston, S. C. (2017). Self-Care through Self-Compassion: A Balm for Burnout. *The Professional Counselor*, *7*(3), 285–297. doi:10.15241cc.7.3.285

Coatsworth, J. D., Duncan, L. G., Berrena, E., Bamberger, K. T., Loeschinger, D., Greenberg, M. T., & Nix, R. L. (2014). The Mindfulness-enhanced Strengthening Families Program: Integrating brief mindfulness activities and parent training within an evidence-based prevention program. *New Directions for Youth Development*, *2014*(142), 45–58. doi:10.1002/yd.20096 PMID:25100494

CommLabIndia. (2016, February 24). *Top Mobile Learning Trends*. Retrieved December 02, 2017, from http://blog.tristit.com/top-mobile-learning-trends/271

Congressional Research Service. (2021, September 1). *Unaccompanied Alien Children: An Overview.* https://crsreports.congress.gov

Cooke, F. J., Dickmann, M., & Parry, E. (2021). IJHRM after 30 years: Taking stock in times of COVID-19 and looking towards the future of HR research. *International Journal of Human Resource Management*, *32*(1), 1–23. doi:10.1080/09585192.2020.1833070

Corbin, J., & Strauss, A. (2015). Basics of Qualitative Research. *Sage (Atlanta, Ga.)*.

Corley, K. G. (2015). A commentary on 'what grounded theory is…' engaging a phenomenon from the perspective of those living it. *Organizational Research Methods*, *18*(4), 600–605. doi:10.1177/1094428115574747

Coronavirus Resource Center. (2021). *COVID-19 Data in Motion*. https://coronavirus.jhu.edu/

Craig, L., & Churchill, B. (2021). Dual-earner parent couples' work and care during COVID-19. *Gender, Work and Organization*, *28*(S1), 66–79. doi:10.1111/gwao.12497 PMID:32837023

Crosbie, T., & Moore, J. (2004). Work–life balance and working from home. *Social Policy and Society*, *3*(3), 223–233. doi:10.1017/S1474746404001733

Cruse, E. (2006). Using educational video in the classroom: Theory, research and practice. *Library Video Company*, *12*(4), 56–80.

Cullen, S., O'Loughlin, G., McGoldrick, A., Smyth, B., May, G., & Warrington, G. D. (2015). Physiological Demands of Flat Horse Racing Jockeys. *Journal of Strength and Conditioning Research*, *29*(11), 3060–3066. doi:10.1519/JSC.0000000000000977 PMID:25932980

Curinga, M. X., & Saravanos, A. (2016). Mobile First E-Learning. In D. Mentor (Ed.), *Handbook of Research on Mobile Learning in Contemporary Classrooms* (pp. 23–36). IGI Global. doi:10.4018/978-1-5225-0251-7.ch002

Currie, C. L. (2001). Facilitating adult learning: The role of the academic librarian. *The Reference Librarian*, *33*(69-70), 219–231. doi:10.1300/J120v33n69_21

Custer, O., Deutscher, P., & Haddad, S. (Eds.). (2016). *Foucault/Derrida Fifty Years Later: The Futures of Genealogy, Deconstruction, and Politics*. Columbia University Press. doi:10.7312/cust17194

Dąbrowska, A., Bartkowiak, G., & Kotas, R. (2021). Evaluation of Functionality of Warning System in Smart Protective Clothing for Firefighters. *Sensors (Basel)*, *21*(5), 1767. Advance online publication. doi:10.339021051767 PMID:33806399

Dahlgren, R. L. (2017). Education and Popular Culture Narratives. In *From Martyrs to Murderers* (pp. 13–30). Sense-Publishers. doi:10.1007/978-94-6300-965-2_2

Daniel, J. (2013). *Lack of funds hampers library development in Nigeria Premium Times*. Nigeria Premium Times.

Das, M., Tang, J., Ringland, K. E., & Piper, A. M. (2021). Towards Accessible Remote Work: Understanding Work-from-Home Practices of Neurodivergent Professionals. *Proceedings of the ACM on Human-Computer Interaction, 5*(CSCW1), 1-30. 10.1145/3449282

Dauch, C., Imwalle, M., Ocasio, B., & Metz, A. E. (2018). The influence of the number of toys in the environment on toddlers' play. *Infant Behavior and Development*, *50*, 78–87. doi:10.1016/j.infbeh.2017.11.005 PMID:29190457

David, M. E., & Roberts, J. A. (2021). Smartphone Use during the COVID-19 Pandemic: Social Versus Physical Distancing. *International Journal of Environmental Research and Public Health*, *18*(3), 1034. PMID:33503907

Davidson, S. P., Cain, S. M., McGinnis, R. S., Vitali, R. R., Perkins, N. C., & McLean, S. G. (2016). Quantifying warfighter performance in a target acquisition and aiming task using wireless inertial sensors. *Applied Ergonomics*, *56*, 27–33. doi:10.1016/j.apergo.2016.03.001 PMID:27184308

Davidson-Shivers, G. V., Rasmussen, K. L., & Lowenthal, P. R. (2018). Foundations of Online Learning and Instructional Design. In *Web-Based Learning* (pp. 43–79). Springer.

Davies, I. E. E., Nwankwo, C. O., Olofinnade, O. M., & Michaels, T. A. (2019). Insight review on impact of infrastructural development in driving the SDGs in developing nations: A case study of Nigeria. In 1st International conference on sustainable infrastructural development. IOP Publishing. https://doi.org/ 10.1088/1757-899X/640/1/012112.

Dawson, M. R. W. (2013). *Mind, body, world: Foundations of cognitive science*. AU Press.

de Block, L., Buckingham, D., & Banaji, S. (2005). *Final project report: Children in communication about migration*. London: Institute of Education, University of London.

De Smidt, J., Odendaal, H. J., Nel, D. G., Nolan, H., Du Plessis, C., Brink, L. T., & Oelofse, A. (2019). In Utero Teratogen Exposure and Cardiometabolic Risk in 5-Year-Old Children : A Prospective Pediatric Study. *The Journal of Maternal-Fetal & Neonatal Medicine*, *0*(0), 1–10. doi:10.1080/14767058.2019.1692337 PMID:31762362

Delgado, R. (1989). Storytelling for oppositionists and others: A plea for narrative. *Michigan Law Review*, *87*(8), 2411–2441. doi:10.2307/1289308

Dennison, K. J., Mullineaux, D. R., Yates, J. W., & Abel, M. G. (2012). The Effect of Fatigue and Training Status on Firefighter Performance. *Journal of Strength and Conditioning Research*, *26*(4), 1101–1109. doi:10.1519/JSC.0b013e31822dd027 PMID:22446677

Deol, N. K., & Brar, K. S. (2021). The pandemic of COVID 19 and Role of Academic Libraries. *Library Philosophy and Practice*, 1-10. http://ezproxy.cul.columbia.edu/login?url=https://www.proquest.com/scholarly-journals/pandemic-covid-19-role-academic-libraries/docview/2561526465/se-2

Department of Education, Skills and Employment. (2020). *Higher Education Statistics Data Cube*. http://highereducationstatistics.education.gov.au/

Department of Justice. (2018). *Sixth Report Assessing Settlement Agreement Compliance by Suffolk County Police Department.* Retrieved from https://www.justice.gov/crt/case-document/file/1054396/download

Dewey, J. (1938). *Experience and Education*. Collier Books.

Dhar, B. V. (2013). Dhar_Data_Science_Prediction. *Communications of the ACM*, *56*(12), 64–73. doi:10.1145/2500499

Dhawan, S. (2020). Online Learning: A Panacea in the Time of COVID-19 Crisis. *Journal of Educational Technology Systems*, *49*(1), 5–22. doi:10.1177/0047239520934018

Dias, P., & Brito, R. (2021). Criteria for selecting apps: Debating the perceptions of young children, parents and industry stakeholders. *Computers & Education*, *165*, 104134. doi:10.1016/j.compedu.2021.104134

Dillahunt, T. R., Wang, B. Z., & Teasley, S. (2014). Democratizing higher education: Exploring MOOC use among those who cannot afford a formal education. *The International Review of Research in Open and Distributed Learning*, *15*(5).

Dobson, M., Choi, B., Schnall, P. L., Wigger, E., Garcia-Rivas, J., Israel, L., & Baker, D. B. (2013). Exploring Occupational and Health Behavioral Causes of Firefighter Obesity: A Qualitative Study. *American Journal of Industrial Medicine*, *56*(7), 776–790. doi:10.1002/ajim.22151 PMID:23335437

Domoff, S. E., Borgen, A. L., & Radesky, J. S. (2020). Interactional theory of childhood problematic media use. *Human Behavior and Emerging Technologies*, *2*(4), 343–353. doi:10.1002/hbe2.217

Donald, I. (2013). *History A Short History of Sonography in Obstetrics and Gynaecology*. Academic Press.

Donald, W. E. (2021). *Conceptualisation of a new 'Early Careers Talent Pipeline' Framework: Enhancing Organizational Sustainability via Feedback-Seeking Behaviour*. Graduate Recruitment Bureau.

Donald, W. E., Ashleigh, M. J., & Baruch, Y. (2021, September 03). (in press). The university-to-work transition: Responses of universities and organizations to the COVID-19 pandemic. *Personnel Review*. Advance online publication. doi:10.1108/PR-03-2021-0170

Donald, W. E., Baruch, Y., & Ashleigh, M. J. (2019). The undergraduate self-perception of employability: Human capital, careers advice, and career ownership. *Studies in Higher Education*, *44*(4), 599–614. doi:10.1080/03075079.2017.1387107

Donald, W. E., Baruch, Y., & Ashleigh, M. J. (2020). Striving for sustainable graduate careers: Conceptualization via career ecosystems and the new psychological contract. *Career Development International*, *25*(2), 90–110. doi:10.1108/CDI-03-2019-0079

Donker, M. H., Mastrotheodoros, S., & Branje, S. (2021). Development of parent-adolescent relationships during the COVID-19 pandemic: The role of stress and coping. *Developmental Psychology*, *57*(10), 1611–1622. doi:10.1037/dev0001212 PMID:34807684

Donovan, G. (2009).. . *Validity and Reliability of Short-Term Heart-Rate Variability from the Polar*, *S810*(January). Advance online publication. doi:10.1249/MSS.0b013e318184a4b1

Dorsey, E. R., & Topol, E. J. (2016). State of Telehealth. *The New England Journal of Medicine*, *375*(2), 154–161. doi:10.1056/NEJMra1601705 PMID:27410924

Dreesen, T., Akseer, S., Brossard, M., Dewan, P., Giraldo, J. P., Kamei, A., Mizunoyai, S., & Ortiz, J. S. (2020). *Promising practices for equitable remote learning: Emerging lessons from COVID-19 education responses in 127 countries*. UNICEF Office of Research.

Driscoll, M. P. (2017). Psychological foundations of instructional design. In R. A. Reiser & J. V. Dempsey (Eds.), *Trends and Issues in Instructional Design and Technology* (pp. 52–60). Pearson.

Dunn, R., & Dunn, K. (1974). Learning style as a criterion for placement in alternative programs. *Phi Delta Kappan*, *56*(4), 275–278.

Dwikoranto, D., Setiani, R., Prahani, B. K., & Mubarok, H. (2020). Mobile learning to improve student collaborative skills: An alternative to online learning in the era of Covid-19 pandemic. *Jurnal Penelitian dan Pengkajian Ilmu Pendidikan: e-Saintika, 4*(3), 259-271.

Eastman, J. K., Iyer, R., & Eastman, K. L. (2011). Business students' perceptions, attitudes, and satisfaction with interactive technology: An exploratory study. *Journal of Education for Business*, *86*(1), 36–43. doi:10.1080/08832321003774756

Ebersole, K. T., Cornell, D. J., Flees, R. J., Shemelya, C. M., & Noel, S. E. (2020). Contribution of the Autonomic Nervous System to Recovery in Firefighters. *Journal of Athletic Training*, *55*(9), 1001–1008. doi:10.4085/1062-6050-0426.19 PMID:32841323

Ebner, M., Schön, S., Braun, C., Ebner, M., Grigoriadis, Y., Haas, M., Leitner, P., & Taraghi, B. (2020). COVID-19 epidemic as E-learning boost? Chronological development and effects at an Austrian university against the background of the concept of "E-learning readiness." *Future Internet*, *12*(6).

Edelson, D. C. (2002). Design research: What we learn when we engage in design. *Journal of the Learning Sciences*, *11*(1), 105–121. doi:10.1207/S15327809JLS1101_4

Egenfeldt-Nielsen, S. (2006). Overview of research on the educational use of video games. *Nordic Journal of Digital Literacy*, *1*(03), 184–214. doi:10.18261/ISSN1891-943X-2006-03-03

el Kaliouby, R. (2017). We need computers with empathy. *MIT's Technology Review*, *120*(6), 8–9.

Eliakim, R., Yassin, K., Shlomi, I., Suissa, A., & Eisen, G. M. (2004). A novel diagnostic tool for detecting oesophageal pathology: The PillCam oesophageal video capsule. *Alimentary Pharmacology & Therapeutics*, *20*(10), 1083–1089. doi:10.1111/j.1365-2036.2004.02206.x PMID:15569110

Elias, J. L., & Merriam, S. B. (1995). *Philosophical foundations of adult education*. Krieger Publishing.

Emotion. (n.d.). Retrieved February 23, 2018 from https://en.wikipedia.org/wiki/Emotion

Epelboin, Y. (2017). MOOCs: A Viable Business Model? In *Open Education: from OERs to MOOCs* (pp. 241–259). Springer Berlin Heidelberg. doi:10.1007/978-3-662-52925-6_13

Epure, A. M., Rios-Leyvraz, M., Anker, D., Di Bernardo, S., da Costa, B. R., Chiolero, A., & Sekarski, N. (2020). Risk Factors during First 1,000 Days of Life for Carotid Intima-Media Thickness in Infants, Children, and Adolescents: A Systematic Review with Meta-Analyses. *PLoS Medicine*, *17*(11), 1–29. doi:10.1371/journal.pmed.1003414 PMID:33226997

Eriksen, D., & Watstein, S. B. (2022). Collaborating to Remove Barriers to Success. *portal*. *Portal (Baltimore, Md.)*, *22*(1), 241–257.

Ertmer, P. A., & Newby, T. J. (1993). Behaviorism, cognitivism, constructivism: Comparing critical features from an instructional design perspective. *Performance Improvement Quarterly*, *6*(4), 50–72. doi:10.1111/j.1937-8327.1993.tb00605.x

Evans, B. J., & Baker, R. B. (2016). MOOCs and persistence: Definitions and predictors. *New Directions for Institutional Research*, *2015*(167), 69–85.

Everson, M. E. (2011). Best practices in teaching logographic and non-Roman writing systems to L2 learners. *Annual Review of Applied Linguistics*, *31*, 249–274. doi:10.1017/S0267190511000171

Fan, J., & Smith, A. P. (2021). Information Overload, Wellbeing and COVID-19: A Survey in China. *Behavioral Sciences (Basel, Switzerland)*, *11*(5), 62. doi:10.3390/bs11050062 PMID:33925611

Farag, D. M., Park, S., & Kaupins, G. (2015). Faculty perceptions of the adoption and use of clickers in the legal studies in business classroom. *Journal of Education for Business*, *90*(4), 208–216. doi:10.1080/08832323.2015.1014459

Farioli, A., Yang, J., Teehan, D., Baur, D. M., Smith, D. L., & Kales, S. N. (2014). Duty-related risk of sudden cardiac death among young US firefighters. *Occupational Medicine*, *64*(6), 428–435. doi:10.1093/occmed/kqu102 PMID:25104277

Farrugia, L., Lauri, M. A., Borg, J., & O'Neill, B. (2019). Have You Asked for It? An Exploratory Study About Maltese Adolescents' Use of Ask.fm. *Journal of Adolescent Research*, *34*(6), 738–756. doi:10.1177/0743558418775365

FBI. (2018, September 14). *Hate Crime*. Retrieved December 28, 2021, from https://www.fbi.gov/services/cjis/ucr/hate-crime

Feairheller, D. L. (2015). Blood pressure and heart rate responses in volunteer firefighters while wearing personal protective equipment. *Blood Pressure Monitoring*, *20*(4), 194–198. doi:10.1097/MBP.0000000000000120 PMID:25856421

Feijt, M. (2017). *Perceived drivers and barriers to the adoption of online counseling by psychologists: the construction of the levels of adoption of online counseling model.* Master Thesis.

Felder, R. M., & Silverman, L. K. (1988). Learning and teaching styles in engineering education. *Engineering Education, 78*(7), 674-681.

Feldon, D. F., Callan, G., Juth, S., & Jeong, S. (2019). Cognitive Load as Motivational Cost. *Educational Psychology Review*, *31*(2), 319–337. doi:10.100710648-019-09464-6

Felicia, P. (Ed.). (2011). *Handbook of Research on Improving Learning and Motivation through Educational Games: Multidisciplinary Approaches: Multidisciplinary Approaches*. IGI Global. doi:10.4018/978-1-60960-495-0

Fenn, J., & Linden, A. (2005). *Gartner's Hype Cycle Special Report for 2005*. Academic Press.

Fernandes, T. (2021, February 24). *How you can apply the 80/20 rule in your life and work*. Medium. Retrieved January 10, 2022, from https://medium.com/pm101/how-you-can-apply-the-80-20-rule-in-your-life-and-work-7d094a78e136

Fernandez, P. (2020). "Through the looking glass: envisioning new library technologies" pandemic response technologies: remote working. *Library Hi Tech News*, *37*(5), 21–23. doi:10.1108/LHTN-04-2020-0039

Fernros, L., Furhoff, A. K., & Wändell, P. E. (2008). Improving quality of life using compound mind-body therapies: Evaluation of a course intervention with body movement and breath therapy, guided imagery, chakra experiencing and mindfulness meditation. *Quality of Life Research: An International Journal of Quality of Life Aspects of Treatment, Care and Rehabilitation*, *17*(3), 367–376. doi:10.100711136-008-9321-x PMID:18324479

Fiebig, J. H., Gould, E. R., Ming, S., & Watson, R. A. (2020). An Invitation to Act on the Value of Self-Care: Being a whole person in all that you do. *Behavior Analysis in Practice*, *13*(3), 1–9. doi:10.100740617-020-00442-x PMID:32837703

Firoozeh, M., Saremi, M., Kavousi, A., & Maleki, A. (2017). Demographic and occupational determinants of the work ability of firemen. *Journal of Occupational Health*, *59*(1), 81–87. doi:10.1539/joh.15-0296-FS PMID:27916763

Fischer, F., Kollar, I., Stegmann, K., & Wecker, C. (2013). Toward a script theory of guidance in computer-supported collaborative learning. *Educational Psychologist*, *48*(1), 56–66.

Flaherty, M., & Miller, D. (2016). Rural Public Libraries as Community Change Agents: Opportunities for Health Promotion. *Journal of Education for Library and Information Science Online*, *57*(2), 143–150. https://doi.org/10.12783/issn.2328-2967/57/2/6

Flenn, J., & Blosch, M. (2018, August 20). *Understanding Gartner's hype cycles*. Gartner. https://www.gartner.com/en/documents/3887767

Fletcher, C. (2019). Educational Technology and the Humanities: A History of Control. In M. K. Gold & L. F. Klein (Eds.), *Debates in the Digital Humanities 2019* (pp. 369–381). University of Minnesota Press. doi:10.5749/j.ctvg251hk.33

Fordham University of Law & Vera Institute of Justice. (2015). *Unaccompanied immigrant youth in New York: Study for identity and inclusion- a participatory research study*. Retrieved from https://www.fordham.edu/download/downloads/id/2416/unaccompanied_immigrant_youth_in_new_york_august_2015.pdf

Freifeld, L. (2020, September 8). *2020 Emerging Training Leader Winners*. Retrieved December 28, 2021, from https://trainingmag.com/2020-emerging-training-leader-winners/

Friesen, N. (2012). *Report: Defining blended learning.* http://learningspaces. org/papers/Defining_Blended_Learning_NF. pdf

Fromberg, D. P., & Bergen, D. (2006). *Play from birth to twelve: Contexts, perspectives, and meanings*. Routledge.

Frost, D. M., Beach, T. A. C., Crosby, I., & McGill, S. M. (2015). Firefighter injuries are not just a fireground problem. *Work (Reading, Mass.)*, *52*(4), 835–842. doi:10.3233/WOR-152111 PMID:26409354

Fuchs, E., Bruch, A., & Annegarn-Gläß, M. (2016). Introduction: Educational Films: A Historical Review of Media Innovation in Schools. Journal of Educational Media. *Memoria y Sociedad: Revista del Departamento de Historia y Geografia*, *8*(1), 1–13.

Furini, M., Geraci, F., Montangero, M., & Pellegrini, M. (2009). STIMO: STIll and MOving video storyboard for the web scenario. *Multimedia Tools and Applications*, *46*(1), 47–69. doi:10.100711042-009-0307-7

Gaebel, M. (2014). *MOOCs: Massive open online courses*. EUA.

Galyer, K. T., & Evans, I. M. (2001). Pretend play and the development of emotion regulation in preschool children. *Early Child Development and Care*, *166*(1), 93–108. doi:10.1080/0300443011660108

Gao, Y., Liu, T. C., & Paas, F. (2016). Effects of mode of target task selection on learning about plants in a mobile learning environment: Effortful manual selection versus effortless QR-code selection. *Journal of Educational Psychology*, *108*(5), 694.

Garcia, J., & Nelson, S. (2007). *Public Library Service Responses*. American Library Association.

Gaskin, J. E., & Skousen, T. (2016). Time-chunking and hyper-refocusing in a digitally-enabled workplace: Six forms of knowledge workers. *Frontiers in Psychology*, *7*, 1627. doi:10.3389/fpsyg.2016.01627 PMID:27822193

Gaughan, D. M., Siegel, P. D., Hughes, M. D., Chang, C. Y., Law, B. F., Campbell, C. R., Richards, J. C., Kales, S. F., Chertok, M., Kobzik, L., Nguyen, P., O'Donnell, C. R., Kiefer, M., Wagner, G. R., & Christiani, D. C. (2014). Arterial stiffness, oxidative stress, and smoke exposure in wildland firefighters. *American Journal of Industrial Medicine*, *57*(7), 748–756. doi:10.1002/ajim.22331 PMID:24909863

Gendron, P., Lajoie, C., Laurencelle, L., & Trudeau, F. (2018). Cardiovascular Disease Risk Factors in Québec Male Firefighters. *Journal of Occupational and Environmental Medicine*, *60*(6), e300–e306. doi:10.1097/JOM.0000000000001309 PMID:29461386

Gershman, A. V., McCarthy, J. F., & Frano, A. E. (1999). Situated computing: Bridging the gap between intention and action. In *Wearable Computers, 1999. Digest of Papers. The Third International Symposium on Wearable Computers* (pp. 3-9). IEEE.

Ghamrawi, N. (2022). Teachers' virtual communities of practice: A strong response in times of crisis or just another fad? *Education and Information Technologies*. Advance online publication. doi:10.100710639-021-10857-w PMID:35095322

Ghanim, M., Abu Obaid, A., Salha, S., & Affouneh, S. (2021). The Motives and Challenges of developing and delivering MOOCs courses. *Education in the Knowledge Society*.

Gier, V. S., & Kreiner, D. S. (2009). Incorporating active learning with PowerPoint-based lectures using content-based questions. *Teaching of Psychology*, *36*(2), 134–139. doi:10.1080/00986280902739792

Giudice, Dilillo, Tromba, La Torre, Blasi, Conti, Viola, Cucchiara, & Duse. (2018). *Aortic, Carotid Intima-Media Thickness and Flow- Mediated Dilation as Markers of Early Atherosclerosis in a Cohort of Pediatric Patients with Rheumatic Diseases*. . doi:10.1007/s10067-017-3705-7

Glavas, C., & Schuster, L. (2020). Design principles for electronic work integrated learning (eWIL). *The Internet and Higher Education*, *47*, 100760. Advance online publication. doi:10.1016/j.iheduc.2020.100760

Global Human Capital Trends. (2016). *The New Organization: Different by Design*. Deloitte University Press.

Gobert, J. D., Sao Pedro, M., Raziuddin, J., & Baker, R. S. (2013). From Log Files to Assessment Metrics: Measuring Students' Science Inquiry Skills Using Educational Data Mining. *Journal of the Learning Sciences*, *22*(4), 521–563. doi:10.1080/10508406.2013.837391

Goh, P. S., & Sandars, J. (2020). A vision of the use of technology in medical education after the COVID-19 pandemic. *MedEdPublish*, *49*(9).

Gómez-Galán, J., Martín Padilla, A., Bravo, C. B., & Meneses, E. L. (2019). *MOOC Courses and the Future of Higher Education : A New Pedagogical Framework*. River Publishers.

Goodman, S. (2010). Educating for democracy: An uncommon standard. *The New York Times,* pp. 1-6.

Goodman, S. (2020). Teaching for Environmental Justice at the Educational Video Center. *Journal of Sustainability Education*.

Goodman, S. (2003). *Teaching youth media*. Teachers College Columbia University.

Goodyear, P., Jones, C., & Thompson, K. (2014). Computer-supported collaborative learning: Instructional approaches, group processes and educational designs. In *Handbook of research on educational communications and technology* (pp. 439–451). Springer.

Goran, S. F. (2020). Chapter Twenty-One The Telehealth Nurse: Yesterday, Today And In The Future Susan Flewelling Goran, MSN, RN. *The Many Roles of the Registered Nurse*, 217.

Great School Partnership. (2014, March 5). *Bloom's Taxonomy Definition by the glossary of education reform*. Retrieved March 06, 2018, from https://www.edglossary.org/blooms-taxonomy/

Grund, C. K., & Tulis, M. (2019). Facilitating student autonomy in large-scale lectures with audience response systems. *Educational Technology Research and Development*, *68*(3), 975–993. doi:10.100711423-019-09713-z

Gumzej, R. (2021). E-Health. In *Intelligent Logistics Systems for Smart Cities and Communities* (pp. 45–51). Springer. doi:10.1007/978-3-030-81203-4_5

Guo, P. (2017). MOOC and SPOC, Which One is Better? *Eurasia Journal of Mathematics, Science and Technology Education*, *13*(8). Advance online publication. doi:10.12973/eurasia.2017.01044a

Guo, Y. J., Liu, Y. Q., & Bielefield, A. (2018). The provision of mobile services in US Urban Libraries. *Information Technology and Libraries*, *37*(2), 78–93. https://doi.org/10.6017/ital.v37i2.10170

Guzdial, M. (2014). Limitations of MOOCs for Computing Education-Addressing our needs: MOOCs and technology to advance learning and learning research (Ubiquity symposium). *Ubiquity*, *2014*(July), 1.

Gyongyi, Z., Koutrika, G., & Pedersen, J. (2008). Questioning yahoo! answers. *Www2008*. http://ilpubs.stanford.edu:8090/819

Halbeisen, G., & Walther, E. (2021). How to promote healthy eating in preschool children: Evidence from an associative conditioning procedure with non-food stimuli. *Appetite*, *166*, 105472. doi:10.1016/j.appet.2021.105472 PMID:34153424

Hall, Coffin, Cyr, Persutte, Roberts, Spitz, & Waggoner. (1999). *The Ultrasound Practitioner*. Academic Press.

Han, I. (2019). Investigating lecturers' reasons for adoption of mobile learning in higher education: A case study. *Research Repository*, 435.

Hancock, C. V., & Bone, G. E. (1964). Producing 8mm teaching films. *Education + Training*.

Han, J. H. (2014). Unpacking and repacking the factors affecting students' perceptions of the use of classroom communication systems (CCS) technology. *Computers & Education*, *79*, 159–176. doi:10.1016/j.compedu.2014.07.011

Harasim, L. (2017). *Learning theory and online technologies*. Taylor & Francis Group. doi:10.4324/9781315716831

Harati, H., Yen, C.-J., Tu, C.-H., Cruickshank, B. J., & Armfield, S. W. J. (2020). Online Adaptive Learning. *International Journal of Web-Based Learning and Teaching Technologies*, *15*(4), 18–35. doi:10.4018/IJWLTT.2020100102

Harris, D. (2016). Rhizomatic education and Deleuzian theory. *Open Learning*, *31*(3), 219–232. doi:10.1080/02680513.2016.1205973

Hart, J. (2013). *Art of the Storyboard: A Filmmaker's Introduction*. CRC Press LLC. doi:10.4324/9780080552781

Havenith, G., & van Middendorp, H. (1990). The relative influence of physical fitness, acclimatization state, anthropometric measures and gender on individual reactions to heat stress. *European Journal of Applied Physiology and Occupational Physiology*, *61*(5), 419–427. doi:10.1007/BF00236062 PMID:2079061

Hawkins, J. B. (2011). *Bridging the knowledge gap: The effectiveness of compulsory computer-based training in federal employees' professional education* (Doctoral dissertation). Retrieved from https://search-proquest-com.ezproxy.cul.columbia.edu/docview/916240004?accountid=10226

Hawk, T. F., & Shah, A. J. (2007). Using Learning Style Instruments to Enhance Student Learning. *Decision Sciences Journal of Innovative Education*, *5*(1), 1–19. doi:10.1111/j.1540-4609.2007.00125.x

Haynes, T. (2018, May 1). *Dopamine, Smartphones & You: A battle for your time* [Web log post]. Retrieved December 18, 2021, from https://sitn.hms.harvard.edu/flash/2018/dopamine-smartphones-battle-time/

Hedgcock, W. H., & Rouwenhorst, R. M. (2014). Clicking their way to success: Using student response systems as a tool for feedback. *Journal for Advancement of Marketing Education*, *22*(2), 16–25.

Heesch, M. W. S., & Slivka, D. R. (2015). Running Performance, Pace Strategy, and Thermoregulation Differ Between a Treadmill and Indoor Track. *Journal of Strength and Conditioning Research*, *29*(2), 330–335. doi:10.1519/JSC.0000000000000662 PMID:25162647

Heifetz, R. A. (1994). *Leadership without easy answers* (Vol. 465). Harvard University Press. doi:10.4159/9780674038479

Heifetz, R. A., & Linsky, M. (2014). *Adaptive Leadership: The Heifetz Collection (3 Items)*. Harvard Business Review Press.

Hellemans, J., Willems, K., & Brengman, M. (2020).. . *Daily Active Users of Social Network Sites: Facebook, Twitter, and Instagram-Use Compared to General Social Network Site Use.*, *1*, 194–202.

Hennessy, J. L., & Patterson, D. A. (2019). *Computer architecture: A quantitative approach* (6th ed.). Morgan Kaufmann Publishers., doi:10.1145/3282307

Henriksen, A., Haugen Mikalsen, M., Woldaregay, A. Z., Muzny, M., Hartvigsen, G., Hopstock, L. A., & Grimsgaard, S. (2018). Using Fitness Trackers and Smartwatches to Measure Physical Activity in Research: Analysis of Consumer Wrist-Worn Wearables. *Journal of Medical Internet Research*, *20*(3), e110. doi:10.2196/jmir.9157 PMID:29567635

Henry, J. C. (2020). *Management Ethics: How Social Media Affects Employees' Privacy and Organizational Climate?* (Doctoral dissertation). Northcentral University.

Hernández-Vicente, A., Hernando, D., Marín-Puyalto, J., Vicente-Rodríguez, G., Garatachea, N., Pueyo, E., & Bailón, R. (2021). Validity of the Polar H7 Heart Rate Sensor for Heart Rate Variability Analysis during Exercise in Different Age, Body Composition and Fitness Level Groups. *Sensors (Basel)*, *21*(3), 902. Advance online publication. doi:10.339021030902 PMID:33572800

Hernando, D., Roca, S., Sancho, J., Alesanco, Á., & Bailón, R. (2018). Validation of the Apple Watch for Heart Rate Variability Measurements during Relax and Mental Stress in Healthy Subjects. *Sensors (Basel)*, *18*(8), 2619. Advance online publication. doi:10.339018082619 PMID:30103376

Hinde, K., White, G., & Armstrong, N. (2021). Wearable Devices Suitable for Monitoring Twenty Four Hour Heart Rate Variability in Military Populations. *Sensors (Basel)*, *21*(4), 1061. Advance online publication. doi:10.339021041061 PMID:33557190

Hodges, C., Moore, S., Lockee, B., Trust, T., & Bond, A. (2020). The difference between emergency remote teaching and online learning. *Educause Review*. Retrieved January 15, 2022 from: https://er.educause.edu/articles/2020/3/the-difference-between-emergency-remote-teaching-and-online-learning

Hollands, F. M., & Escueta, M. (2017). *EdTech decision-making in higher education*. Columbia University, Teachers College, Center for Benefit-Cost Studies of Education.

Hollowood, E., & Mostrous, A. (2020, March 23). *Fake news in the time of C-19.* Tortoise. Retrieved March 15, 2022, from https://www.tortoisemedia.com/2020/03/23/the-infodemic-fake-news-coronavirus/

Hom, M. A., Stanley, I. H., Rogers, M. L., Tzoneva, M., Bernert, R. A., & Joiner, T. E. (2016). The association between sleep disturbances and depression among firefighters: Emotion dysregulation as an explanatory factor. *Journal of Clinical Sleep Medicine*, *12*(2), 235–245. doi:10.5664/jcsm.5492 PMID:26350604

Howell, E. (2017, May 20). *Planet Classification: How to Group Exoplanets*. Retrieved December 27, 2021, from https://www.space.com/36935-planet-classification.html

Hricko, M. (2017). Personal Learning Environments. In *Handbook of Research on Instructional Systems and Educational Technology* (pp. 236–248). IGI Global.

Hsu, Y. C., Baldwin, S., & Ching, Y. H. (2017). Learning through making and maker education. *TechTrends*, 1–6.

Hubbard, J. K., & Couch, B. A. (2018). The positive effect of in-class clicker questions on later exams depends on initial student performance level but not question format. *Computer Education*, *120*, 1–12. doi:10.1016/j.compedu.2018.01.008

Huber, B., Yeates, M., Meyer, D., Fleckhammer, L., & Kaufman, J. (2018). The effects of screen media content on young children's executive functioning. *Journal of Experimental Child Psychology*, *170*, 72–85. doi:10.1016/j.jecp.2018.01.006 PMID:29448235

Hull, R., Neaves, P., & Bedford-Roberts, J. (1997). Towards situated computing. In *Wearable Computers, 1997. Digest of Papers. The First International Symposium on Wearable Computers* (pp. 146-153). IEEE. 10.1109/ISWC.1997.629931

Hunsu, N. J., Adesope, O., & Bayly, D. J. (2016). A meta-analysis of the effects of audience response systems (clicker-based technologies) on cognition and affect. *Computer Education*, *94*, 102–119. doi:10.1016/j.compedu.2015.11.013

Ifijeh, G., & Yusuf, F. (2020). Covid – 19 pandemic and the Future of Nigeria's University System: The quest for libraries' relevance. *Journal of Academic Librarianship*, *46*(6), 102226. https://doi.org/10.1016/j.acalib.2020.102226

IFLA (International Federation of Library Associations and Institutions). (2017). *How To Spot Fake News*. Retrieved March 15, 2022, from https://www.ifla.org/publications/node/11174

Ikram, C., Mohamed, E., Souhaib, A., & Mohamed, K. (2021). Integration of Pedagogical Videos as Learning Object in an Adaptive Educational Hypermedia Systems According To The Learner Profile. *International Journal of Computer Trends and Technology*, *69*(6), 1–6. doi:10.14445/22312803/IJCTT-V69I6P101

Illeris, K. (2018). An overview of the history of learning theory. *European Journal of Education*, *53*(1), 86–101. doi:10.1111/ejed.12265

Illinois Department of Commerce. (2020, March 9). *Executive Order 20-10*. www.2illinois.gov. https://www2.illinois.gov/Pages/Executive-Orders/ExecutiveOrder2020-10.aspx

Inbar-Furst, H., Douglas, S. N., & Meadan, H. (2020). Promoting caregiver coaching practices within early intervention: Reflection and feedback. *Early Childhood Education Journal*, *48*(1), 21–27. doi:10.100710643-019-00980-2

Ingold, J., & Valizade, D. (2017). Employers' recruitment of disadvantaged groups: Exploring the effective labour market programme agencies as labour market intermediaries. *Human Resource Management Journal*, *27*(4), 530–547. doi:10.1111/1748-8583.12154

Isakadze, N., & Martin, S. S. (2020). How useful is the smartwatch ECG? *Trends in Cardiovascular Medicine*, *30*(7), 442–448. doi:10.1016/j.tcm.2019.10.010 PMID:31706789

Ito, Y., Oka, Y., & Kuriyama, Y. (2020). Applicability of the Reflection Index of Respiration Based on Heart Rate Variability Analysis to Firefighting Activity. *Fire Science & Technology*, *39*(1), 1–15. doi:10.3210/fst.39.1

Jacoby, J., Heugh, S., Bax, C., & Branford-White, C. (. (2014). Enhancing learning through formative assessment. *Innovations in Education and Teaching International*, *51*(1), 72–83. doi:10.1080/14703297.2013.771970

Jæger, M. M., & Blaabæk, E. H. (2020). Inequality in learning opportunities during covid-19: Evidence from library takeout. *Research in Social Stratification and Mobility*, *68*, 100524. https://doi.org/10.1016/j.rssm.2020.100524

Jahnke, S. A., Poston, W. S. C., Jitnarin, N., & Haddock, C. K. (2012). Health Concerns of the U.S. Fire Service: Perspectives from the Firehouse. *American Journal of Health Promotion*, *27*(2), 111–118. doi:10.4278/ajhp.110311-QUAL-109 PMID:23113781

Jaidi, Y., Van Hooft, E. A. J., & Arends, L. R. (2011). Recruiting Highly Educated Graduates: A Study on the Relationship Between Recruitment Information Sources, the Theory of Planned Behavior, and Actual Job Pursuit. *Human Performance*, *24*(2), 135–157. doi:10.1080/08959285.2011.554468

Jamu, J. T., Lowi-Jones, H., & Mitchell, C. (2016). Just in time? Using QR codes for multi-professional learning in clinical practice. *Nurse Education in Practice*, *19*, 107–112. PMID:27428702

Jang, T. W., Jeong, K. S., Ahn, Y. S., & Choi, K. S. (2020). The relationship between the pattern of shift work and sleep disturbances in Korean firefighters. *International Archives of Occupational and Environmental Health*, *93*(3), 391–398. doi:10.100700420-019-01496-3 PMID:31768636

Järvisalo, Jartti, Näntö-Salonen, Irjala, Rönnemaa, Hartiala, Celermajer, & Raitakari. (2001). *Increased Aortic Intima-Media Thickness*. Academic Press.

Jeklin, A. T., Perrotta, A. S., Davies, H. W., Bredin, S. S. D., Paul, D. A., & Warburton, D. E. R. (2021). The association between heart rate variability, reaction time, and indicators of workplace fatigue in wildland firefighters. *International Archives of Occupational and Environmental Health*, *94*(5), 823–831. Advance online publication. doi:10.100700420-020-01641-3 PMID:33426591

Jena, P. K. (2020). Online learning during lockdown period for covid-19 in India. *International Journal of Multidisciplinary Educational Research, 9*.

Jena, P. K. (2020). Impact of COVID-19 on higher education in India. *International Journal of Advanced Education and Research*, *5*(3), 77–81.

Johnson, Q. R., Goatcher, J. D., Diehl, C., Lockie, R. G., Orr, R. M., Alvar, B., ... Dawes, J. J. (2020). Heart rate responses during simulated fire ground scenarios among full-time firefighters. *International Journal of Exercise Science*, *13*(2), 374–382. PMID:32148623

Joshi, N., Lau, S. K., Pang, M. F., & Lau, S. S. Y. (2021). Clickers in class: Fostering higher cognitive thinking using ConcepTests in a large undergraduate class. *The Asia-Pacific Education Researcher*, *30*(5), 375–394. doi:10.100740299-020-00525-x

Julien, M., Bergeron, M., & Hébert, M. (2020). Programme Empreinte: Évaluation des capsules vidéo web destinées aux parents d'adolescent. *Revue de psychoéducation*, *49*(1), 27–45. doi:10.7202/1070056ar

Kabat-Zinn, J. (2003). Mindfulness-based interventions in context: Past, present, and future. *Clinical Psychology: Science and Practice*, *10*(2), 144–156. doi:10.1093/clipsy.bpg016

Kane, G. C., Nanda, R., Phillips, A., & Copulsky, J. (2021). Redesigning the Post-Pandemic Workplace. *MIT Sloan Management Review*, *62*(3), 12–14.

Kang, H., Lundeberg, M., Wolter, B., delMas, R., & Herreid, C. F. (2012). Gender differences in student performance in large lecture classrooms using personal response systems ("clickers") with narrative case studies. *Learning, Media and Technology*, *37*(1), 53–76. doi:10.1080/17439884.2011.556123

Kanuka, H. (2008). Understanding e-Learning Technologies-in-Practice through Philosophies-in-Practice. In T. Anderson & F. Elloumni (Eds.), *Theory and Practice of Online Learning*. Athabasca University Press.

Kaplan Andreas, M., & Michael, H. (2016). Higher education and the digital revolution: About MOOCs, SPOCs, social media, and the Cookie Monster. *Business Horizon, 59*.

Karriker, J. H., & Hartman, N. S. (2018). Social Media and Dynamic Capabilities: Mining Millennial Resources. *Journal of Organizational Psychology, 18*(4), 43–56.

Kasworm, C. E., Rose, A. D., & Ross-Gordon, J. M. (Eds.). (2010). *Handbook of adult and continuing education*. Sage.

Kattoor, A. J., Naga Venkata, K. P., Palagiri, D., & Mehta, J. L. (2017). Oxidative Stress in Atherosclerosis. *Current Atherosclerosis Reports*, *19*(11), 42. Advance online publication. doi:10.100711883-017-0678-6 PMID:28921056

Kay, B. H., & LeSage, A. (2009). Examining the benefits and challenges of using audience response systems: A review of the literature. *Computers & Education*, *53*(3), 819–827. doi:10.1016/j.compedu.2009.05.001

Kegan, R., & Lahey, L. L. (2009). *Immunity to change: How to overcome it and unlock potential in yourself and your organization*. Harvard Business Press.

Kelly, T. (1966). *Early public libraries a history of public libraries in great-Britain before 1850*. The Library Association.

Kennedy, J. (2014). Characteristics of massive open online courses (MOOCs): A research review, 2009-2012. *Journal of Interactive Online Learning*, *13*(1).

Keough, S. M. (2012). Clickers in the classroom: A review and a replication. *Journal of Management Education*, *36*(6), 822–847. doi:10.1177/1052562912454808

Khaddage, F., Müller, W., & Flintoff, K. (2016). Advancing mobile learning in formal and informal settings via mobile app technology: Where to from here, and how? *Journal of Educational Technology & Society*, *19*(3), 16.

Khoury, B., Sharma, M., Rush, S. E., & Fournier, C. (2015). Mindfulness-based stress reduction for healthy individuals: A meta-analysis. *Journal of Psychosomatic Research*, *78*(6), 519–528. doi:10.1016/j.jpsychores.2015.03.009 PMID:25818837

Khurgin, A. (2017). *Microlearning for Transformation, Not Information Transfer* (Webinar video). Training Magazine Network. https://youtu.be/kGff91akTJ0

Kiechl, S. J., Staudt, A., Stock, K., Gande, N., Bernar, B., Hochmayr, C., Winder, B., Geiger, R., Griesmacher, A., Egger, A. E., Pechlaner, R., Kiechl, S., Knoflach, M., & Kiechl-Kohlendorfer, U. (2022). Diagnostic Yield of a Systematic Vascular Health Screening Approach in Adolescents at Schools. *Diagnostic Yield of a Systematic Vascular Health Screening Approach in Adolescents at Schools.*, *70*(1), 70–76. doi:10.1016/j.jadohealth.2021.10.019 PMID:34930573

Kisicki, A., Becker, S., Chaple, M., Gustafson, D. H., Hartzler, B., Jacobson, N., ... Molfenter, T. (2021). *Behavioral Healthcare Providers' Experiences Related to use of Telehealth as a Result of the COVID-19 Pandemic: An Exploratory Study*. Academic Press.

Koksalmis. (2019). *Drivers to Adopting B-Flow Ultrasonography : Contextualizing the Integrated Technology Acceptance Model*. Academic Press.

Kolb, A. Y., & Kolb, D. A. (2012). Experiential learning theory. In Encyclopedia of the Sciences of Learning (pp. 1215-1219). Springer US. doi:10.1007/978-1-4419-1428-6_227

Kolb, D. A. (2014). *Experiential learning: Experience as the source of learning and development*. FT Press.

Kolb, A. Y., & Kolb, D. A. (2005). Learning styles and learning spaces: Enhancing experiential learning in higher education. *Academy of Management Learning & Education*, *4*(2), 193–212. doi:10.5465/amle.2005.17268566

Kolb, D. (2013). *Kolb Learning Style Inventory Version 3.2 Single Copy*. Hay Group.

Kolb, D. A. (1981). Experiential Learning Theory and the Learning Style Inventory: A Reply to Freedman and Stumpf. *Academy of Management Review*, *6*(2), 289. doi:10.2307/257885

Kolb, D. A. (1984). *Experience as the source of learning and development Prentice-Hall*.

Ko, S., & Rossen, S. (2017). *Teaching online: A practical guide*. Taylor & Francis. doi:10.4324/9780203427354

Kounaves, S., Archer, L., King, H., & Pegram, E. (2016). Science Learning and Engagement in the Digital Age: Understanding the Effect of Mobile Technology on Adult Engagement Experiences at a Natural History Museum. *Mobile Learning Futures–Sustaining Quality Research and Practice in Mobile Learning*, 361.

Kozakova, M., & Palombo, C. (2016). *Vascular Ultrasound and Cardiovascular Risk Assessment*. Academic Press.

KPMG. (2015). *Corporate digital learning*. Retrieved from https://assets.kpmg.com/content/dam/kpmg/pdf/2015/09/corporate-digital-learning-2015-KPMG.pdf

Krenn, J. (2015, August 18). *Humor, Screens & Children: Understanding a child's humor as stages applies to their programming* [Web log post]. Retrieved from https://www.psychologytoday.com/blog/screen-time/201508/humor-screens-children

Krenn, J. (2015, June 10). *Appisode Applications: Tips & Developmental Recommendations for Disney, Jr.'s Interactive Entertainment* [Web log post]. Retrieved from https://www.psychologytoday.com/blog/screen-time/201506/appisode-applications

Krenn, J. (2015, October 2). *New Screen Suggestions by The American Academy of Pediatrics. Insights as a media professor and parent* [Web log post]. Retrieved from https://www.psychologytoday.com/blog/screen-time/201510/new-screen-suggestions-the-american-academy-pediatrics

Kretz, C., Payne, C., & Reijerkerk, D. (2021). Study room time machine: Creating a Virtual Library escape game during COVID. *College & Undergraduate Libraries*, 1–23. doi:10.1080/10691316.2021.1975341

Krizhevsky, A., Sutskever, I., & Hinton, G. E. (2012). ImageNet Classification with Deep Convolutional Neural Networks. *Communications of the ACM*, *60*(6), 84–90. doi:10.1145/3065386

Kruger, J. L., & Doherty, S. (2016). Measuring cognitive load in the presence of educational video: Towards a multimodal methodology. *Australasian Journal of Educational Technology*, *32*(6). Advance online publication. doi:10.14742/ajet.3084

Krygier, J. R., Heathers, J. A., Shahrestani, S., Abbott, M., Gross, J. J., & Kemp, A. H. (2013). Mindfulness meditation, well-being, and heart rate variability: A preliminary investigation into the impact of intensive Vipassana meditation. *International Journal of Psychophysiology*, *89*(3), 305–313. doi:10.1016/j.ijpsycho.2013.06.017 PMID:23797150

Kuhn, P., & Skuterud, M. (2004). Internet job search and unemployment durations. *The American Economic Review*, *94*(1), 218–232. doi:10.1257/000282804322970779

Kumar, B. A., & Mohite, P. (2018). Usability of mobile learning applications: A systematic literature review. *Journal of Computers in Education,* 1-17.

Kuorinka, I., & Korhonen, O. (1981). Firefighters' reaction to alarm, an ECG and heart rate study. *Journal of Occupational Medicine. Official Publication of the Industrial Medical Association*, *23*(11), 762–766. doi:10.1097/00043764-198111000-00010 PMID:7320775

Laaser, W., & Toloza, E. A. (2017). The changing role of the educational video in higher distance education. *The International Review of Research in Open and Distributed Learning*, *18*(2). Advance online publication. doi:10.19173/irrodl.v18i2.3067

Lades, L. K., Laffan, K., Daly, M., & Delaney, L. (2020). Daily emotional well-being during the COVID-19 pandemic. *British Journal of Health Psychology*, *25*(4), 902–911. doi:10.1111/bjhp.12450 PMID:32573074

Ladson-Billings, G. (1995). Toward a theory of culturally relevant pedagogy. *Educational Research*, *32*(3), 465–491.

Ladson-Billings, G. (2021). Three Decades of Relative, Responsive, & Sustaining Pedagogy: What Lies Ahead? *The Educational Forum*, *85*(4), 351–354. doi:10.1080/00131725.2021.1957632

Lai, C., Wang, Q., & Lei, J. (2012). What factors predict undergraduate students' use of technology for learning? A case from Hong Kong. *Computers & Education*, *59*(2), 569–579. doi:10.1016/j.compedu.2012.03.006

Lai, G., Hill, V., & Ma, Y. (2015). Clickers in the classroom: A business professor's adoption of a classroom response system. *International Journal of Innovation and Learning*, *18*(4), 451–470. doi:10.1504/IJIL.2015.072458

Lai, P. C. (2017). The literature review of technology adoption models and theories for the novelty technology. *JISTEM-Journal of Information Systems and Technology Management*, *14*(1), 21–38. doi:10.4301/S1807-17752017000100002

Laker, B., Godley, W., Patel, C., & Kudret, S. (2021). Four Steps to Successful Virtual Hiring. *Sloan Management Review*.

Lamya, A., Mohamed, E., & Mohamed, K. (2021). Adaptive E-Learning and Scenarization Tools: The Case of Personalization. *International Journal of Computer Trends and Technology*, *69*(6), 28–35. doi:10.14445/22312803/IJCTT-V69I6P105

Lantz, M. E. (2010). The use of "clickers" in the classroom: Teaching innovation or merely an amusing novelty? *Computers in Human Behavior*, *26*(4), 556–561. doi:10.1016/j.chb.2010.02.014

Lantz, M. E., & Stawiski, A. (2014). Effectiveness of clickers: Effect of feedback and the timing of questions on learning. *Computers in Human Behavior*, *31*, 280–286. doi:10.1016/j.chb.2013.10.009

Larsen, B., Snow, R., & Aisbett, B. (2015). Effect of heat on firefighters' work performance and physiology. *Journal of Thermal Biology*, *53*, 1–8. doi:10.1016/j.jtherbio.2015.07.008 PMID:26590449

Larsen, C. A., & Vesan, P. (2012). Why public employment services always fail: Double-sided asymmetric information and placement of low-skill work in six European countries. *Public Administration*, *90*(2), 466–479. doi:10.1111/j.1467-9299.2011.02000.x

Latham, A., & Hill, N. S. (2014). Preference for anonymous classroom participation: Linking student characteristics and reactions to electronic response systems. *Journal of Management Education*, *38*(2), 192–215. doi:10.1177/1052562913488109

Lave, J., & Wenger, E. (1998). *Communities of practice*. Academic Press.

Lavie, C. J., Arena, R., Swift, D. L., Johannsen, N. M., Sui, X., Lee, D. C., Earnest, C. P., Church, T. S., O'Keefe, J. H., Milani, R. V., & Blair, S. N. (2015). Exercise and the cardiovascular system: Clinical science and cardiovascular outcomes. *Circulation Research*, *117*(2), 207–219. doi:10.1161/CIRCRESAHA.117.305205 PMID:26139859

Lazaroiu, G., Popescu, G. H., & Nica, E. (2016, July). Democratizing education: the potential of EdX in revolutionizing learning. In *The International Scientific Conference eLearning and Software for Education* (*Vol. 3*, p. 34). "Carol I" National Defence University.

Lazaroiu, G., Popescu, G. H., & Nica, E. (2016, July). The sustainability of udacity's business model of producing first-rate online content and incorporating interactive learning aspects into an online course. In *The International Scientific Conference eLearning and Software for Education* (*Vol. 3*, p. 40). " Carol I" National Defence University.

Leary & Polak. (2002). *Intima-Media Thickness : A Tool for Atherosclerosis Imaging and Event Prediction.* Academic Press.

Lee, E. A. (2017). *Plato and the nerd: The creative partnership of humans and technology*. The MIT Press., doi:10.7551/mitpress/11180.001.0001

Lee, E. A. (2020). *The coevolution: The entwined futures of humans and machines*. The MIT Press., doi:10.7551/mitpress/12307.001.0001

Lee, F. F. (2017). Q+A. *MIT's Technology Review*, *120*(6), 26.

Lee, L. (2015b). Technology play and learning. In D. P. Fromberg & D. Bergen (Eds.), *Play from birth to twelve: Contexts, perspectives, and meanings* (pp. 217–224). Routledge.

LeHong, H., Fenn, J., & Leeb-du Toit, R. (2013). *Hype cycle for emerging technologies*. Gartner Inc.

Lenstra, N., & D'Arpa, C. (2019). Food justice in the Public Library: Information, resources, and meals. *The International Journal of Information, Diversity, & Inclusion, 3*(4). doi:10.33137/ijidi.v3i4.33010

Lenstra, N. (2017). Let's move! fitness programming in public libraries. *Public Library Quarterly*, *37*(1), 61–80. https://doi.org/10.1080/01616846.2017.1316150

Lenstra, N. (2018). The experiences of Public Library staff developing programs with physical activities: An exploratory study in North Carolina. *The Library Quarterly*, *88*(2), 142–159. https://doi.org/10.1086/696580

Letswalo, Schmid, Brix, Matjuda, Klosz, Obernhumer, Gaisl, Fredriksen, Engwa, & Sewani. (2021). *Cardiometabolic Risk Factors and Early Indicators of Vascular Dysfunction : A Sectional Cohort Study in South African Adolescents*. . doi:10.1136/bmjopen-2020-042955

Levels, K., de Koning, J. J., Foster, C., & Daanen, H. A. M. (2012). The effect of skin temperature on performance during a 7.5-km cycling time trial. *European Journal of Applied Physiology*, *112*(9), 3387–3395. doi:10.100700421-012-2316-x PMID:22270485

Lewis, G. A. (2017). Cloud computing. *Computer*, *50*(5), 8–9. doi:10.1109/MC.2017.141

Lewis, O. (1959). *Five families: Mexican case studies in the culture of poverty*. Basic Books.

Li, C., & Lalani, F. (2020, April 29). T*he COVID-19 pandemic has changed education forever. This is how.* Retrieved December 30, 2021, from https://www.weforum.org/agenda/2020/04/coronavirus-education-global-covid19-online-digital-learning/

Liao, L.-M., Al-Zaiti, S. S., & Carey, M. G. (2014). Depression and heart rate variability in firefighters. *SAGE Open Medicine*, *2*. doi:10.1177/2050312114545530 PMID:26770735

Li, K. C., & Wong, B. T. M. (2020). The use of student response systems with learning analytics: A review of case studies (2008–2017). *International Journal of Mobile Learning and Organization*, *14*(1), 63–79. doi:10.1504/IJMLO.2020.103901

Limbers, C. A., McCollum, C., & Greenwood, E. (2020). Physical activity moderates the association between parenting stress and quality of life in working mothers during the COVID-19 pandemic. *Mental Health and Physical Activity*, *19*, 100358. doi:10.1016/j.mhpa.2020.100358 PMID:33072187

Lin, C. C. C., Dievler, A., Robbins, C., Sripipatana, A., Quinn, M., & Nair, S. (2018). Telehealth in health centers: Key adoption factors, barriers, and opportunities. *Health Affairs*, *37*(12), 1967–1974. doi:10.1377/hlthaff.2018.05125 PMID:30633683

Lippi, G., Mattiuzzi, C., & Sanchis-Gomar, F. (2020). Updated overview on interplay between physical exercise, neurotrophins, and cognitive function in humans. *Journal of Sport and Health Science*, *9*(1), 74–81. doi:10.1016/j.jshs.2019.07.012 PMID:31921482

Loksa, D., Ko, A. J., Jernigan, W., Oleson, A., Mendez, C. J., & Burnett, M. M. (2016, May). Programming, Problem Solving, and Self-Awareness: Effects of Explicit Guidance. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems* (pp. 1449-1461). ACM.

Long, K., Vines, J., Sutton, S., Brooker, P., Feltwell, T., Kirman, B., Barnett, J., & Lawson, S. (2017). *"Could You Define That in Bot Terms"?* Academic Press.

Lopez-Leon, S., Forero, D. A., & Ruiz-Díaz, P. (2020). Recommendations for working from home during the COVID-19 pandemic (and beyond). *Work (Reading, Mass.)*, *66*(2), 371–375. doi:10.3233/WOR-203187 PMID:32568161

Lottero-Perdue, P. S. (2019). Engaging young children in engineering design: Encouraging them to think, create, try and try again. In *STEM in Early Childhood Education* (pp. 99–117). Routledge. doi:10.4324/9780429453755-6

Lowenthal, P. R. (2010). Social presence. In S. Dasgupta (Ed.), *Social computing: Concepts, methodologies, tools, and applications* (pp. 129–136). IGI Global. doi:10.4018/978-1-60566-984-7.ch011

Lu, X., Lin, Z., Yang, J., & Wang, J. Z. (2014). RAPID : Rating Pictorial Aesthetics using Deep Learning * Categories and Subject Descriptors. *ACM Multimedia*, 457–466.

Lukoff, K., Lyngs, U., Gueorguieva, S., Dillman, E. S., Hiniker, A., & Munson, S. A. (2020, July). From ancient contemplative practice to the app store: Designing a digital container for mindfulness. In *Proceedings of the 2020 ACM Designing Interactive Systems Conference* (pp. 1551-1564). 10.1145/3357236.3395444

Lupi, V. (2020, March 10). *Covid-19 and fake news in the social media*. FBK. Retrieved March 15, 2022, from https://www.fbk.eu/en/press-releases/covid-19-and-fake-news-in-the-social-media/

Lynch, B. (2008). *Startup Poll Everywhere invented the technology to conduct real time polls through cell phones*. Boston Business Journal.

Lynch, M. (2020). E-Learning during a global pandemic. *Asian Journal of Distance Education*, *15*(1), 189–195.

Lyytikäinen, K., Toivonen, L., Hynynen, E., Lindholm, H., & Kyröläinen, H. (2017). Recovery of rescuers from a 24-h shift and its association with aerobic fitness. *International Journal of Occupational Medicine and Environmental Health*, *30*(3), 433–444. doi:10.13075/ijomeh.1896.00720 PMID:28481376

MacGeorge, E. K., Homan, S. R., Dunning, J. B., Elmore, D., Bodie, G. D., Evans, E., Khichadia, S., & Lichti, S. M. (2008). The influence of learning characteristics on evaluation of audience response technology. *Journal of Computing in Higher Education*, *19*(2), 25–46. doi:10.1007/BF03033425

Maclay, K. (2003, May 6). *Clay cuneiform from ancient Mesopotamia to be placed online*. UCBerkeleyNews. https://www.berkeley.edu/news/media/releases/2003/05/06_tablet.shtml

Maher, D. (2020). Video conferencing to support online teaching and learning. *Teaching, technology, and teacher education during the COVID-19 pandemic: Stories from the field*.

Maity, S., Sahu, T. N., & Sen, N. (2021). Panoramic view of digital education in COVID-19: A new explored avenue. *Review of Education*, *9*(2), 405–423. doi:10.1002/rev3.3250

Majchrzak, A., Rice, R. E., King, N., Malhotra, A., & Ba, S. (2014). *Computer-mediated inter-organizational knowledge-sharing: Insights from a virtual team innovating using a collaborative tool*. Academic Press.

Malanga, D. F. (2017). Implementation of Mobile Health Initiatives in Malawi: Current Status, Issues, and Challenges. *Health Information Systems and the Advancement of Medical Practice in Developing Countries*, 115-128.

Malik, M., Bigger, J. T., Camm, A. J., Kleiger, R. E., Malliani, A., Moss, A. J., & Schwartz, P. J. (1996). Heart rate variability: Standards of measurement, physiological interpretation, and clinical use. *European Heart Journal*, *17*(3), 354–381. doi:10.1093/oxfordjournals.eurheartj.a014868 PMID:8737210

Maltese, A. V., Simpson, A., & Anderson, A. (2018). Failing to learn: The impact of failures during making activities. *Thinking Skills and Creativity*, *30*, 116–124. doi:10.1016/j.tsc.2018.01.003

Mancilla, G. (2018). Latinx Youth Counterstories in a Court Diversion Program. *Taboo: The Journal of Culture and Education, 17*(4). Retrieved from https://digitalcommons.lsu.edu/taboo/vol17/iss4/5

Marcel-Millet, P., Groslambert, A., Gimenez, P., Grosprêtre, S., & Ravier, G. (2021). Psychophysiological responses of firefighters to day and night rescue interventions. *Applied Ergonomics*, *95*(April), 103457. Advance online publication. doi:10.1016/j.apergo.2021.103457 PMID:33984583

Marcel-Millet, P., Ravier, G., Esco, M. R., & Groslambert, A. (2020). Does firefighters' physical fitness influence their cardiac parasympathetic reactivation? Analysis with post-exercise heart rate variability and ultra-short-term measures. *International Journal of Occupational Safety and Ergonomics*, 1–9. doi:10.1080/10803548.2020.1738689 PMID:32586212

Marcel-Millet, P., Ravier, G., Grospretre, S., Gimenez, P., Freidig, S., & Groslambert, A. (2018). Physiological responses and parasympathetic reactivation in rescue interventions: The effect of the breathing apparatus. *Scandinavian Journal of Medicine & Science in Sports*, *28*(12), 2710–2722. doi:10.1111ms.13291 PMID:30171784

Marciniak, R. A., Wahl, C. A., & Ebersole, K. T. (2021). Autonomic Nervous System Response to Far-Infrared Sauna Exposure in Firefighters. *Annals of Work Exposures and Health*. Advance online publication. doi:10.1093/annweh/wxab088 PMID:34632485

Marin, K. A., & Rotondo, E. K. (2017). Rumination and self-reflection in stress narratives and relations to psychological functioning. *Memory (Hove, England)*, *25*(1), 44–56. doi:10.1080/09658211.2015.1124122 PMID:27905255

Mark, G., Iqbal, S., & Czerwinski, M. (2017, September). How blocking distractions affects workplace focus and productivity. In *Proceedings of the 2017 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2017 ACM International Symposium on Wearable Computers* (pp. 928-934). 10.1145/3123024.3124558

Marsick, V. J. (1998). Transformative learning from experience in the knowledge era. *Daedalus*, *127*(4), 119–136.

Marsick, V. J., & Volpe, M. (1999). The nature and need for informal learning. *Advances in Developing Human Resources*, *1*(3), 1–9.

Marsick, V. J., & Watkins, K. E. (2001). Informal and incidental learning. *New Directions for Adult and Continuing Education*, *2001*(89), 25–34.

Martini & Nath. (n.d.). *Fundamentals of Anatomy and Physiology*. Academic Press.

Martzoukou, K. (2020). Academic libraries in covid-19: A renewed mission for Digital Literacy. *Library Management*, *42*(4/5), 266–276. https://doi.org/10.1108/lm-09-2020-0131

Masicampo, E. J., & Baumeister, R. F. (2011). Consider it done! Plan making can eliminate the cognitive effects of unfulfilled goals. *Journal of Personality and Social Psychology*, *101*(4), 667–683. doi:10.1037/a0024192 PMID:21688924

Masikunis, G., Panayiotidis, A., & Burke, L. (2009). Changing the nature of lectures using a personal response system. *Innovations in Education and Teaching International*, *46*(2), 199–212. doi:10.1080/14703290902843935

Masrom, M., Nadzari, A. S., Mahmood, N. H., Zakaria, W. N., & Ali, N. R. (2016). Mobile learning in Malaysia education institutions. *Issues in Information Systems*, *17*(4), 152–157.

Mayer, R. E. (2001). A Cognitive Theory of Multimedia Learning. In *Multimedia Learning* (pp. 41–62). Cambridge University Press. doi:10.1017/CBO9781139164603.004

Mayer, R. E., & Chandler, P. (2001). When learning is just a click away: Does simple user interaction foster deeper understanding of multimedia messages? *Journal of Educational Psychology*, *93*(2), 390–397. doi:10.1037/0022-0663.93.2.390

Mayer, R. E., & Moreno, R. (1998). A split-attention effect in multimedia learning: Evidence for dual processing systems in working memory. *Journal of Educational Psychology*, *90*(2), 312–320. doi:10.1037/0022-0663.90.2.312

Mayer, R. E., Stull, A., DeLeeuw, K., Almeroth, K., Bimber, B., Chun, D., Bulger, M., Campbell, J., Knight, A., & Zhang, H. (2009). Clickers in college classrooms: Fostering learning with questioning methods in large lecture classes. *Contemporary Educational Psychology*, *34*(1), 51–57. doi:10.1016/j.cedpsych.2008.04.002

McCarthy, J. (2007). *What is artificial intelligence?* Retrieved from http://www-formal.stanford.edu/jmc/whatisai/whatisai.html

McCarthy, J. (2017). Enhancing feedback in higher education: Students' attitudes towards online and in-class formative assessment feedback models. *Active Learning in Higher Education*, *18*(2), 127–141. doi:10.1177/1469787417707615

McClusky, F. D. (1947). The nature of the educational film. *Hollywood Quarterly*, *2*(4), 371–380. doi:10.2307/1209533

McCracken, M., Currie, D., & Harrison, J. (2016). Understanding graduate recruitment, development and retention for the enhancement of talent management: Sharpening 'the edge' of graduate talent. *International Journal of Human Resource Management*, *27*(22), 2727–2752. doi:10.1080/09585192.2015.1102159

McDermott, I. E. (2016). Fun with virtual and augmented reality. *Online Searcher*, (Nov-Dec), 27–29.

McGreal, R., Kinuthia, W., Marshall, S., & McNamara, T. (2013). *Open educational resources: Innovation, research and practice*. Commonwealth of Learning.

McLoughlin, C., & Lee, M. (2007). Social software and participatory learning: Pedagogical choices with technology affordances in the Web 2.0 era. ICT: Providing choices for learners and learning. Proceedings ascilite Singapore 2007.

McQuiggan, S., McQuiggan, J., Sabourin, J., & Kosturko, L. (2015). *Mobile learning: A handbook for developers, educators, and learners*. John Wiley & Sons.

Media, M. (2013). *We Need a Plan*. Retrieved June 9, 2015, from https://www.aap.org/en-us/about-the-aap/aap-press-room/pages/managing-media-we-need-a-plan.aspx

Mehrotra, C., Hollister, C. D., & McGahey, L. (2001). *Distance learning: Principles for effective design, delivery, and evaluation*. Sage Publications.

Mehta, R. K. (2015). Impacts of obesity and stress on neuromuscular fatigue development and associated heart rate variability. *International Journal of Obesity*, *39*(2), 208–213. doi:10.1038/ijo.2014.127 PMID:25042859

Meier, E. (2015). Beyond a Digital Status Quo: Re-conceptualizing Online Learning Opportunities. *Occasional Paper Series, 2015*(34).

Meina, M., Ratajczak, E., Sadowska, M., Rykaczewski, K., Dreszer, J., Bałaj, B., Biedugnis, S., Węgrzyński, W., & Krasuski, A. (2020). Heart rate variability and accelerometry as classification tools for monitoring perceived stress levels—A pilot study on firefighters. *Sensors (Switzerland)*, *20*(10), 1–21. doi:10.339020102834 PMID:32429383

Meinel, C., Totschnig, M., & Willems, C. (2013). openHPI: Evolution of a MOOC platform from LMS to SOA. In *Proceedings of the 5th International Conference on Computer Supported Education (CSEDU), INSTICC, Aachen, Germany* (*Vol. 5*). Academic Press.

Mentor, D. (2006). Media-ting meaning via multi-modal means. In T. Reeves & S. Yamashita (Eds.), *Proceedings of E-Learn 2006--World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education* (pp. 763-769). Association for the Advancement of Computing in Education (AACE). Retrieved November 14, 2021 from https://www.learntechlib.org/primary/p/23784/

Mentor, D. (2011). We Are New York Social Media for Adult Education. In C. Ho & M. Lin (Eds.), *Proceedings of E-Learn 2011--World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education* (pp. 1499-1504). Association for the Advancement of Computing in Education (AACE). Retrieved December 24, 2017 from https://www.learntechlib.org/p/38929/

Mentor, D. (2012). *TEDxTalks*. YouTube. www.youtube.com/watch?v=-I545RYiSjg

Mentor, D. (2014, February 14). Symposium Presentations. In *UNESCO Mobile Learning Week 2014*. Retrieved March 12, 2017, from http://www.unesco.org/new/en/unesco/themes/icts/m4ed/unesco-mobile-learning-week-2014/

Mentor, D. (2016). EMxC3= e&mLearning Cultivating Connected Communities: Sustainable Workforce Talent Development. Handbook of Research on Mobile Learning in Contemporary Classrooms, 240-259.

Mentor, D. (2016). EMxC3= e&m-learningCultivating Connected Communities: Sustainable Workforce Talent Development. Handbook of Research on Mobile Learning in Contemporary Classrooms, 240-259.

Mentor, D. (2016). The Commuter's Learning Journey: Field Observations Informing Mobile Learning Initiatives. In Handbook of Research on Mobile Learning in Contemporary Classrooms (pp. 315-335). IGI Global.

Mentor, D. (2017, April 25). Cultivating Digital TLC – Teaching and Learning Communities. In *ModSim World 2017*. Retrieved July 23, 2017, from http://www.modsimworld.org/2017/documents/Working-Agenda-17-April.pdf

Mentor, D. (2017, April 27). Cultivating Digital TLC Teaching and Learning Communities. In *ModSim 2017 International Congress on Modelling and Simulation - Modeling and Simulation in the Age of Data*. Retrieved December 24, 2017, from http://modsimworld.org/papers/2017/Cultivating_Digital_TLC_Teaching_and_Learning_Communities.pdf

Mentor, D. (2018). mClass Planet of the Apps: The Rise of Mobile Learning. In Computer-Mediated Learning for Workforce Development (pp. 196-215). IGI Global.

Mentor, D. (2018). mClass planet of the apps: The rise of mobile learning. In Computer-mediated learning for workforce development (pp. 196–215). IGI Global. doi:10.4018/978-1-5225-4111-0.ch010

Mentor, D. (2018). TLC for MOOCS: Teaching and Learning Communities for Computer Programming. In Computer-Mediated Learning for Workforce Development (pp. 93-110). IGI Global.

Mentor, D. (2018). TLC for MOOCS: Teaching and Learning Communities for Computer Programming. In Computer-Mediated Learning for Workforce Development (pp. 93–110). IGI Global.

Mentor, D. (2020, June 21). *2020: A Case Odyssey – Training for a Data Governance Software Technology Company*. https://www.learningideasconf.org/programs/2020

Mentor, D. (Ed.). (2019). Advancing Mobile Learning in Contemporary Educational Spaces. IGI Global, Information Science Reference. doi:10.4018/978-1-5225-9351-5

Mentor, D. J. (2011) *Exploring social connectedness via mobile phone texting* (Ph.D. thesis). Teachers College, Columbia University. Retrieved December 25, 2017 from https://www.learntechlib.org/p/117314/

Mentor, D. J. (2011). *Exploring social connectedness via mobile phone texting* (Doctoral dissertation). Teachers College, Columbia University.

Mentor, D. (2016). *Handbook of Research on Mobile Learning in Contemporary Classrooms*. IGI Global. doi:10.4018/978-1-5225-0251-7

Mentor, D. (2016). Learning cultivating connected communities: Sustainable workforce talent development. In *Handbook of Research on Mobile Learning in Contemporary Classrooms* (pp. 240–259). IGI Global. doi:10.4018/978-1-5225-0251-7.ch012

Mentor, D. (2016). The commuter's learning journey: field observations informing mobile learning initiatives. In *Handbook of Research on Mobile Learning in Contemporary Classrooms* (pp. 315–335). IGI Global.

Mentor, D. (2018). Micro to macro social connectedness through mobile phone engagement. In *Encyclopedia of Information Science and Technology* (4th ed., pp. 6184–6194). IGI Global.

Mentor, D. (2018). Micro to Macro Social Connectedness Through Mobile Phone Engagement. In *Encyclopedia of Information Science and Technology* (4th ed., pp. 6184–6194). IGI Global.

Mentor, D. (2019). Electronic and Mobile Learning for Workforce Development. In *Advancing Mobile Learning in Contemporary Educational Spaces* (pp. 181–208). IGI Global.

Mentor, D., & Ahmad, N. (2010). Teaching America's First Course on Mobile Phone Learning. *EDUCAUSE Quarterly*, 33.

Mercer, S., & Ryan, S. (2010). A mindset for EFL: Learners' beliefs about the role of natural talent. *ELT Journal*, *64*(4), 436–444.

Merchant, Z., Goetz, E. T., Cifuentes, L., Keeney-Kennicutt, W., & Davis, T. J. (2014). Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis. *Computers & Education*, *70*, 29–40. doi:10.1016/j.compedu.2013.07.033

Merriam, S. B., Caffarella, R. S., & Baumgartner, L. M. (2012). *Learning in adulthood: A comprehensive guide*. John Wiley & Sons.

Mezirow, J. (2000). Learning as Transformation: Critical Perspectives on a Theory in Progress. The Jossey-Bass Higher and Adult Education Series. Jossey-Bass Publishers.

Michel, E., Roebers, C. M., & Schneider, W. (2007). Educational films in the classroom: Increasing the benefit. *Learning and Instruction*, *17*(2), 172–183. doi:10.1016/j.learninstruc.2007.01.005

Mikolajczak, M., & Roskam, I. (2020). Parental burnout: Moving the focus from children to parents. *New Directions for Child and Adolescent Development*, (174), 7–13.

Milligan, C., & Littlejohn, A. (2017). Why study on a MOOC? The motives of students and professionals. *The International Review of Research in Open and Distributed Learning*, *18*(2). https://doi.org/10.19173/irrodl.v18i2.3033

Milteer, R. M., Ginsburg, K. R., Mulligan, D. A., Ameenuddin, N., Brown, A., Christakis, D. A., Narayanan, L., Menon, S., Plaisent, M., & Bernard, P. (2017). Telecommuting: The work anywhere, anyplace, anytime organization in the 21st century. *Journal of Marketing Management*, *8*(2), 47–54.

Ministry of Social Development New Zealand. (2016). The Social Report 2016 – Te pūrongo oranga tangata (pp. 1-332, Rep.). Ministry of Social Development New Zealand Government.

Ministry of Social Development New Zealand. (2018, October 10). *Social connectedness and wellbeing literature review*. Retrieved from https://www.msd.govt.nz/about-msd-and-our-work/publications-resources/literature-reviews/social-connectedness-and-wellbeing.html

Mirra, N., Morrell, E., & Filipiak, D. (2018). From Digital Consumption to Digital Invention: Toward a New Critical Theory and Practice of Multiliteracies. *Theory into Practice*, *57*(1), 12–19. doi:10.1080/00405841.2017.1390336

Mirrlees, T., & Alvi, S. (2014). Taylorizing Academia, Deskilling Professors and Automating Higher Education: The Recent Role of MOOCs. *The Journal for Critical Education Policy Studies*, *12*(2).

Mishra, D., Chew, E., Ostrovska, S., & Wong, J. (2020). Personal response systems through the prism of students' experiences. *Computer Applications in Engineering Education*, *28*(5), 1232–1246. doi:10.1002/cae.22298

Mishra, P., & Koehler, M. J. (2006). Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge. *Teachers College Record*, *108*(6), 1017–1054. doi:10.1111/j.1467-9620.2006.00684.x

Misirli, O., & Ergulec, F. (2021). Emergency remote teaching during the COVID-19 pandemic: Parents experiences and perspectives. *Education and Information Technologies*, *26*(6), 6699–6718. doi:10.100710639-021-10520-4 PMID:33814956

Mitchell, W. (2019). 6 Assessing Health Program Performance in Low-and Middle-Income Countries: Building a Feasible, Credible, and Comprehensive Framework. *Private Sector Entrepreneurship in Global Health: Innovation, Scale, and Sustainability*, 129.

Moens, A. L., Goovaerts, I., Claeys, M. J., & Vrints, C. J. (2005). Flow-Mediated Vasodilation: A Diagnostic Instrument, or an Experimental Tool? *Chest*, *127*(6), 2254–2263. doi:10.1378/chest.127.6.2254 PMID:15947345

Moghli, M. A., & Shuayb, M. (2020). *Education under COVID-19 Lockdown: Reflections from Teachers, Students & Parents*. Social Sciences and Humanities Research Council of Canada.

Molenda, M. (2008). Historical foundations. Handbook of research on educational communications and technology, 3, 3-20.

Montgomery, K. (n.d.). *Silicon Valley Now Selling Trade School Diplomas Called "Nanodegrees"*. Retrieved December 10, 2017, from http://valleywag.gawker.com/silicon-valley-now-selling-trade-school-diplomas-called-1638663780

Morresi, N., Casaccia, S., Sorcinelli, M., Arnesano, M., & Revel, G. M. (2020). Analysing performances of heart rate variability measurement through a smartwatch. *2020 IEEE International Symposium on Medical Measurements and Applications (MeMeA)*, 1–6. 10.1109/MeMeA49120.2020.9137211

Morse, J. M. (1994). *Critical issues in qualitative research methods*. Sage Publications.

Moss, J., & Crowley, M. (2011). Effective learning in science: The use of personal response systems with a wide range of audiences. *Computers & Education*, *56*(1), 36–43. doi:10.1016/j.compedu.2010.03.021

Mousa, A. A., & El-Salam, M. A. (2016). Employing QR Code as an Effective Educational Tool for Quick Access to Sources of Kindergarten Concepts. *World Academy of Science, Engineering and Technology, International Journal of Social, Behavioral, Educational, Economic*, *Business and Industrial Engineering*, *10*(7), 2358–2361.

Mrazek, A. J., Mrazek, M. D., Cherolini, C. M., Cloughesy, J. N., Cynman, D. J., Gougis, L. J., Landry, A. P., Reese, J. V., & Schooler, J. W. (2019). The future of mindfulness training is digital, and the future is now. *Current Opinion in Psychology*, *28*, 81–86. doi:10.1016/j.copsyc.2018.11.012 PMID:30529975

Mustafa, Y. E. A., & Sharif, S. M. (2011). An approach to adaptive e-learning hypermedia system based on learning styles (AEHS-LS): Implementation and evaluation. *International Journal of Library and Information Science*, *3*(1), 15–28.

Mutlu-Bayraktar, D., Cosgun, V., & Altan, T. (2019). Cognitive load in multimedia learning environments: A systematic review. *Computers & Education*, *141*, 103618. doi:10.1016/j.compedu.2019.103618

Myers, J. (2021, August 10). *This is how much data we're using on our phones*. Retrieved December 19, 2021, from https://www.weforum.org/agenda/2021/08/how-the-pandemic-sparked-a-data-boom/

Myers, K., & Clough, A. (2004). *Making Sense of Vascular Ultrsound: A Hands-on Guide.* doi:10.1201/b13409

Naeem, S. B., & Bhatti, R. (2020). The Covid-19 'infodemic': A new front for information professionals. *Health Information and Libraries Journal*, *37*(3), 233–239. https://doi.org/10.1111/hir.12311

Naismith, L., Lonsdale, P., Vavoula, G., & Sharples, M. (2004). Literature Review in Mobile Technologies and Learning (Futurelab Series Report 11). Bristol: Futurelab.

Naismith, L., Sharples, M., Vavoula, G., & Lonsdale, P. (2004). *Literature review in mobile technologies and learning*. Academic Press.

Naismith, L., Lonsdale, P., Vavoula, G., & Sharples, M. (2004). *Literature Review in Mobile Technologies and Learning: Report 11*. Futurelab.

Nakhoda, A. (2020, June 29). Bridging Digital Divide in Pakistan. *The Express Tribune*. Retrieved January 17, 2022, from https://tribune.com.pk/story/2252437/bridging-digital-divide-in-pakistan

National Center for Education Statistics. (2018) https://nces.ed.gov

Navarro, K. M., Kleinman, M. T., Mackay, C. E., Reinhardt, T. E., Balmes, J. R., Broyles, G. A., Ottmar, R. D., Naher, L. P., & Domitrovich, J. W. (2019). Wildland firefighter smoke exposure and risk of lung cancer and cardiovascular disease mortality. *Environmental Research*, *173*(March), 462–468. doi:10.1016/j.envres.2019.03.060 PMID:30981117

Nazari, G., MacDermid, J. C., Sinden, K. E., & Overend, T. J. (2018). The Relationship between Physical Fitness and Simulated Firefighting Task Performance. *Rehabilitation Research and Practice, 2018*(2007), 1–7. doi:10.1155/2018/3234176

Negm, A., MacDermid, J., Sinden, K., D'Amico, R., Lomotan, M., & MacIntyre, N. J. (2017). Prevalence and distribution of musculoskeletal disorders in firefighters are influenced by age and length of service. *Journal of Military, Veteran and Family Health*, *3*(2), 33–41. doi:10.3138/jmvfh.2017-0002

Neill, M. S., & Bowen, S. A. (2021). Ethical listening to employees during a pandemic: New approaches, barriers and lessons. *Journal of Communication Management (London)*, *25*(3), 276–297. doi:10.1108/JCOM-09-2020-0103

Nelson, M. K., & Hauck, R. V. (2008). Clicking to learn: A case study of embedding radio-frequency based clickers in an introductory management information systems course. *Journal of Information Systems Education*, *19*(1), 55–64.

Nguyen, L., & Do, P. (2008). Learner model in adaptive learning. *World Academy of Science, Engineering and Technology*, *45*(70), 395–400.

Nicolaides, A., & Marsick, V. J. (2016). Understanding Adult Learning in the Midst of Complex Social "Liquid Modernity". *New Directions for Adult and Continuing Education*, *2016*(149), 9–20.

Niesyto, B., Buckingham, D., & Fisherkeller, J. E. (2003). Video culture: Crossing borders with young people's video productions. *Television & New Media*, *4*(4), 461–482. doi:10.1177/1527476403255813

Nieto, S. (2002). *Language, culture and teaching critical perspectives for a new century*. Lawrence Erlbaum Associates, Inc.

Nikou, S. A., & Economides, A. A. (2018). Mobile-based assessment: A literature review of publications in major referred journals from 2009 to 2018. *Computers & Education*, *125*, 101–119. doi:10.1016/j.compedu.2018.06.006

Nimmi, P. M., Kuriakose, V., Donald, W. E., & Nowfal, M. (2021). HERO Elements of Psychological Capital: Fostering Career Sustainability via Resource Caravans. *Australian Journal of Career Development*, *30*(3), 199–210. doi:10.1177/10384162211066378

Nordin, N. M., Embi, M. A., Norman, H., & Panah, E. (2017). A historical review of mobile learning research in malaysia and its implications for malaysia and the Asia-Pacific region. In *Mobile learning in higher education in the Asia-Pacific region* (pp. 137–150). Springer.

Nordmann, E., Horlin, C., Hutchison, J., Murray, J.-A., Robson, L., Seery, M. K., & MacKay, J. R. D. (2020). Ten simple rules for supporting a temporary online pivot in higher education. *PLoS Computational Biology*, *16*(10), e1008242. Advance online publication. doi:10.1371/journal.pcbi.1008242 PMID:33001990

NYC Mayor Office of Immigrant Affairs. (2020). *State of Our Immigrant City*. Retrieved from https://www1.nyc.gov/assets/immigrants/downloads/pdf/MOIA-Annual-Report-for-2020.pdf

NYCLU. (2017). *How this New York County is Helping ICE Trap Teens*. Retrieved from https://www.nyclu.org/en/news/how-ny-county-helping-ice-trap-teens

NYSED. (2018). *Culturally Responsive-Sustaining Education Framework*. http://www.nysed.gov/common/nysed/files/programs/crs/culturally-responsive-sustaining-education-framework.pdf

O'Reilly, T. (2005). *What is Web 2.0: Design Patterns and Business Models for the Next Generation of Software.* Retrieved from: http://www.oreillynet.com/lpt/a/6228

Obrenović, Ž. (2011). Design-based research: What we learn when we engage in design of interactive systems. *Interactions, 18*(5), 56-59.

Ofcom. (2020, April 9). *Covid-19 news and information: Consumption and attitudes*. Results from week one of Ofcom's online survey. Retrieved March 16, 2022, from https://www.ofcom.org.uk/__data/assets/pdf_file/0031/194377/covid-19-news-consumption-weeks-one-to-three-findings.pdf

Okan, Z. (2003). Edutainment: Is learning at risk? *British Journal of Educational Technology*, *34*(3), 255–264. doi:10.1111/1467-8535.00325

Oka, Y., Sawaguchi, Y., Kuriyama, Y., & Ito, Y. (2021). Proposal for alert threshold for “stop activity” to improve firefighters’ occupational safety based on heart rate variability analysis. *Safety Science*, *144*, 105449. doi:10.1016/j.ssci.2021.105449

Oldewage, T., Egal, A., & Grobler, C. (2017). *Anthropometry as cardiovascular risk factors and their association with dietary intakes in children from rural*. Academic Press.

Omboni, S. (2019). Connected health in hypertension management. *Frontiers in Cardiovascular Medicine*, *6*, 76. doi:10.3389/fcvm.2019.00076 PMID:31263703

Orgeron, D., Orgeron, M., & Streible, D. (Eds.). (2011). *Learning with the lights off: Educational film in the United States*. Oxford University Press.

Orhan, M. A., Castellano, S., Khelladi, I., Marinelli, L., & Monge, F. (2021). Technology distraction at work. Impacts on self-regulation and work engagement. *Journal of Business Research*, *126*, 341–349. doi:10.1016/j.jbusres.2020.12.048

OrthoLive. (2018, October 11). *Five Ways Telehealth Helps Sports Doctors Improve Their Practice*. Retrieved December 31, 2021, from https://www.ortholive.com/blog/five-ways-telehealth-helps-sports-doctors-improve-their-practice/

Ortigosa, A., Martin, J. M., & Carro, R. M. (2013). Sentiment analysis in Facebook and its application to e-learning. *Computers in Human Behavior*, *31*(1), 527–541. doi:10.1016/j.chb.2013.05.024

Ospina, M. B., Bond, K., Karkhaneh, M., Buscemi, N., Dryden, D. M., Barnes, V., & Shannahoff Khalsa, D. (2008). Clinical trials of meditation practices in health care: Characteristics and quality. *Journal of Alternative and Complementary Medicine (New York, N.Y.)*, *14*(10), 1199–1213. doi:10.1089/acm.2008.0307 PMID:19123875

Othman, M. K., Nogoibaeva, A., Leong, L. S., & Barawi, M. H. (2021). Usability evaluation of a virtual reality smartphone app for a living museum. *Universal Access in the Information Society*, 1–18. doi:10.100710209-021-00820-4

Oubenaissa, L., Giardina, M., & Battacharya, M. (2002). Designing a framework for the implementation of situated online, collaborative, problem-based activity: Operating within a local and multi-cultural learning context. *International Journal on E-Learning*, *1*(3), 41–46.

Ovadia, S. (2011). Internet connection quora.com: Another place for users to ask questions. *Behavioral & Social Sciences Librarian*, *30*(3), 176–180. doi:10.1080/01639269.2011.591279

Paas, F., & Sweller, J. (2014). Implications of Cognitive Load Theory for Multimedia Learning. In R. Mayer (Ed.), The Cambridge Handbook of Multimedia Learning (pp. 27-42). Cambridge University Press. doi:10.1017/CBO9781139547369.004

Packiam, T., & Geoffrey, R. (2012). The impact of engagement with social networking sites (SNSs) on cognitive skills. *Computers in Human Behavior*, *28*(5), 1748–1754. doi:10.1016/j.chb.2012.04.015

Pal, A., Herdagdelen, A., Chatterji, S., Taank, S., & Chakrabarti, D. (2016). Discovery of Topical Authorities in Instagram Categories and Subject Descriptors. *Www*, 1203–1213.

Paller, K. A., Creery, J. D., & Schechtman, E. (2021). Memory and sleep: How sleep cognition can change the waking mind for the better. *Annual Review of Psychology*, *72*(1), 123–150. doi:10.1146/annurev-psych-010419-050815 PMID:32946325

Pappano, L. (2012). The Year of the MOOC. *The New York Times, 2*(12), 2012.

Paris, D. (2012). Culturally sustaining pedagogy: A needed change in stance, terminology, and practice. *Educational Researcher*, *41*(3), 93–97. doi:10.3102/0013189X12441244

Paris, D., & Alim, S. (2017). *Culturally sustaining pedagogy: Teaching and learning for justice in a changing world*. Teachers College Press.

Parry, E., & Wilson, H. (2009). Factors influencing the adoption of online recruitment. *Personnel Review*, *38*(6), 655–673. doi:10.1108/00483480910992265

Parsons, D., & MacCallum, K. (2020). A learning theory rubric for evaluating mobile learning activities. In *Mobile devices in education: Breakthroughs in research and practice* (pp. 983–998). IGI Global. doi:10.4018/978-1-7998-1757-4.ch056

Pask, G. (1976). *Conversation theory: Applications in education and epistemology*. Elsevier Publishing Company.

Pass, F., & Renkl, A. (2003). *Cognitive Load Theory and Instructional Design: Recent Developments*. Academic Press.

Patky, J. (2020). The influence of organizational learning on performance and innovation: A literature review. *Journal of Workplace Learning*, *32*(3), 229–242. doi:10.1108/JWL-04-2019-0054

Patterson, C., Stephens, M., Chiang, V., Price, A. M., Work, F., & Snelgrove-Clarke, E. (2017). The significance of personal learning environments (PLEs) in nursing education: Extending current conceptualizations. *Nurse Education Today*, *48*, 99–105. PMID:27744138

Pearson, R. J. (2020). Clickers versus Plickers: Comparing two audience response systems in a smartphone-free teaching environment. *Journal of Chemical Education*, *97*(8), 2342–2346. doi:10.1021/acs.jchemed.0c00464

Pegrum, M. (2014). *Mobile learning: Languages, literacies and cultures*. Springer.

Pekrun, R., Goetz, T., Daniels, L. M., Stupnisky, R. H., & Perry, R. P. (2010). Boredom in achievement settings: Control-value antecedents and performance outcomes of a neglected emotion. *Journal of Educational Psychology*, *102*(3), 531–549. doi:10.1037/a0019243

Pekrun, R., Goetz, T., Frenzel, A. C., Barchfeld, P., & Perry, R. (2011). Measuring emotions in students' learning and performance: The Achievement Emotions Questionnaire (AEQ). *Contemporary Educational Psychology*, *36*(1), 36–48. doi:10.1016/j.cedpsych.2010.10.002

Pekrun, R., Goetz, T., Titz, W., & Perry, R. P. (2002). Academic emotions in students' self-regulated learning and achievement: A program of quantitative and qualitative research. *Educational Psychologist*, *37*(2), 91–105. doi:10.1207/S15326985EP3702_4

Pelster, B., Haims, J., Stempel, J., & Vyver, B. (2016). Learning: Employees take charge. Global Human Capital Trends 2016. *The new organization: Different by design*. Retrieved from https://www2.deloitte.com/us/en/pages/human-capital/articles/introduction-human-capital-trends-2016.html

Peltokorpi, V. (2021). In search of 'low-hanging fruits' or 'ideal' candidates? Understanding headhunters' candidate search activities. *Human Resource Management Journal*, *31*(3), 639–657. doi:10.1111/1748-8583.12325

Peltz, J. S., Daks, J. S., & Rogge, R. D. (2020). Mediators of the association between COVID-19-related stressors and parents' psychological flexibility and inflexibility: The roles of perceived sleep quality and energy. *Journal of Contextual Behavioral Science*, *17*, 168–176. doi:10.1016/j.jcbs.2020.07.001 PMID:32834971

Pereira, F., & Fife, E. (2021). *Tele-health in theory versus practice: A comparative look at the United States and Singapore*. Academic Press.

Pernin, J. P., & Lejeune, A. (2004). Dispositifs d'apprentissage instrumentes par les technologies: vers une ingénierie centrée sur les scénarios. Actes du colloque TICE 2004, 407-414.

Peters, M. A. (2016). The postcolonial university. *Linguistic and Philosophical Investigations*, *15*, 77.

Phelps, L. E. (2020). Adapting to Adaptive Learning. *Peabody Journal of Education*, *95*(2), 160–172. doi:10.1080/0161956X.2020.1745615

Phillips, S. (2020). Working through the pandemic: Accelerating the transition to remote working. *Business Information Review*, *37*(3), 129–134. doi:10.1177/0266382120953087

Picard, R. W. (1995). *Affective Computing-MIT Media Laboratory Perceptual Computing Section Technical Report No. 321*. Cambridge, MA: MIT.

Picard, R. W. (2003). Affective computing: Challenges. *International Journal of Human-Computer Studies*, *59*(1-2), 55–64. doi:10.1016/S1071-5819(03)00052-1

Pick, J. B., & Sarkar, A. (2020). Geographies of global digital divides. In *Geographies of the Internet* (pp. 115–135). Routledge.

Pignoli, P., Tremoli, E., Poli, A., Oreste, P., & Paoletti, R. (1986). Intimal plus Medial Thickness of the Arterial Wall. *Direct Measurement with Ultrasound Imaging A.*, *74*(6), 1399–1406. PMID:3536154

Pillutla, P., Li, D., Ahmadi, N., & Budoff, M. J. (2012). Comparison of Coronary Calcium in Firefighters With Abnormal Stress Test Findings and in Asymptomatic Nonfirefighters With Abnormal Stress Test Findings. *The American Journal of Cardiology*. doi:10.1016/j.amjcard.2011.09.044

Pimmer, C., Brühlmann, F., Odetola, T. D., Oluwasola, D. O., Dipeolu, O., & Ajuwon, A. J. (2019). Facilitating professional mobile learning communities with instant messaging. *Computers & Education*, *128*, 102–112. doi:10.1016/j.compedu.2018.09.005

Pintrich, P. R. (1995). Understanding Self-Regulated Learning What Is Self-Regulated Learning? *New Directions for Teaching and Learning*, *63*(63), 3–12. doi:10.1002/tl.37219956304

Plass, J. L., Moreno, R., & Brünken, R. (2010). *Cognitive load theory*. Cambridge University Press. doi:10.1017/CBO9780511844744

Plaza, I., Demarzo, M. M. P., Herrera-Mercadal, P., & García-Campayo, J. (2013). Mindfulness based mobile applications: Literature review and analysis of current features. *JMIR mHealth and uHealth*, *1*(2), e24. doi:10.2196/mhealth.2733 PMID:25099314

Plews, D. J., Scott, B., Altini, M., Wood, M., Kilding, A. E., & Laursen, P. B. (2017). Comparison of Heart-Rate-Variability Recording With Smartphone Photoplethysmography, Polar H7 Chest Strap, and Electrocardiography. *International Journal of Sports Physiology and Performance*, *12*(10), 1324–1328. doi:10.1123/ijspp.2016-0668 PMID:28290720

Pluntke, U., Gerke, S., Sridhar, A., Weiss, J., & Michel, B. (2019). Evaluation and Classification of Physical and Psychological Stress in Firefighters using Heart Rate Variability. *2019 41st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*, 2207–2212. doi:10.1109/EMBC.2019.8856596

Popenici, S. (2015). Deceptive Promises: The Meaning of MOOCs. *Macro-Level Learning Through Massive Open Online Courses (MOOCs): Strategies and Predictions for the Future*, 158-167.

Porto, L. G. G., Schmidt, A. C. B., de Souza, J. M., Nogueira, R. M., Fontana, K. E., Molina, G. E., Korre, M., Smith, D. L., Junqueira, L. F., & Kales, S. N. (2019). Firefighters' basal cardiac autonomic function and its associations with cardiorespiratory fitness. *Work (Reading, Mass.)*, *62*(3), 485–495. doi:10.3233/WOR-192883 PMID:30909264

Potdevin, F., Vors, O., Huchez, A., Lamour, M., Davids, K., & Schnitzler, C. (2018). How can video feedback be used in physical education to support novice learning in gymnastics? Effects on motor learning, self-assessment and motivation. *Physical Education and Sport Pedagogy*, *23*(6), 559–574. doi:10.1080/17408989.2018.1485138

Prahani, B., Jatmiko, B., Hariadi, B., Sunarto, D., Sagirani, T., Amelia, T., & Lemantara, J. (2020). Blended Web Mobile Learning (BWML) model to improve students' higher order thinking skills. *International Journal of Emerging Technologies in Learning*, *15*(11), 42–55. doi:10.3991/ijet.v15i11.12853

Prathapagiri, V. G. (2020). Digital Divide and Its Dimensions: A Study in India. In Leveraging Digital Innovation for Governance, Public Administration, and Citizen Services: Emerging Research and Opportunities (pp. 79-100). IGI Global.

Prell, R., Opatz, O., Merati, G., Gesche, B., Gunga, H. C., & Maggioni, M. A. (2020). Heart Rate Variability, Risk-Taking Behavior and Resilience in Firefighters During a Simulated Extinguish-Fire Task. *Frontiers in Physiology*, *11*(July), 1–11. doi:10.3389/fphys.2020.00482 PMID:32754042

Preszler, R. W., Dawe, A., Shuster, C. B., & Shuster, M. (2007). Assessment of the effects of student response systems on student learning and attitudes over a broad range of biology courses. *CBE Life Sciences Education*, *6*(1), 29–41. doi:10.1187/cbe.06-09-0190 PMID:17339392

Preuss, H., Capito, K., van Eickels, R. L., Zemp, M., & Kolar, D. R. (2021). Cognitive reappraisal and self-compassion as emotion regulation strategies for parents during COVID-19: An online randomized controlled trial. *Internet Interventions: the Application of Information Technology in Mental and Behavioural Health*, *24*, 100388. doi:10.1016/j.invent.2021.100388 PMID:33912402

Priyadarshini, C., Dubey, R. K., Kumar, Y. L. N., & Jha, R. R. (2020). Impact of a Social Media Addiction on Employees' Wellbeing and Work Productivity. *Qualitative Report*, *25*(1), 181–196. doi:10.46743/2160-3715/2020.4099

Project Management Institute. (2017). *A Guide to the Project Management Body of Knowledge (PMBOK)* (6th ed.). Project Management Institute.

Project Management Institute. (2021). *Project Management Professional (PMP)® examination content outline: January 2021 exam update*. https://www.pmi.org/-/media/pmi/documents/public/pdf/certifications/pmp-examination-content-outline.pdf?v=ef41743a-9156-4137-a9a6-fd31e19a9668&sc_lang_temp=en

Project Management Institute. (n.d.). *New item types*. https://www.pmi.org/-/media/pmi/documents/public/pdf/certifications/prototype-exam-questions.pdf?v=5ce972c2-1f02-49d9-aaff-c23c1ebb43f6

Putwain, D. W., Becker, S., Symes, W., & Pekrun, R. (2018). Reciprocal relations between students' academic enjoyment, boredom, and achievement over time. *Learning and Instruction*, *54*, 73–81. doi:10.1016/j.learninstruc.2017.08.004

Qiu, S., Cai, X., Sun, Z., Li, L., Zuegel, M., Steinacker, J. M., & Schumann, U. (2017). *Heart Rate Recovery and Risk of Cardiovascular Events and All-Cause*. doi:10.1161/JAHA.117.005505

Quality Indicators for Learning and Teaching. (2020). *2020 Graduate Outcomes Survey.* https://qilt.edu.au/surveys/graduate-outcomes-survey-(gos)

Quilty-Dunn, J. (2019). Is Iconic Memory Iconic? *Philosophy and Phenomenological Research*, *101*(3), 660–682. doi:10.1111/phpr.12625

Rafiq, M., Batool, S. H., Ali, A. F., & Ullah, M. (2021). University libraries response to COVID-19 pandemic: A developing country perspective. *Journal of Academic Librarianship*, *47*(1), 102280. https://doi.org/10.1016/j.acalib.2020.102280

Rahayuningsih, H., & Yuniarti, K. W. (2017). *Balancing Development and Sustainability in Tourism Destinations*. Balancing Development and Sustainability in Tourism Destinations.

Rai, L., & Chunrao, D. (2016). Influencing factors of success and failure in MOOC and general analysis of learner behavior. *International Journal of Information and Education Technology (IJIET)*, *6*(4), 262.

Raj, N., Dey, L., & Gaonkar, B. (2011). Expertise prediction for social network platforms to encourage knowledge sharing. *Proceedings - 2011 IEEE/WIC/ACM International Conference on Web Intelligence, WI 2011, 1*(September), 380–383. 10.1109/WI-IAT.2011.93

Ralph, T. W. (1949). Basic principles of curriculum and instruction. Syllabus for Education.

Rana, N. P., & Dwivedi, Y. K. (2015). Using clickers in a large business class: Examining use behavior and satisfaction. *Journal of Marketing Education*, *38*(1), 47–64. doi:10.1177/0273475315590660

Rana, N. P., & Dwivedi, Y. K. (2018). An empirical examination of antecedents determining students' usage of clickers in a digital marketing module. *International Journal of Business Information Systems*, *27*(1), 86–104. doi:10.1504/IJBIS.2018.088572

Rana, N. P., Dwivedi, Y. K., & Al-Khowaiter, W. A. A. (2016). A review of literature on the use of clickers in the business and management discipline. *International Journal of Management Education*, *14*(2), 74–91. doi:10.1016/j.ijme.2016.02.002

Ranasinghe, N., Karunanayaka, K., Cheok, A. D., Fernando, O. N. N., Nii, H., & Gopalakrishnakone, P. (2011, November). Digital taste and smell communication. In *Proceedings of the 6th international conference on body area networks* (pp. 78-84). Academic Press.

Rapp, A. K., Healy, M. G., Charlton, M. E., Keith, J. N., Rosenbaum, M. E., & Kapadia, M. R. (2016). YouTube is the most frequently used educational video source for surgical preparation. *Journal of Surgical Education*, *73*(6), 1072–1076. doi:10.1016/j.jsurg.2016.04.024 PMID:27316383

Ras, J., & Leach, L. (2021). Prevalence of coronary artery disease risk factors in firefighters in the city of Cape Town fire and rescue service – A descriptive study. *Journal of Public Health Research, 10*(1). doi:10.4081/jphr.2021.2000

Ras, J., Mosie, D., Strauss, M., & Leach, L. (2021). Knowledge and attitude toward health and CVD risk factors among firefighters in Cape Town, South Africa. *Journal of Public Health Research*. Advance online publication. doi:10.4081/jphr.2021.2307 PMID:34351095

Ras, R. T., Streppel, M. T., Draijer, R., & Zock, P. L. (2013). Flow-Mediated Dilation and Cardiovascular Risk Prediction : A Systematic Review with Meta-Analysis. *International Journal of Cardiology*, *168*(1), 344–351. doi:10.1016/j.ijcard.2012.09.047 PMID:23041097

Ratan, Z. A., Zaman, S. B., Islam, S., & Hosseinzadeh, H. (2021). Smartphone overuse: A hidden crisis in COVID-19. *Health Policy and Technology*, *10*(1), 21–22. doi:10.1016/j.hlpt.2021.01.002 PMID:33520635

Rayfield, S., Plugge, E., Rayfield, S., & Plügge, E. (2016). *Systematic Review and Meta-Analysis of the Association between Maternal Sm*. doi:10.1136/jech-2016-207376

Restubog, S. L. D., Ocampo, A. C. G., & Wang, L. (2020). Taking control amidst the chaos: Emotion regulation during the COVID-19 pandemic. *Journal of Vocational Behavior*, *119*, 103440. doi:10.1016/j.jvb.2020.103440 PMID:32390659

Richardson, J. (2010). History of American library science: Its origins and early development. In Encyclopedia of library and information sciences. Academic Press.

Richards, R. (2012). Exploring Formative Assessment with a Project Using Mobile Phones.*Ubiquitous Learning*. *International Journal (Toronto, Ont.)*, *4*(2).

Rich, M. J., & Pather, S. (2020). A response to the persistent digital divide: Critical components of a community network ecosystem. *Information Development*.

Rikala, J., & Kankaanranta, M. (2012, October). The Use of Quick Response Codes in the Classroom. In mLearn (pp. 148-155). Academic Press.

Rikala, J., & Kankaanranta, M. (2013). Mobile learning. A Review of Current Research. *Reports of the Department of Mathematical Information Technology Series E. Educational Technology,* 1–65.

Rios, J. A., Ling, G., Pugh, R., Becker, D. M., & Bacall, A. N. (2020). Identifying critical 21st Century for workplace success: A content analysis of job advertisements. *Educational Researcher*, *49*(2), 80–89. doi:10.3102/0013189X19890600

Robbins, P., & Aydede, M. (2009). A short primer on situated cognition. In P. Robbins & M. Aydede (Eds.), *The Cambridge Handbook of Situated Cognition*. Cambridge University Press.

Robertson, A. H., Larivière, C., Leduc, C. R., McGillis, Z., Eger, T., Godwin, A., Larivière, M., & Dorman, S. C. (2017). Novel tools in determining the physiological demands and nutritional practices of Ontario firerangers during fire deployments. *PLoS One*, *12*(1), 40–50. doi:10.1371/journal.pone.0169390 PMID:28107380

Roblyer, M. D., & Wiencke, W. R. (2003). Design and use of a rubric to access and encourage interactive qualities in distance courses. *American Journal of Distance Education*, *17*(2), 77–98. doi:10.1207/S15389286AJDE1702_2

Rodrigues, S., Dias, D., Paiva, J. S., & Cunha, J. P. S. (2018). Psychophysiological Stress Assessment among On-Duty Firefighters. *Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBS,* 4335–4338. doi:10.1109/EMBC.2018.8513250

Rodrigues, S., Paiva, J. S., Dias, D., & Cunha, J. P. S. (2018). Stress among on-duty firefighters: An ambulatory assessment study. *PeerJ*, *6*, e5967. doi:10.7717/peerj.5967 PMID:30581658

Rodrigues, S., Paiva, J. S., Dias, D., Pimentel, G., Kaiseler, M., & Cunha, J. P. S. (2018). Wearable Biomonitoring Platform for the Assessment of Stress and its Impact on Cognitive Performance of Firefighters: An Experimental Study. *Clinical Practice and Epidemiology in Mental Health*, *14*(1), 250–262. doi:10.2174/1745017901814010250 PMID:30972123

Rogers, E. M. (2010). *Diffusion of innovations*. Simon and Schuster.

Rojas, L. B. R. (2012, March 21). *Gen 1.5: Where an immigrant generation fits in*. Southern California Public Radio. Retrieved January 21, 2022, from https://archive.kpcc.org/blogs/multiamerican/2012/03/21/7963/what-is-a-1-5-where-an-immigrant-generation-fits-i/

Rubenstein, E. L., Burke, S. K., D'Arpa, C., & Lenstra, N. (2021). Health equity and small and rural public libraries during COVID -19. *Proceedings of the Association for Information Science and Technology*, *58*(1), 827–829. https://doi.org/10.1002/pra2.577

Rubinstein, J. S., Meyer, D. E., & Evans, J. E. (2001). Executive control of cognitive processes in task switching. *Journal of Experimental Psychology. Human Perception and Performance*, *27*(4), 763–797. doi:10.1037/0096-1523.27.4.763 PMID:11518143

Rudrum, S., Rondinelli, E., Carlson, J., Frank, L., Brickner, R. K., & Casey, R. (2022). When work came home: Formation of feeling rules in the context of a pandemic. *Emotion, Space and Society*, *42*, 100861. doi:10.1016/j.emospa.2021.100861

Russell, B. S., Tomkunas, A. J., Hutchison, M., Tambling, R. R., & Horton, A. L. (2021). The protective role of parent resilience on mental health and the parent–child relationship during COVID-19. *Child Psychiatry and Human Development*, 1–14. PMID:34533667

Ryoo, J. J., & Kekelis, L. (2018). Reframing "failure" in making: The value of play, social relationships, and ownership. *Journal of Youth Development*, *13*(4), 49–67. doi:10.5195/JYD.2018.624

Saadatdoost, R., Jafarkarimi, H., Sim, A. T. H., & Hee, J. M. (2019). Understanding MOOC Learners. *International Journal of Web-Based Learning and Teaching Technologies*, *14*(1), 93–112. doi:10.4018/IJWLTT.2019010107

Sablić, M., Mirosavljević, A., & Škugor, A. (2020). *Video-Based Learning (VBL)—Past, Present and Future: An Overview of the Research Published from 2008 to 2019*. Technology, Knowledge and Learning. doi:10.100710758-020-09455-5

Sadati, L., Motaharipour, M., Farajidana, H., & Abjar, R. (2021). Designing, implementing and evaluation of educational program of ethics in education by scenario based discussion: A Scholarship study. *Journal of Medical Education and Development*. doi:10.18502/jmed.v16i2.7145

Sadka, O., Erel, H., Grishko, A., & Zuckerman, O. (2018, June). Tangible interaction in parent-child collaboration: Encouraging awareness and reflection. In *Proceedings of the 17th ACM Conference on Interaction Design and Children* (pp. 157-169). 10.1145/3202185.3202746

Sahin, F., & Mentor, D. (2017). Creating Teaching and Learning Accountabilities Through Data Analytic Feedback Loops. In *ModSim 2017 International Congress on Modelling and Simulation - Modeling and Simulation in the Age of Data*. Retrieved December 24, 2017 from http://modsimworld.org/papers/2017/Creating_Teaching_and_Learning_Accountabilities_Through_Data_Analytic_Feedback_Loops.pdf

Şahin, F., & Mentor, D. (2017). Creating teaching and learning accountabilities through data analytic feedback loops. *Proceedings of the MODSIM World Conference & Expo*.

Şahin, F., & Mentor, D. (2019). Mobile Phones for Assessment: Anywhere, Anytime, by Anyone. In Advancing Mobile Learning in Contemporary Educational Spaces (pp. 128-159). IGI Global.

Saldaña, J. (2015). *The Coding Manual for Qualitative Researchers*. Sage Publications.

Saliimah, F. R. (2021). The Influence between Synchronous and Asynchronous Learning Model toward Students' English Achievement at SMAN 1 Sambit (Doctoral dissertation, IAIN Ponorogo

Saltz, J. S., Shamshurin, I., & Crowston, K. (2017). Comparing data science project management methodologies via a controlled experiment. *Proceedings of the Annual Hawaii International Conference on System Sciences,* 1013–1022. 10.24251/HICSS.2017.120

Sandars, J., Correia, R., Dankbaar, M., de Jong, P., Goh, P., Hege, I., Masters, K., Oh, S., Patel, R., Premkumar, K., Webb, A., & Pusic, M. (2020). Twelve tips for rapidly migrating to online learning during the COVID-19 pandemic. *MedEdPublish*, 9.

Santos, M. C. (2020). Libraries respond to COVID-19. *Texas Library Journal, 96*(2), 64-70, 72-73. http://ezproxy.cul.columbia.edu/login?url=https://www.proquest.com/scholarly-journals/libraries-respond-covid-19/docview/2418802935/se-2?accountid=10226

Saremi, M., Fallah, R., Laal, F., Noorizade, N., & Rahimi, E. (2019). Assessment of mental workload, work ability and musculoskeletal disorders of firefighters. Journal of Community Health Research. doi:10.18502/jchr.v8i3.1562

Saunders, M., & Townsend, K. (2016). Reporting and justifying the number of interview participants in organization and workplace research. *British Journal of Management*, *27*(4), 836–852. doi:10.1111/1467-8551.12182

Savage, M. J., James, R., Mahistro, D., Donaldson, J., Healy, L. C., Nevill, M., & Hennis P. J. (2020). Mental health and movement behaviour during the COVID-19 pandemic in UK university students: Prospective cohort study. *Mental Health and Physical Activity, 19*.

Savall, A., Charles, R., Bertholon, A., Gramont, B., Trombert, B., Barthélémy, J. C., & Roche, F. (2020). Volunteer and career French firefighters: Cardiovascular risk factors and cardiovascular risk assessment. *European Journal of Preventive Cardiology*, *27*(1), 107–109. doi:10.1177/2047487319827463 PMID:30722684

Save Our Schools. (2021) *Knowledge is Power*. https://saveourschools.me/knowledge-is-power/

Savino, D. M. (2014). The impact of MOOCs on human resource training and development. *Journal of Higher Education Theory and Practice*, *14*(3), 59.

Scardamalia, M. (2002). Collective cognitive responsibility for the advancement of knowledge. In B. Smith (Ed.), *Liberal education in a knowledge society* (pp. 67–98). Open Court.

Schaub, F. (2018). The implications of the fcc's net neutrality repeal. *Media and Communication*, *6*(3), 69–72.

Schieman, S., Badawy, P. J. A., Milkie, M., & Bierman, A. (2021). Work-life conflict during the COVID-19 pandemic. *Socius: Sociological Research for a Dynamic World*, *7*, 2378023120982856. doi:10.1177/2378023120982856

Schlaudecker, E. P., Munoz, F. M., Bardají, A., Boghossian, N. S., Khalil, A., Mousa, H., Nesin, M., Nisar, M. I., Pool, V., Spiegel, H. M. L., Tapia, M. D., Kochhar, S., & Black, S. (2017). Small for Gestational Age: Case Definition & Guidelines for Data Collection, Analysis, and Presentation of Maternal Immunisation Safety Data. *Vaccine*, *35*(48), 6518–6528. doi:10.1016/j.vaccine.2017.01.040 PMID:29150057

Schlicht, E., Caruso, R., Denby, K., Matias, A., Dudar, M., & Ives, S. J. (2018). Effects of Wrist Cooling on Recovery From Exercise-Induced Heat Stress With Firefighting Personal Protective Equipment. *Journal of Occupational and Environmental Medicine*, *60*(11), 1049–00. doi:10.1097/JOM.0000000000001436 PMID:30188495

Schmid, R. F., Bernard, R. M., Borokhovski, E., Tamim, R. M., Abrami, P. C., Surkes, M. A., Wade, C. A., & Woods, J. (2014). The effects of technology use in postsecondary education: A meta-analysis of classroom applications. *Computers & Education*, *72*, 271–291. doi:10.1016/j.compedu.2013.11.002

Schmit, M., & DeBeliso, M. (2019). The Relationship between Firefighters' Physical Performance Aspects and Simulated Firefighting Demands. *Turkish Journal of Kinesiology*, *5*(2), 63–75. doi:10.31459/turkjkin.560623

Schulze, A. S., Leigh, D., Sparks, P., & Spinello, E. (2017). Massive Open Online Courses and Completion Rates: Are Self-Directed Adult Learners the Most Successful at MOOCs? In Handbook of Research on Individualism and Identity in the Globalized Digital Age (pp. 24-49). IGI Global.

Schuster, A. K., Fischer, J. E., Thayer, J. F., Mauss, D., & Jarczok, M. N. (2016). Decreased heart rate variability correlates to increased cardiovascular risk. *International Journal of Cardiology*, *203*, 728–730. doi:10.1016/j.ijcard.2015.11.027 PMID:26587729

Schwerdtfeger, A. R., & Dick, K. (2019). Episodes of momentary resilience in daily life are associated with HRV reductions to stressful operations in firefighters: An ambulatory assessment approach using bayesian multilevel modeling. *The Journal of Positive Psychology*, *14*(5), 593–602. doi:10.1080/17439760.2018.1497689

Sciutti, A., Damonte, F., Alloisio, M., & Sandini, G. (2019). Visuo-Haptic Exploration for Multimodal Memory. *Frontiers in Integrative Neuroscience*, *13*, 15. Advance online publication. doi:10.3389/fnint.2019.00015 PMID:31156402

Scott, J. E., & Walczak, S. (2009). Cognitive engagement with a multimedia ERP training tool: Assessing computer self-efficacy and technology acceptance. *Information & Management*, *46*(4), 221–232. doi:10.1016/j.im.2008.10.003

Scoulas, J. M. (2021). College students' perceptions on sense of belonging and inclusion at the academic library during COVID-19. *Journal of Academic Librarianship*, *47*(6), 102460. https://doi.org/10.1016/j.acalib.2021.102460

Selwyn, N. (2016). *Education and technology: Key issues and debates*. Bloomsbury Publishing.

Sessa, F., Anna, V., Messina, G., Cibelli, G., Monda, V., Marsala, G., Ruberto, M., Biondi, A., Cascio, O., Bertozzi, G., Pisanelli, D., Maglietta, F., Messina, A., Mollica, M. P., & Salerno, M. (2018). Heart rate variability as predictive factor for sudden cardiac death. *Aging (Albany NY)*, *10*(2), 166–177. doi:10.18632/aging.101386 PMID:29476045

Setyowibowo, F., Sabandi, M., & Sunarto, M. (2017). Structural Relationships between Technological Knowledge, Content Knowledge and Pedagogical Knowledge. In *International Conference on Teacher Training and Education 2017 (ICTTE 2017).* Atlantis Press. 10.2991/ictte-17.2017.51

Sevilla, A., Phimister, A., Krutikova, S., Kraftman, L., Farquharson, C., Costa Dias, M., Cattan, S., & Andrew, A. (2020). *Learning during the lockdown: Real-time data on children's experiences during home learning*. doi:10.1920/bn.ifs.2020.bn0288

Shaffer, D. M., & Collura, M. J. (2009). Evaluating the effectiveness of a personal response system in the classroom. *Teaching of Psychology*, *36*(4), 273–277. doi:10.1080/00986280903175749

Shaffer, F., & Ginsberg, J. P. (2017). An Overview of Heart Rate Variability Metrics and Norms. *Frontiers in Public Health*, *5*, 258. doi:10.3389/fpubh.2017.00258 PMID:29034226

Shah, D. (2016, December 25). *By the numbers: MOOCS in 2016*. Retrieved from https://www.class-central.com/report/mooc-stats-2016/

Shah, D. (2020, December 7). *EdX's 2020: Year in Review - Class Central*. Retrieved November 30, 2021, from https://www.classcentral.com/report/edx-2020-review/

Shah, K., & Tomljenovic-Berube, A. (2021). A New Dimension of Health Care: The Benefits, Limitations and Implications of Virtual Medicine. *Journal of Undergraduate Life Sciences*, *15*(1), 10–10. doi:10.33137/juls.v15i1.37034

Shapiro, A. M., Sims-Knight, J., O'Rielly, G. V., Capaldo, P., Pedlow, T., Gordon, K., & Monteiro, K. (2017). Clickers can promote fact retention but impede conceptual understanding: The effect of the interaction between clicker use and pedagogy on learning. *Computers & Education*, *111*, 44–59. doi:10.1016/j.compedu.2017.03.017

Sharma, K., Blaha, M. J., Blumenthal, R. S., & Musunuru, K. (2009). Clinical and Research Applications of Carotid Intima-Media Thickness. *AJC*, *103*(9), 1316–1320. doi:10.1016/j.amjcard.2009.01.020 PMID:19406278

Sharma, M., Batra, K., & Flatt, J. (2021, July). Testing the multi-theory model (MTM) to predict the use of new technology for social connectedness in the COVID-19 pandemic. *Health Care*, *9*(7), 838. PMID:34356216

Sharples, M., Taylor, J., & Vavoula, G. (2007). A Theory of Learning for the Mobile Age. In R. Andrews & C. Haythornthwaite (Eds.), *The Sage Handbook of Elearning Research* (pp. 221–247). Sage. doi:10.4135/9781848607859.n10

Shastri, D. K., & Chudasma, P. (2021). The perception of ICT skills and challenges of usage of technologies among the library professionals of the Gujarat state during the COVID 19: A comprehensive study. *Quality & Quantity*. doi:10.1007/s11135-021-01167-x

Shaw, A. (2021). Teaching or Cheating? Using Collaboration and Technology to Support Student Learning. *International Journal on E-Learning*, *20*(1), 47–58.

Shenoy, V., & Aithal, P. S. (2018). Literature Review of Primary Organizational Recruitment Sources. *International Journal of Management, Technology, and Social Sciences*, *3*(1), 37–58. doi:10.47992/IJMTS.2581.6012.0035

Sheth, A. (2010). Computing for human experience: Semantics-empowered sensors, services, and social computing on the ubiquitous web. *IEEE Internet Computing*, *14*(1), 88–91. doi:10.1109/MIC.2010.4

Sheth, A., Anantharam, P., & Henson, C. (2016). Semantic, cognitive, and perceptual computing: Paradigms that shape human experience. *Computer*, *49*(3), 64–72. doi:10.1109/MC.2016.75

Shih, R. (2012). Can Web 2.0 technology assist college students inlearning English writing? Integrating Facebookand peer assessment with blended learning. *Australasian Journal OfEducational Technology*, *37*(2), 36–39.

Shin, J. H., Lee, J. Y., Yang, S. H., Lee, M. Y., & Chung, I. S. (2016). Factors related to heart rate variability among firefighters. *Annals of Occupational and Environmental Medicine*, *28*(1), 1–9. doi:10.118640557-016-0111-6 PMID:27298728

Shoaib, M., Rasool, D., & Anwar, D. (2021). Evaluating Research Support Facilities to University Students during COVID-19. *Library Philosophy and Practice*, *4953*(1), 1–18.

Shuler, C. (2009). *Pockets of potential: Using mobile technologies to promote children's learning*. The Joan Ganz Cooney Center at Sesame Workshop.

Siau, J., Sheng, H., & Nah, F. F. H. (2006). Use of a classroom response system to enhance classroom interactivity. *IEEE Transactions on Education*, *49*(3), 398–403. doi:10.1109/TE.2006.879802

Siddall, A. G., Stevenson, R. D. M., Turner, P. J. F., & Bilzon, J. L. J. (2018). Physical and Physiological Performance Determinants of a Firefighting Simulation Test. *Journal of Occupational and Environmental Medicine*, *60*(7), 637–643. doi:10.1097/JOM.0000000000001313 PMID:29485491

Simons, C. (2013). Perspectives on the Development of Humor during Infancy, Childhood, and Adolescence. *Humor and Aging, 53*.

Simpson, J. (2016). The heart of the university: Library link location on doctoral granting institutions webpages and correlation with research output. *Journal of Academic Librarianship*, *42*(5), 503–508. https://doi.org/10.1016/j.acalib.2016.06.011

Simpson, V., & Oliver, M. (2007). Electronic voting systems for lectures then and now: A comparison of research and practice. *Australasian Journal of Educational Technology*, *23*(2), 187–208. doi:10.14742/ajet.1264

Singh, S., & Balhara, Y. P. S. (2021). "Screen-time" for children and adolescents in COVID-19 times: Need to have the contextually informed perspective. *Indian Journal of Psychiatry*, *63*(2), 192. doi:10.4103/indianjpsychiatry.indianjpsychiatry_886_21 PMID:34194066

Skilton, M. R., Celermajer, D. S., Cosmi, E., Crispi, F., Gidding, S. S., Raitakari, O. T., & Urbina, E. M. (2019). Natural History of Atherosclerosis and Abdominal Aortic Intima-Media Thickness: Rationale, Evidence, and Best Practice for Detection of Atherosclerosis in the Young. *Journal of Clinical Medicine*, *8*(8), 1201. doi:10.3390/jcm8081201 PMID:31408952

Slattery, F., Johnston, K., Paquet, C., Bennett, H., & Crockett, A. (2018). The long-term rate of change in lung function in urban professional firefighters: A systematic review. *BMC Pulmonary Medicine*, *18*(1), 149. doi:10.118612890-018-0711-8 PMID:30189854

Slavkovic, N., & Savic, A. (2015). The usage of m learning for adult education in Serbia. *Procedia: Social and Behavioral Sciences*, *174*, 2806–2812. doi:10.1016/j.sbspro.2015.01.971

Slyper, A. H. (2004). *Clinical Review 168 What Vascular Ultrasound Testing Has Revealed about Pediatric Atherogenesis, and a Potential Clinical Role for Ultrasound in Pediatric Risk Assessment.* Academic Press. . doi:10.1210/jc.2003-030644

Smagorinsky, P. (2017). Deconflating the ZPD and instructional scaffolding: Retranslating and reconceiving the zone of proximal development as the zone of next development. *Learning, Culture and Social Interaction*.

Smith, D. L., Haller, J. M., Benedict, R., & Moore-merrell, L. (2015). *Cardiac Strain Associated with High-rise Firefighting*. doi:10.1080/15459624.2014.970272

Smith. (n.d.). *Operations*. https://about.att.com/category/all_news.html

Smith, D. L., Barr, D. A., & Kales, S. N. (2013). Extreme sacrifice: Sudden cardiac death in the US Fire Service. *Extreme Physiology & Medicine*, *2*(1), 1–9. doi:10.1186/2046-7648-2-6 PMID:23849605

Smith, D. L., DeBlois, J. P., Kales, S. N., & Horn, G. P. (2016). Cardiovascular strain of firefighting and the risk of sudden cardiac events. *Exercise and Sport Sciences Reviews*, *44*(3), 90–97. doi:10.1249/JES.0000000000000081 PMID:27111479

Smith, D. L., Haller, J. M., Korre, M., Sampani, K., Porto, L. G. G., Fehling, P. C., Christophi, C. A., & Kales, S. N. (2019). The Relation of Emergency Duties to Cardiac Death Among US Firefighters. *The American Journal of Cardiology*, *123*(5), 736–741. doi:10.1016/j.amjcard.2018.11.049 PMID:30567633

Smith, D. L., Horn, G. P., Woods, J., Ploutz-Snyder, R., & Fernhall, B. (2016). Effect of Aspirin Supplementation on Hemostatic Responses in Firefighters Aged 40 to 60 Years. *The American Journal of Cardiology*, *118*(2), 275–280. doi:10.1016/j.amjcard.2016.04.032 PMID:27241836

Snelson, C., & Perkins, R. A. (2009). From silent film to YouTube™: Tracing the historical roots of motion picture technologies in education. *Journal of Visual Literacy*, *28*(1), 1–27. doi:10.1080/23796529.2009.11674657

Solorzano, D., & Yosso, T. (2002). Critical race methodology: Counter-storytelling as an analytical framework for education research. *Qualitative Inquiry*, *8*(1), 23–44. doi:10.1177/107780040200800103

Somers, J. (2017). Is AI riding a one-trick pony? *MIT's Technology Review*, *120*(6), 29–36.

Song, P., Zhang, Y., Yu, J., Zha, M., Zhu, Y., Rahimi, K., & Rudan, I. (2019). Global Prevalence of Hypertension in Children: A Systematic Review and Meta-Analysis. *JAMA Pediatrics*, *173*(12), 1154–1163. doi:10.1001/jamapediatrics.2019.3310 PMID:31589252

Sönmez, A., Göçmez, L., Uygun, D., & Ataizi, M. (2018). A review of current studies of mobile learning. *Journal of Educational Technology and Online Learning*, *1*(1), 12–27. doi:10.31681/jetol.378241

Sorof, J. M., Turner, J., Martin, D. S., Garcia, K., & Garami, Z. (2004). *Cardiovascular Risk Factors and Sequelae in Hypertensive Children Identified by Referral Versus*. doi:10.1161/01.HYP.0000114696.96318.4e

Soteriades, E. S., Smith, D. L., Tsismenakis, A. J., Baur, D. M., & Kales, S. N. (2011). (in Review). Cardiovascular disease in US firefighters: A systematic review. *Cardiology*, *19*(4), 202–215. doi:10.1097/CRD.0b013e318215c105 PMID:21646874

Soteriades, E. S., Targino, M. C., Talias, M. A., Hauser, R., Kawachi, I., Christiani, D. C., & Kales, S. N. (2011). Obesity and Risk of LVH and ECG Abnormalities in US Firefighters. *Journal of Occupational and Environmental Medicine*, *53*(8), 867–871. doi:10.1097/JOM.0b013e318221c6fe PMID:21775903

Soukup, M., & Lužný, D. (2019). The Story of Storyboards from East Sepik, Papua New Guinea. *Annals of the Náprstek Museum*, *40*(1), 59–74. doi:10.2478/anpm-2019-0005

Southern Poverty Law Center. (2009). *Climate of Fear* Retrieved from https://www.splcenter.org/20090831/climate-fear-latino-immigrants-suffolk-county-ny

Southern Poverty Law Center. (2020). *The Year in Hate and Extremism*. Retrieved from https://www.splcenter.org/news/2021/02/01/year-hate-2020

Spaccarotella, C. A. M., Polimeni, A., Migliarino, S., Principe, E., Curcio, A., Mongiardo, A., Sorrentino, S., De Rosa, S., & Indolfi, C. (2020). Multichannel Electrocardiograms Obtained by a Smartwatch for the Diagnosis of ST-Segment Changes. *JAMA Cardiology*, *5*(10), 1176–1180. doi:10.1001/jamacardio.2020.3994 PMID:32865545

Spector, F., & Alsemari, A. (2018). Echoic Memory. In Encyclopedia of Clinical Neuropsychology (pp. 1264–1265). Springer International Publishing. doi:10.1007/978-3-319-57111-9_1121

Spence, M. (1973). Job Market Signaling. *The Quarterly Journal of Economics*, *87*(3), 355–374. doi:10.2307/1882010

Sporea, I. (2019). *US4all (Ultrasound for All)*. . doi:10.11152/mu-2178

Sprague, E. W., & Dahl, D. W. (2010). Learning to click: An evaluation of the personal response system clicker technology in introductory marketing courses. *Journal of Marketing Education*, *32*(1), 93–103. doi:10.1177/0273475309344806

Springshare. (n.d.). *Libguides*. Retrieved March 15, 2022, from https://www.springshare.com/libguides/

Srivastava, S. (2021, September 21). *Unhooking the Drama: Meditation App Statistics To Know in 2021*. Retrieved December 31, 2021, from https://appinventiv.com/blog/latest-meditation-app-statistics/

St. Wulfram's Church. (n.d.) *The Trigge Library*. http://www.discoverstwulframs.org.uk/the-trigge-library.aspx

Stankov, U., Filimonau, V., Gretzel, U., & Vujičić, M. D. (2020). E-mindfulness–the growing importance of facilitating tourists' connections to the present moment. *Journal of Tourism Futures*.

Stanton, K., & Mwanri, L. (2014). Global Maternal and Child Health Outcomes. *The Role of Obstetric Ultrasound Global Maternal and Child Health Outcomes : The Role of Obstetric Ultrasound in Low Resource Settings*, (May). Advance online publication. doi:10.12691/jpm-1-3-3

State of Illinois Coronavirus Response. (2020, March 16). *Gov. Pritzker's Coronavirus (COVID-19) Press Conference (3/16/2020)* [Video file]. Retrieved from https://coronavirus.illinois.gov/media/videos/2020/gov-coronavirus-031620-mp4.html

Stewart, K. A., Navarro, S. M., Kambala, S., Tan, G., Poondla, R., Lederman, S., Barbour, K., & Lavy, C. (2020). Trends in Ultrasound Use in Low and Middle Income Countries : A Systematic Review. *International Journal of Maternal and Child Health and AIDS*, *9*(1), 103–120. doi:10.21106/ijma.294 PMID:32123634

Stone, C., & Springer, M. (2019). Interactivity, connectedness and'teacher-presence': Engaging and retaining students online. *Australian Journal of Adult Learning*, *59*(2), 146–169.

Stowell, J. R. (2015). Use of clickers vs. mobile devices for classroom polling. *Computers & Education*, *82*, 329–334. doi:10.1016/j.compedu.2014.12.008

Stowell, J. R., & Nelson, J. M. (2007). Benefits of electronic audience response systems on student participation, learning, and emotion. *Teaching of Psychology*, *34*(4), 253–258. doi:10.1080/00986280701700391

Strasser, B., & Fuchs, D. (2015). Role of physical activity and diet on mood, behavior, and cognition. *Neurology, Psychiatry & Brain Research*, *21*(3), 118–126. doi:10.1016/j.npbr.2015.07.002

Streeter, B. H. (2011). *The chained library: A survey of four centuries in the evolution of the English library*. Cambridge University Press. doi:10.1017/CBO9780511920141

Strukova, S., Ruipérez-Valiente, J. A., & Mármol, F. G. (2022). A Survey on Data-Driven Evaluation of Competencies and Capabilities across Multimedia Environments. *International Journal of Interactive Multimedia & Artificial Intelligence*.

Stuart, S., Brown, M., & Draper, S. (2004). Using an electronic voting system in logic lectures: One practitioner's application. *Journal of Computer Assisted Learning*, *20*(2), 95–102. doi:10.1111/j.1365-2729.2004.00075.x

Suarez-Orozco, C. S.-O., Marcelo, M., & Todorova, I. (2008). Learning a new land. The Belknap Press of Harvard University Press.

Subat, A., Rahman, M. M., & Rahman, M. R. (2020). Employees Perception on Recruitment and Selection Process in Banking Sector in Bangladesh. *The Journal of Management Theory and Practice*, *1*(3), 21–27. doi:10.37231/jmtp.2020.1.3.41

Suddaby, R. (2006). From the Editors: What Grounded Theory is Not. Academy of Management Journal, 49(4), 633-642.

Sun, J. C. Y. (2014). Influence of polling technologies on student engagement: An analysis of student motivation, academic performance, and brainwave data. *Computers & Education*, *72*, 80–89. doi:10.1016/j.compedu.2013.10.010

Swanson, W. S. (2012). The importance of play in promoting healthy child development and maintaining strong parent-child bond: Focus on children in poverty. *Pediatrics*, *129*(1), e204–e213. doi:10.1542/peds.2011-2953 PMID:22201149

Syaparuddin, S., & Elihami, E. (2020). Improving student learning motivation through the utilization of video media in education students. *Jurnal Edukasi Nonformal*, *1*(2), 228–235.

Tajik, F., & Vahedi, M. (2021). Quarantine and Education: An Assessment of Iranian Formal Education during the COVID-19 Outbreak and School Closures. *International Journal of Education and Development Using Information and Communication Technology*, *17*(1), 159–175.

Talebi, H., & Milanfar, P. (2018). NIMA: Neural Image Assessment. *IEEE Transactions on Image Processing*, *27*(8), 3998–4011. doi:10.1109/TIP.2018.2831899 PMID:29994025

Tana, A., Hasa, E., Shengjergji, A., & Osmanaj, E. (2021). Roma children's access to education during COVID-19 pandemic: The case of Albania. *Linguistics and Culture Review*, *5*(S3), 1527–1533. doi:10.21744/lingcure.v5nS3.1824

Tansey, B. (2018, January 16). *Google Launches a MOOC to Train Entry-Level IT Support Staffers*. Retrieved December 30, 2021, from https://xconomy.com/san-francisco/2018/01/16/google-launches-a-mooc-to-train-entry-level-it-support-staffers/

Tarofder, A. K., Azam, S. M. F., & Jalal, A. N. (2017). Operational or strategic benefits: Empirical investigation of internet adoption in supply chain management. *Management Research Review*, *40*(1), 28–52. doi:10.1108/MRR-10-2015-0225

Täuscher, K., & Kietzmann, J. (2017). Learning from Failures in the Sharing Economy. *MIS Quarterly Executive*, *16*(4).

Taylor, D., Grant, J., Hamdy, H., Grant, L., Marei, H., & Manda, V. (2020). Transformation to learning from a distance. *MedEdPublish*, *9*(76).

Taylor, E. W., & Cranton, P. (2012). *The handbook of transformative learning: Theory, research, and practice*. John Wiley & Sons.

Thai, M., Sheeran, N., & Cummings, D. J. (2019). We're all in this together: The impact of Facebook groups on social connectedness and other outcomes in higher education. *Internet and Higher Education, 40*(February), 44–49.

Thanuskodi, S. (2015). ICT skills among library professionals. *Advances in Library and Information Science*, 1–20. doi:10.4018/978-1-4666-8178-1.ch001

The Economist. (2017, January 12). *Established education providers v new contenders*. Retrieved December 10, 2017, from https://www.economist.com/news/special-report/21714173-alternative-providers-education-must-solve-problems-cost-and

Thijssen, D. H. J., Bruno, R. M., Van Mil, A. C. C. M., Holder, S. M., Faita, F., Greyling, A., Zock, P. L., Taddei, S., Deanfield, J. E., Luscher, T., Green, D. J., & Ghiadoni, L. (2019). Expert Consensus and Evidence-Based Recommendations for the Assessment of Flow-Mediated Dilation in Humans. *European Heart Journal*, *40*(30), 2534–2547. doi:10.1093/eurheartj/ehz350 PMID:31211361

Thrush, A., & Hartshorne, T. (2005). *Peripheral Vascular Ultrasound. second* (D. Thom & K. McGechie, Eds.). Elsevier Ltd.

Tiruneh, D. T., De Cock, M., & Elen, J. (2018). Designing Learning Environments for Critical Thinking: Examining Effective Instructional Approaches. *International Journal of Science and Mathematics Education*, *16*(6), 1065–1089. doi:10.100710763-017-9829-z

Tloaele, M., Hofman, A., Naidoo, A., & Winnips, K. (2014). Using clickers to facilitate interactive engagement activities in a lecture room for improved performance by students. *Innovations in Education and Teaching International*, *51*(5), 497–509. doi:10.1080/14703297.2013.796725

Tochon, F. V. (2007). From video cases to video pedagogy: A framework for video feedback and reflection in pedagogical research praxis. *Video research in the learning sciences*, 53-65.

Togo, F., & Takahashi, M. (2009). Heart rate variability in occupational health - A systematic review. *Industrial Health*, *47*(6), 589–602. doi:10.2486/indhealth.47.589 PMID:19996534

Tomes, C., Schram, B., & Orr, R. (2020). Relationships Between Heart Rate Variability, Occupational Performance, and Fitness for Tactical Personnel: A Systematic Review. *Frontiers in Public Health*, *8*(November), 583336. Advance online publication. doi:10.3389/fpubh.2020.583336 PMID:33240835

Tomlinson, M., & Anderson, V. (2020). Employers and graduates: The mediating role of signals and capitals. *Journal of Higher Education Policy and Management*, *43*(4), 384–399. doi:10.1080/1360080X.2020.1833126

Tomporowski, P. D., & Pesce, C. (2019). Exercise, sports, and performance arts benefit cognition via a common process. *Psychological Bulletin*, *145*(9), 929–951. doi:10.1037/bul0000200 PMID:31192623

Toniolo-Barrios, M., & Pitt, L. (2021). Mindfulness and the challenges of working from home in times of crisis. *Business Horizons*, *64*(2), 189–197. doi:10.1016/j.bushor.2020.09.004 PMID:33041346

Toresdahl, B. G., Young, W. K., Quijano, B., & Scott, D. A. (2021). A systematic review of telehealth and sport-related concussion: Baseline testing, diagnosis, and management. *HSS Journal*, *17*(1), 18–24. doi:10.1177/1556331620975856 PMID:33967637

Touboul, Hennerici, Bornstein, & Csiba. (2012). *Mannheim Carotid Intima-Media Thickness and Plaque Consensus (2004 – 2006 – 2011).* . doi:10.1159/000343145

Tousoulis, Antoniades, & Stefanadis. (2005). *Evaluating endothelial function in humans : A guide to invasive and non-invasive techniques*. . doi:10.1136/hrt.2003.032847

Traxler, J., & Kukulska-Hulme, A. (2016). Introduction to the next generation of mobile learning. *Mobile learning: The next generation*, 1-10.

Traxler, J. (2007). Defining, Discussing and Evaluating Mobile Learning: The moving finger writes and having writ..... *The International Review of Research in Open and Distributed Learning*, *8*(2). Advance online publication. doi:10.19173/irrodl.v8i2.346

Tredinnick, L. (2006). Web 2.0 and Business: A pointer to the intranets of the future? *Business Information Review*, *23*(4), 228–234. doi:10.1177/0266382106072239

Trees, A. R., & Jackson, M. H. (2007). The learning environment in clicker classrooms: Student processes of learning and involvement in large university-level courses using student response systems. *Learning, Media and Technology*, *32*(1), 21–40. doi:10.1080/17439880601141179

Trendence. (2020). *Black Lives Matter Infographic: Racial justice in the workplace.* https://trendence.co.uk/thought-leadership/reports

Trew, J. L., & Nelsen, J. L. (2012). Getting the most out of audience response systems: Predicting student reactions. *Learning, Media and Technology*, *37*(4), 379–394. doi:10.1080/17439884.2011.621957

Tsang, J., So, M., Chong, A., Lam, B., & Chu, A. (2021). Higher education during the pandemic: The predictive factors of learning effectiveness in covid-19 online learning. *Education Sciences*, *11*(8), 446. doi:10.3390/educsci11080446

Turkay, S., Hoffman, D., Kinzer, C. K., Chantes, P., & Vicari, C. (2014). Toward understanding the potential of games for learning: Learning theory, game design characteristics, and situating video games in classrooms. *Computers in the Schools*, *31*(1-2), 2–22. doi:10.1080/07380569.2014.890879

Turki, F. J., Jdaitawi, M., & Sheta, H. (2018). Fostering positive adjustment behaviour: Social connectedness, achievement motivation and emotional-social learning among male and female university students. *Active Learning in Higher Education*, *19*(2), 145–158. doi:10.1177/1469787417731202

Turkle, S. (2006). Tethering. In C. A. Jones, B. Arning, & J. Farver (Eds.), *Sensorium: Embodied Experience, Technology, and Contemporary Art* (pp. 220–226). The MIT Press.

Turkle, S. (2008). Always-on/always-on-you: The tethered self. In J. E. Katz (Ed.), *Handbook of Mobile Communication Studies* (pp. 121–137). MIT Press. doi:10.7551/mitpress/9780262113120.003.0010

Udacity. (2014). *Nanodegree Programs*. Retrieved December 10, 2017, from https://www.udacity.com/nanodegree

Ulla, M. B., & Perales, W. F. (2021). Facebook as an integrated online learning support application during the COVID19 pandemic: Thai university students' experiences and perspectives. *Heliyon*, *7*(11), e08317. doi:10.1016/j.heliyon.2021.e08317 PMID:34746477

UNESCO. (2021). *Education: From disruption to recovery*. https://en.unesco.org/covid19/educationresponse

UNICEF Annual Report 2009. (2010). United Nations Children's Fund (UNICEF).

United States Census Bureau. (2020). *QuickFacts South Holland village, Illinois*. https://www.census.gov/quickfacts/fact/table/southhollandvillageillinois/INC110219

US Health and Human Services. (2021, September). https://www.hhs.gov/programs/social- services/unaccompanied-children-released-to-sponsors-by-county-september-2021.html

Van Cleynenbreugel, P. (2020). Article 101 TFEU's association of undertakings notion and its surprising potential to help distinguish acceptable from unacceptable algorithmic collusion. *The Antitrust Bulletin*, *65*(3), 423–444.

Van der Heijden, B. I. J. M. (2020). Sustainable careers across the lifespan: Moving the field forward. *Journal of Vocational Behavior, 117*.

Van der Stappen, E., & Zitter, I. (2016). Exploring Design Principles for Technology-Enhanced Workplace Learning. In Bled eConference (p. 14). Academic Press.

Van Dijk, J. (2020). *The digital divide*. John Wiley & Sons.

Van Hooft, E. A. J., Kammeyer-Mueller, J. D., Wanberg, C. R., Kanfer, R., & Basbug, G. (2021). Job search and employment success: A quantitative review and future research agenda. *The Journal of Applied Psychology*, *106*(5), 674–713. doi:10.1037/apl0000675 PMID:32658493

Van Kleef Conley, N. (2018, November 27). *Closing the Skills Gap One MOOC at a Time: How Google is Transforming the Lifelong Learning Environment*. Retrieved December 29, 2021, from https://evolllution.com/revenue-streams/workforce_development/closing-the-skills-gap-one-mooc-at-a-time-how-google-is-transforming-the-lifelong-learning-environment/

Vanneste, P., Raes, A., Morton, J., Bombeke, K., van Acker, B. B., Larmuseau, C., & van den Noortgate, W. (2020). Towards measuring cognitive load through multimodal physiological data. *Cognition Technology and Work*, *23*(3), 567–585. doi:10.100710111-020-00641-0

Vasudevan, L. (2004). *Telling different stories differently: The possibilities of (counter)storytelling with African-American adolescent boys* (Doctoral Dissertation). Retrieved from https://repository.upenn.edu/dissertations

Vaulerin, J., d'Arripe-Longueville, F., Emile, M., & Colson, S. S. (2016). Physical exercise and burnout facets predict injuries in a population-based sample of French career firefighters. *Applied Ergonomics*, *54*, 131–135. doi:10.1016/j.apergo.2015.12.007 PMID:26851472

Verger, A., Lubienski, C., & Steiner-Khamsi, G. (2016). The emergence and structuring of the global education industry: Towards an analytical framework. In A. Verger, C. Lubienski, & G. Steiner-Khamsi (Eds.), *World Yearbook of Education 2016: The Global Education Industry*. Routledge. doi:10.4324/9781315720357

Vesselinov, R., & Grego, J. (2012, December). Duolingo Effectiveness Study. *City University of New York, USA*, *28*, 1–25.

Viikari, J. S. A., Gall, S., Venn, A., Dwyer, T., Magnussen, C. G., Huynh, Q. L., Raitakari, O. T., Kähönen, M., & Juonala, M. (2014). Exposure to Parental Smoking in Childhood or Adolescence Is Associated with Increased Carotid Intima-Media Thickness in Young Adults: Evidence from the Cardiovascular Risk in Young Finns Study and the Childhood Determinants of Adult Health Study. *European Heart Journal*, *35*(36), 2484–2491. doi:10.1093/eurheartj/ehu049 PMID:24595866

Villanueva, K., & Vaidya, J. (2016). Transforming Learning with Mobile Games: Learning with mGames. In D. Mentor (Ed.), *Handbook of Research on Mobile Learning in Contemporary Classrooms* (pp. 260–278). IGI Global. doi:10.4018/978-1-5225-0251-7.ch013

Vinayak, P. C., Khan, B. M., & Jain, M. C. (2017). Role of signaling theory in potential applicant attraction: An employer branding perspective. *International Journal of Emerging Research in Management & Technology*, *6*(4), 2278–9359. doi:10.23956/ijermt/V7I3/0188

Vincent, J. (2016, March 24). *Twitter taught Microsoft's AI chatbot to be a racist asshole in less than a day.* Retrieved from https://www.theverge.com/2016/3/24/11297050/tay-microsoft-chatbot-racist

Vincent, G. E., Aisbett, B., Larsen, B., Ridgers, N. D., Snow, R., & Ferguson, S. A. (2017). The Impact of Heat Exposure and Sleep Restriction on Firefighters' Work Performance and Physiology during Simulated Wildfire Suppression. *International Journal of Environmental Research and Public Health*, *14*(2), 180. Advance online publication. doi:10.3390/ijerph14020180 PMID:28208688

Vinh, T. L., Bouzefrane, S., Farinone, J., Attar, A., & Kennedy, B. P. (2015). Middleware to integrate mobile devices, sensors, and cloud computing. *Procedia Computer Science*, *52*, 234–243. doi:10.1016/j.procs.2015.05.061

Vitsas, P. A. (2016). Commercial simulator applications in flight test training. *Journal of Aerospace Engineering*, *29*(4), 1–12. doi:10.1061/(ASCE)AS.1943-5525.0000589

Vlasenko, N. Yu. (2020). Peculiarities of Complex Visual–Motor Reaction and Heart Rate Variability Influenced by Working Load in Rescue Firefighters. *Human Physiology*, *46*(5), 522–530. doi:10.1134/S0362119720040143

Voelkel, S., & Bennett, D. (2014). New uses for a familiar technology: Introducing mobile phone polling in large classes. *Innovations in Education and Teaching International*, *51*(1), 46–58. doi:10.1080/14703297.2013.770267

Voepel-Lewis, T., Malviya, S., Grant, J. A., Dwyer, S., Becher, A., Schwartz, J. H., & Tait, A. R. (2020). *Effect of a brief scenario-tailored educational program on parents' risk knowledge, perceptions and decisions to administer prescribed opioids*. *Pain*. doi:10.1097/j.pain.0000000000002095

Voith, L. A., Holmes, M. R., & Duda-Banwar, J. (2018). Clicking toward better grades: The use of student response systems in social work education. *Journal of Social Work Education*, *54*(2), 239–249. doi:10.1080/10437797.2017.1283268

Volery, T., & Lord, D. (2000). Critical success factors in online education. *International Journal of Educational Management*, *14*(5), 216–223. doi:10.1108/09513540010344731

Vyas, K., & Mcgregor, C. (2018). The use of heart rate for the assessment of firefighter resilience: A literature review. *2018 IEEE Life Sciences Conference*. *LSC*, *259–262*. Advance online publication. doi:10.1109/LSC.2018.8572095

Wahbeh, H., Elsas, S.-M., & Oken, B. S. (2008). Mind–body interventions: Applications in neurology. *Neurology*, *70*(24), 2321–2328. doi:10.1212/01.wnl.0000314667.16386.5e PMID:18541886

Wallén, M. B., Hasson, D., Theorell, T., Canlon, B., & Osika, W. (2012). Possibilities and limitations of the polar RS800 in measuring heart rate variability at rest. *European Journal of Applied Physiology*, *112*(3), 1153–1165. doi:10.100700421-011-2079-9 PMID:21766225

Walther, J. B., Hoter, E., Ganayem, A., & Shonfeld, M. (2015). Computer-mediated communication and the reduction of prejudice: A controlled longitudinal field experiment among Jews and Arabs in Israel. *Computers in Human Behavior*, *52*, 550–558.

Walton, J., & Acuin, C. (2016). *Worldwide Trends in Body-Mass Index, Underweight, Overweight, and Obesity from 1975 to 2016 : A Pooled Analysis o*. Related Papers.

Wang, G., Gill, K., Mohanlal, M., Zheng, H., & Zhao, B. Y. (2013). *Wisdom in the social crowd*. Academic Press.

Watkins, C. (2016, July 28). *Nanodegree 101: What is a Nanodegree program?* https://blog.udacity.com/2016/07/nanodegree-101.html

Watkins, K. E., Marsick, V. J., & Faller, P. G. (2012). Transformative learning in the workplace: Leading learning for self and organizational change. The handbook of transformative learning, 373-387.

Watkins, K. E., & Marsick, V. J. (2014). Adult education & human resource development: Overlapping and disparate fields. *New Horizons in Adult Education and Human Resource Development*, *26*(1), 42–54. doi:10.1002/nha3.20052

Watson, A. (2020, June 18). *Coronavirus impact: Global device usage increase by country 2020*. Retrieved December 19, 2021, from https://www.statista.com/statistics/1106607/device-usage-coronavirus-worldwide-by-country/

Weekly, T., Walker, N., Beck, J., Akers, S., & Weaver, M. (2018). A review of apps for calming, relaxation, and mindfulness interventions for pediatric palliative care patients. *Children (Basel, Switzerland)*, *5*(2), 16. doi:10.3390/children5020016 PMID:29373515

Wenger, E. (2010). Communities of practice and social learning systems: the career of a concept. *Social learning systems and communities of practice, 3*, 179-198.

What is experiential learning? Institute for Experiential Learning. (2021, October 22). Retrieved January 10, 2022, from https://experientiallearninginstitute.org/resources/what-is-experiential-learning/

Wheeler, A., & Kyprianou-Chavda, V. (2021). "We are all distance learners now": How distance learning informed a library team's response to the COVID-19 pandemic. *Journal of Library & Information Services in Distance Learning*, *15*(2), 84–98. https://doi.org/10.1080/1533290x.2021.1938788

White, T. L., Møller, P., Köster, E. P., Eichenbaum, H., & Linster, C. (2015). Olfactory Memory. In Handbook of Olfaction and Gustation (pp. 337–352). John Wiley & Sons, Inc. doi:10.1002/9781118971758.ch15

Whiteman, E. D., Dupuis, R., Morgan, A. U., D'Alonzo, B., Epstein, C., Klusaritz, H., & Cannuscio, C. C. (2018). Public libraries as partners for Health. *Preventing Chronic Disease, 15*. doi:10.5888/pcd15.170392

WHO. (2020). *WHO Director-General's opening remarks at the media briefing on COVID-19*. Retrieved January 13, 2022 from: https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020

Wielgosz, J., Schuyler, B. S., Lutz, A., & Davidson, R. J. (2016). Long-term mindfulness training is associated with reliable differences in resting respiration rate. *Scientific Reports*, *6*(1), 6. doi:10.1038rep27533 PMID:27272738

Wildi-Yune, J., & Cordero, C. (2015). *Corporate Digital Learning: How to Get It "Right"*. IMD-2015-1. Retrieved from https://www.imd.org/globalassets/publications/working-papers/docs/working-paper_corporate-digital-learning-final--05-05-15.pdf

Wilson, B. G. (2017). Constructivism for active, authentic learning. In R. A. Reiser & J. V. Dempsey (Eds.), *Trends and Issues in Instructional Design and Technology* (pp. 61–67). Pearson.

Winkler, I., Reinikainen, K., & Näätänen, R. (1993). Event-related brain potentials reflect traces of echoic memory in humans. *Perception & Psychophysics*, *53*(4), 443–449. doi:10.3758/BF03206788 PMID:8483708

Woo, Y., & Reeves, T. (2019). Interaction in Asynchronous Web-Based Learning Environments: Strategies Supported by Educational Research. *Online Learning, 12*(3-4).

Woodill, G. (2013, September 3). *MobiLearnAsia: Asia's Growing Mobile Learning Conference*. Retrieved December 03, 2017, from https://gowithfloat.com/2013/09/mobilearnasia-asias-growing-mobile-learning-conference/

Workplace Gender Equality Agency. (2021). *Higher education enrolments and graduate labour market statistics*. https://www.wgea.gov.au/resources/publications/higher-education-enrolments-and-graduate-labour-market-statistics

World Health Organization. (2020). *Munich Security Conference*. Director-General, Tedros Adhanom Ghebreyesus. Available at: https://www.who.int/dg/speeches/detail/munich-security-conference

Wroblewski, L. (2012). *Mobile first: Préface de Jeffrey Zeldmann*. Editions Eyrolles.

Wulsin, L. R., Horn, P. S., Perry, J. L., Massaro, J. M., & D'Agostino, R. B. (2015). Autonomic imbalance as a predictor of metabolic risks, cardiovascular disease, diabetes, and mortality. *The Journal of Clinical Endocrinology and Metabolism*, *100*(6), 2443–2448. doi:10.1210/jc.2015-1748 PMID:26047073

Xu, D., & Xu, Y. (2019). *The promises and limits of online higher education: Understanding how distance education affects access, cost, and quality.* American Enterprise Institute. Retrieved from https://www.aei.org/research-products/report/the-promises-and-limits-of-online-higher-education/

Xu, S., Kee, K., & Mao, C. (2021). Multitasking and Work-Life Balance: Explicating Multitasking When Working from Home. *Journal of Broadcasting & Electronic Media*, *65*(3), 1–29. doi:10.1080/08838151.2021.1976779

Yahoo Answers has shut down. (2021). https://help.yahoo.com/kb/SLN35642.html

Yang, H. C., & Fu, Y. C. (2021). From teachers' professional learning communities to mobile networked learning communities: An additional path to the integration of gender education into medical education. *Journal of Educational Practice and Research*, *34*(3), 165–204.

Yan, X., Yang, J., Obukhov, M., Zhu, L., Bai, J., Wu, S., & He, Q. (2019). Social skill validation at LinkedIn. *Proceedings of the ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*, 2943–2951. 10.1145/3292500.3330752

Yook, Y. S. (2019). Firefighters' occupational stress and its correlations with cardiorespiratory fitness, arterial stiffness, heart rate variability, and sleep quality. *PLoS One*, *14*(12), 1–9. doi:10.1371/journal.pone.0226739 PMID:31869395

Yoo, Y. (2010). Computing in everyday life: A call for research on experiential computing. *Management Information Systems Quarterly*, *34*(2), 213–231. doi:10.2307/20721425

Yosso, V., Delgado Bernal, Solorzano. (2001). *Critical Race Theory in Chicana/o Education*. Paper presented at the National Association for Chicana and Chicano Studies Annual Conference, San Jose State University.

Yourstone, S. A., Kraye, H. S., & Albaum, G. (2008). Classroom questioning with immediate electronic response: Do clickers improve learning? *Decision Sciences Journal of Innovative Education*, *6*(1), 75–88. doi:10.1111/j.1540-4609.2007.00166.x

Yousef, A. M. F., Chatti, M. A., & Schroeder, U. (2014). Video-based learning: A critical analysis of the research published in 2003-2013 and future visions. In *eLmL 2014, The Sixth International Conference on Mobile, Hybrid, and On-line Learning* (pp. 112-119). Academic Press.

Yousef, A. M. F., Chatti, M. A., Schroeder, U., & Wosnitza, M. (2014, July). What drives a successful MOOC? An empirical examination of criteria to assure design quality of MOOCs. In *Advanced Learning Technologies (ICALT), 2014 IEEE 14th International Conference on* (pp. 44-48). IEEE.

Yuan, L., Powell, S., & Cetis, J. (2013). *MOOCs and open education: Implications for higher education*. Academic Press.

Yu, C. C. W., Au, C. T., Lee, F. Y. F., So, R. C. H., Wong, J. P. S., Mak, G. Y. K., Chien, E. P., & McManus, A. M. (2015). Association between leisure time physical activity, cardiopulmonary fitness, cardiovascular risk factors, and cardiovascular workload at work in firefighters. *Safety and Health at Work*, *6*(3), 192–199. doi:10.1016/j.shaw.2015.02.004 PMID:26929827

Yusif, S., Hafeez-Baig, A., & Soar, J. (2017). e-Health readiness assessment factors and measuring tools: A systematic review. *International Journal of Medical Informatics*, *107*, 56–64. doi:10.1016/j.ijmedinf.2017.08.006 PMID:29029692

Yuvaraj, M. (2020). Global responses of health science librarians to the COVID-19 (Corona virus) pandemic: A desktop analysis. *Health Information and Libraries Journal*, *37*(4), 337–342. https://doi.org/10.1111/hir.12321

Zawacki-Richter, O., Bozkurt, A., Alturki, U., & Aldraiweesh, A. (2018). What Research Says About MOOCs – An Explorative Content Analysis. *The International Review of Research in Open and Distributed Learning*, *19*(1). https://doi.org/10.19173/irrodl.v19i1.3356

Zhao, Q. (2017). Summary of Commercial Photography Skills in the Context of Visual Communication. *DEStech Transactions on Social Science, Education and Human Science,* 102–107.

Zhao, M., López-Bermejo, A., Caserta, C. A., Medeiros, C. C. M., Kollias, A., Bassols, J., Romeo, E. L., Ramos, T. D. A., Stergiou, G. S., Yang, L., Xargay-Torrent, S., Amante, A., Gusmão, T. M. E., Grammatikos, E., Zhang, Y., Prats-Puig, A., de Carvalho, D. F., Yang, L., Carreras-Badosa, G., ... Ramalho, M. C. (2019). Metabolically Healthy Obesity and High Carotid Intima-Media Thickness in Children and Adolescents. *International Childhood Vascular Structure Evaluation Consortium.*, *42*(January), 119–125. doi:10.2337/dc18-1536 PMID:30420475

Zhonggen, Y., Ying, Z., Zhichun, Y., & Wentao, C. (2019). Student satisfaction, learning outcomes, and cognitive loads with a mobile learning platform. *Computer Assisted Language Learning*, *32*(4), 323–341.

Zhu, C. (2012). Student satisfaction, performance, and knowledge construction in online collaborative learning. *Journal of Educational Technology & Society*, *15*(1), 127–136.

Zimerman, A., Sheridan, B., Cooke, S., & Jena, A. B. (2020). Trends in New Diagnoses of Atrial Fibrillation after Release of an ECG-Capable Smartwatch. *Circulation*, *814–816*(8), 814–816. Advance online publication. doi:10.1161/CIRCULATIONAHA.119.045562 PMID:32833515

Zimmerman, B. J. (1990). Self-Regulated Learning and Academic Achievement: An Overview. *Educational Psychologist*, *25*(1), 3–17. doi:10.120715326985ep2501_2

# About the Contributors

**Dominic Mentor** is an Adjunct Assistant Professor at Teachers College Columbia University (TCCU), who has won numerous awards for curricula design and interactive courses. Awards for his training, learning and development work include Learning Elite Award for Corporate Training (2020), Named Emerging Training Leader by Training Magazine (2020), Optimas Gold Award for Innovation regarding mHealth App Design & Development (2019), International E-Learning Awards Honorable Mention, Blended Learning (2019), the Blended eLearning Award from The International E-Learning Association (2015) for “E & M Learning for Connected Collaborative Teaching and Learning Communities”, and the Workforce Magazine Optimas Gold Award (2014) for envisioning and enacting a new digital transformation approach (2014). Additionally, his innovative mobile learning work has resulted in him being invited as a speaker to UNESCO’s mLearning conference at the Paris headquarters in France in 2014, 2018 and 2019. Dominic graduated from Teachers College, Columbia University (TCCU). His research interests and publications include issues in cognition and mobile communication, social connectedness, mobile portable communities, mLearning, computer and mobile assisted language learning, teacher and trainer technology development, hypermedia design, including online formative and summative assessment practices. Prior to his studies at TCCU, Dominic served as an award-winning high school teacher and contributing author of a series of modular textbooks offering outcomes-based teaching and learning materials. As a Fulbright scholar Dominic completed another Masters and then his Doctorate at Teachers College Columbia University. Dominic Mentor then served as a National Director of a talent development non-profit training organization serving corporate, civic governments, and other vertical industry clients and was awarded numerous workforce development and educational technology grants. He also initiated and co-designed the USA’s first mLearning course, as well as a social media fellowship for the NY Mayor’s Office of Adult Education. At the talent development non-profit, Dominic digitally transformed the organization’s program from paper-based practices to an engaging multimodal digital participatory environment with 100% adoption. Offering students from impoverished backgrounds, the ability to continue with their studies and training though handheld and mobile devices. Using handheld devices, Dominic also created portable digital learning communities which empowered both staff and students. As a national organization with eight sites in 2012, the organization was able to align eight cities’ curriculum and enhance its delivery modes, offering faster scalability with higher return on investments (ROI). Further helping the training organization to grow to 20 cities in less than three years. Through Dominic’s intentionality and vison, the digital transformation also prepared and catered for the national training organization being approved for higher education credit recommendations with more than 2000 colleges across the USA. While teaching in the Higher Education environment, he also serves as presenter in various teacher and research conferences as well as coordinating professional development computer technology workshops. Dominic also has chapter publications on integrating computer tablet technology into education, as well as chapters in the Encyclopedia of Mobile Phone Behavior (2015). Dominic also served as Editor of the Handbook of Research on Mobile Learning in Contemporary Classrooms contributing 4 chapters as author and co-author (2016). Given the popularity of the books and the topics of cognition and handheld devices, second editions of Dominic's books have been requested and published. One of which was published in 2019 (*Advancing Mobile Learning in Contemporary Educational Spaces*). Dominic's most recent conference presentations were papers titled *2020: A Case Odyssey – Training for a Data Governance Software Technology Company* presented at the 2020 International Conference on E-Learning in the Workplace and a presentation on the award-winning course he designed and enacted interactively titled *mHealth Learning and App Development for health diagnoses and tracking with AI* presented at the UNESCO Mobile Learning Week 2019, at their Headquarters in Paris, France. Dominic has also delivered keynote addresses at the International Conference on Globalization, Education & Diversity in Washington, DC in 2016, the EdTech Summit in South Africa (2014), the 3rd annual Educational Technology Conference at William Paterson University of New Jersey (2012), and Kappa Delta Pi's 2015 inauguration ceremony. Dominic also served as an invited panelist and speaker on technology in education at Adelphi University, Borough of Manhattan Community College, as a speaker at TEDx 2012, Harvard's 21st Century Academic conference, as well as invited panelist and speaker for the inaugural 2015 GlobalMindED conference.

* * *

**Paul Acquaro** is an information technology professional and educator with an Ed.D. in Instructional Technology from Teachers College, Columbia University. He has over 20 years' experience teaching in higher education and is skilled in project and personnel management, full-stack web development, user experience design, content management systems, learning management systems, curriculum development, training, and online learning. Paul currently holds a position as Professor of Web and Digital Management with the FOM Hochschule in Germany, teaching undergraduate and graduate courses in topics such as database development, web technologies, IT and project management, and business communication. He also holds a position as an Adjunct Assistant Professor with New York University's School of Professional Studies. Paul previously worked at Columbia University in IT and communications. He has published articles on online learning and curriculum development, experiential learning, and web development. His current research interests include developing engaging online learning experiences, bringing real-world learning opportunities into the classroom, and helping small businesses manage the impact of digitalization.

**Edward Bednar** has worked in information technology over 30 years, much of that time in chief architect roles at Deloitte, LexisNexis, Sabre, IBM, and EDS. He leads large enterprises through digital strategy initiatives, driving improvements to the business through cloud engineering, platform automation, application modernization, and global infrastructure optimization. Ed holds an M.A. from Columbia and a B.B.A. from Baylor. His academic and research interests are situated computing, affective computing, artificial intelligence, and computational linguistics.

**Regina Casale** is a teacher who helped Patchogue's Ecuadoran community be heard after Marcelo Lucero was murdered in 2008. After she graduated, Regina went to work in Ecuador. She was amazed that her English-language students there knew so much about Long Island. Regina is completing her doctorate at Columbia University and teaching Spanish to the children of Latino immigrants. She is also an advocate for language teachers not to just teach Spanish or French, but to also help educate teenagers about the importance of respecting other cultures and countries and the people who come here from them. Regina was honored by numerous entities for her inspirational work across various spectrums. Regina's human rights work with her students has been showcased at the United Nations and has received numerous grant awards.

**Monica Chan** is a doctoral candidate in the Instructional Technology & Media program at Teachers College, Columbia University. She studies formative assessment practices in K-12 STEAM and Maker education using design-based research methodologies. During the 2021-22 academic year, she serves as a Young NUS Fellow in the Department of Communications & New Media at the National University of Singapore. Monica was also a Research Associate at the Artificial Intelligence in Education workgroup at Singapore's National Institute of Education, Nanyang Technological University. Previously, Monica worked at American educational technology firms such as Houghton Mifflin Harcourt and Amplify Education in research and data science respectively. Monica also has had research consulting experiences, where she consulted a charter school network during her practicum at Columbia Law School's Center for Public Research and Leadership (CPRL). Monica is passionate for leveraging technology for social impact causes and volunteered with non-profits such as Braven and Microsoft's Technology Education and Literacy in Schools (TEALS) program, to teach first-generation, low-income students design thinking and computer science. Now, Monica spends time advising startups focused on K-12 education in Southeast Asia. Monica graduated from Stanford University, where she completed her Master of Arts in Learning, Design & Technology and Bachelor of Science in Mechanical Engineering.

**Simon C. H. Chan** is a Teaching Fellow in the Department of Management and Marketing at the Hong Kong Polytechnic University. He received his Ph.D. from the Hong Kong Polytechnic University. His research interests include management education, human resource information system, leadership.

**Miss Chelliq Ikram** is a PhD candidate in Computer sciences, and member of the Research team in Computer Science and University Pedagogical Engineering Higher Normal School, Abdelmalek Essaadi University, Tetouan, Morocco. She has a Master's degree in Instructional Design Multimedia Engineering at Higher Normal School of Martil, Morocco in 2020. She has previously published articles related to Pedagogical Objects, Adaptive Hypermedia Systems, Personalization, E-learning and Artificial Intelligence.

**Anna Cho** is currently a doctoral student in the Adult Learning and Leadership program at Teachers College, Columbia University. She received her BA in Psychology from Loyola Marymount University, MA in Higher Education from Teachers College, Columbia University, and MS in Applied Psychology from University of Southern California. She is passionate about supporting organizations through strategic thinking, strategic planning, advisory, and implementation. She enjoys figuring out how to implement technology to transform the higher education landscape through her innovative nature. She has worked in higher education institutions and gained extensive experience in enrollment services, student affairs, digital implementation, and diversity initiatives. She has worked at the Center for Public Research and Leadership (CPRL) at Columbia Law School as the Manager of Operations and Administrative Services. She empowered managers and leaders to be more agile and effective during her time while working at the Law School. Before CPRL, she worked at the University of Southern California (USC) Viterbi Graduate School of Engineering in admissions, academic affairs, student affairs, project management, and mobile app development. Anna is passionate about researching how student affairs administrative staff, who counsel and advise a diverse student population, learn to anticipate, and use new technology as it continues to evolve.

**Rizqarossaa (Rossa) Darni** is pursuing her Ph.D. in Education, focusing on the Internalization of Higher Education at the Faculty of Education, University of Cambridge, in the United Kingdom. She earned her BA in International Studies from Earlham College and an MA in International Educational Development from Teachers College, Columbia University, NY. She has received multiple international merit scholarships to fully fund all her studies since first attending the United World College in Southeast Asia (UWCSEA) in Singapore as an International Baccalaureate (IB) high-school student. These included scholarships from Trafigura, Davis, the Indonesian Government, and the Jardine-Cambridge Trust Foundation. She was a recipient of the International House-Davis Peace Project Grant in 2017 which funded her project to facilitate a calligraphic arts training program in Indonesia for Rohingya Refugees. She showed the use of social media as an entrepreneurial tool that the young refugees can use to promote and sell their work. Rossa has been working in the field of International Higher Education since she graduated from college in 2013. She started her career as an EducationUSA Advisor in Jakarta, where her job included facilitating large US-Indonesia educational events, including regular virtual engagements between the two countries. As EducationUSA is the US Department of State's official source for US Higher Education, a large part of her job was to connect virtually with potential students throughout Indonesia and university representatives in the US, as well as other EducationUSA advisors globally. While doing her Masters at Teachers College (TC), she designed her first Educational Technology mobile application (app) under Prof. Dominic Mentor's guidance and has since developed a great passion for incorporating and understanding technology in all the work she does in higher education and in vocational/career training fields. After graduating from TC, Rossa briefly worked as the programs and partnership lead in an Educational financial technology startup that helped more Indonesians afford to go to university. She returned to the United States in early 2019 to work as the Global Programs Coordinator at Earlham College, where she advised and provided intercultural competence training to students preparing for a study/internship abroad experience. Her work included virtualizing classes/global programs due to the COVID-19 Pandemic, managing the program application system website, and interviewing students remotely. Currently, she is based in the UK doing her Ph.D., where her dissertation will explore the 'transition space' international students experience from the university to the global workplace.

**Juléy De Smidt** is a Medical doctor and Senior lecturer in the Medical Bioscience Department, Faculty of Natural Science, at the University of the Western Cape, South Africa. She lectures modules in Neuroscience and Foetal Origins of Adult Disease at the University of the Western Cape. She also supervises Honours, Masters and Doctoral students in Medical Bioscience.

**William Donald** is a Research Scholar at the Ronin Institute (USA) and a Visiting Research Fellow at the University of Southampton (UK). William completed his PhD in 2017, looking at 'Students' Perceptions of Graduate Employability' under the Supervision of Professor Yehuda Baruch and Dr. Melanie Ashleigh. The thesis was awarded the Southampton Business School Runner-Up prize by the Doctoral Research College in 2019. Will has published ten manuscripts in seven different international journals, with a further nine papers currently under review. These include collaborations with authors from America, the UK, Europe, the United Arab Emirates, India, and Australia. Will has also published three book chapters in Edited Collections and sixteen conference papers - including a Best Paper Award in 2016. Will's work has been read over 12,500 times by researchers from over 100 countries (according to ResearchGate) and cited over 250 times (according to Google Scholar). Dr. Donald is Managing Editor of the GiLE Journal of Skills Development, an International Editorial Board Member of the Journal of Management & Organization, a Research and Policy Steering Group Member for the Institute of Student Employers, and an Editorial Board Member of Career Matters. Will is also a qualified Life and Performance Coach, a Fellow of the Learning and Performance Institute (FLPI), an Associate Fellow of the Higher Education Academy (AFHEA), a Member of the National Council of Psychotherapists (MNCP NP), a Member of the Career Development Institute (MCDI), a Member of the Philosophy and Theory of Higher Education Society, and a Lifetime Member of the British Computer Society (MBCS). Before academia, Will worked as a Graduate Recruiter for an Investment Bank in London (UK), where he ranked 'Outstanding' in his final performance review with responsibility for recruiting early careers talent for Financial Services in Europe. For more information, please visit Will's website: https://drwilldonald.wordpress.com/

**Mohamed Erradi** is a professor at Higher Normal School Tetouan, and member of the Research team in Computer Science and University Pedagogical Engineering Higher Normal School, Abdelmalek Essaadi University, Tetouan, Morocco.

**Brennan Harris** is a longtime student of psychology, holding a bachelor's degree from the University of Wisconsin-Madison and a master's degree from Teachers College - Columbia University. His research interests revolve around applying technology to improve the average person's quality of life and access to mental health. Working at the intersection of psychology and technology has led Brennan to accumulate a career-long skill set including addiction counseling, media production, website design, multiple coding languages, and to become a Google Certified Educator. At his institutions of study, Brennan made contributions to research on communication and deception, prejudice and intergroup relations, and spearheaded a project on online emotional support paradigms. He has presented talks and posters on these topics at conferences from Wisconsin, to New York, to Spain.

**Tammy Hartel** is pursuing her PhD in the Medical Bioscience Department, Faculty of Natural Science, at the University of the Western Cape, South Africa. She has experience teaching Anatomy and Physiology at the Cape Peninsula University of Technology, and successfully completed an internship in Microbiology at the Agricultural Research Council, through the National Research Foundation. Currently, she also works as a writing consultant at the University's Writing Centre where she runs academic workshops teaching writing skills and academic integrity, helping students to become better writers. Tammy received several scholarship awards ranging from Pathcare Academy, Ada & Bertie Levenstein bursary, the National Research Foundation and currently holds a scholarship award with the Council for Scientific and Industrial Research. Her research in herbal medicine has also been presented at the American Public Health Association (2018) and the Africa-Asia International Forum on Public Healthcare and Bioethics for Children and Youth (2018). Tammy is passionate about conducting research in low socioeconomic regions in Cape Town, South Africa focusing her research in the Field of Developmental Origins of Health and Disease.

**Mohamed Khaldi** is a professor at the Higher Normal School Tetouan, and a member of the Research team in Computer Science and University Pedagogical Engineering Higher Normal School, Abdelmalek Essaadi University, Tetouan, Morocco.

**Stephen Ko** is a Teaching Fellow in the Department of Management and Marketing at the Hong Kong Polytechnic University. Dr. Ko teaches Entrepreneurship and Research Methods at the undergraduate and postgraduate levels. His research interests focus on entrepreneurial opportunity and business education. He is the author of dozens of business cases and other scholarly articles. To support the scholarship of teaching and learning, he serves as an Associate Editor at the Journal of Education for Business and serves on the editorial review boards of SAGE Business Cases and Emerging Markets Case Studies.

**Jamie Krenn** holds a Ph.D. in Educational Psychology: Cognitive Studies from Teachers College, Columbia University. Jamie has served for more than ten years as an academic and practical application practitioner in cognitive and media psychologies. She also holds three Master degrees in developmental and cognitive psychologies as well as a Bachelor of Science in Art Therapy. Jamie leads the “Children & Media: Analysis & Evaluation” area of focus at Teachers College, Columbia University, which focuses on research and theories relevant to learning and the development of educational materials for children. Her research interest includes cognitive media processing, creative preschool curriculum preparation, and culinary cognition. Over the past several years, she has worked on several research projects regarding the technological impact on young children. She has taught at Barnard College. Jamie has won awards at Long Island University for Outstanding Art Therapy, a Program Award for Outstanding Academic Scholarship, and Senior Award Based on Achieving Highest Visual & Performing Arts.

**Lloyd Leach** is an Associate Professor in the Department of Sport, Recreation and Exercise Science, University of the Western Cape, South Africa and lecture modules in Exercise Physiology, Sport Safety, Exercise Testing and Prescription, and Research methods. He supervises honours, masters and doctoral students in Sport Sciences and Biokinetics. Currently, he is a member of the Biokinetics Association of South Africa (BASA), a Board member of the Physiotherapy, Podiatry and Biokinetics (PPB) division of the Health Professions Council of South Africa (HPCSA), and a committee member of the Sport Science and Medical Committee of the South African Football Association (SAFA), Cape Town (CT). Prof. Leach also serves as an assessor for the Higher Education Qualifications Committee (HEQC) of the Council on Higher Education (CHE), and the Biokinetics Practice sub-committee of the Health Professions Council of South Africa.

**Erradi Mohamed** is a professor at Higher Normal School Tetouan, and Head of the Research team of Computer Science and University Pedagogical Engineering Higher Normal School, Abdelmalek Essaadi University, Tetouan, Morocco. He has published more than 200 papers in international conferences and journals. He has organized and chaired six international scientific events and has been a member of the program committee of multiple international conferences. Professor Erradi Mohammed's research areas of interest include Artificial Intelligence, pedagogical approaches, assessment methods, andragogy, collaboration, personalization and E-learning. He gives training to undergraduate, postgraduate students and guides research scholars in the areas of: E-learning, Andragogy, Collaboration, Personalization, Pedagogical Objects, Adaptive learning, and Educational Technologies.

**Khaldi Mohamed** is a professor at the Higher Normal School of Tetouan, and member of the Research team in Computer Science and University Pedagogical Engineering Higher Normal School, Abdelmalek Essaadi University, Tetouan, Morocco. He is the (co)author or (co)editor of 31 academic books and (co)author of over 200 articles and book chapters in international journals and conferences. He has authored numerous international textbooks with various publishers to add to his patents and copyrights that he has to his credit. Prof Khaldi Mohammed's areas of interest include Artificial Intelligence, pedagogical approaches, assessment methods, adaptive hypermedia systems, E-learning and Bayesian Networks. He gives training to undergraduate, postgraduate students and guides research scholars in the aforementioned areas.

**André Oelofse** is a Professor and Head of the Medical Bioscience Department in the Faculty of Natural Science, University of the Western Cape, South Africa. He is a board member of the Biomedical Research Ethics Committee at the University of the Western Cape. He also supervises Honours, Masters and Doctoral students and lectures modules in Nutrition and Metabolism in Medical Bioscience.

**Peter Pychtin** is an expert in graduate recruitment and is CEO and Founder of GradSift, currently operating in Australia and the USA. As a graduate recruitment practitioner, he has more than twenty years' experience recruiting for leading employers in the USA, Australia and New Zealand. Peter's passion for making recruitment fairer and more efficient for students led to his founding of GradSift. He designed an algorithmic model that accurately and without bias replicates detailed graduate resume reviews. Employer outcomes have confirmed the performance of the model and that they experience an increase in diversity through blind screening. Peter is a regular opinions contributor in the field of graduate recruitment. He has presented at various employer and student conferences and events. He is highly regarded as a mentor and coach to students as well as early career professionals. Peter is an active member of the Australian Association of Graduate Employers (AAGE) and National Association of Colleges and Employers (NACE). Prior to graduate recruitment, his earlier background included process re-engineering consulting and financial management roles with global companies. He completed a Master of Business Administration and Diploma of Accounting at the University of Technology, Sydney and a Bachelor of Commerce at the University of New South Wales.

**Jaron Ras** is a registered biokineticists with the Health Professions Council of South Africa (HPCSA). He is currently completing his PhD in the Department of Sport, Recreation and Exercise Science at the University of the Western Cape, South Africa, where he also works as a Teaching and Lecturing Assistant in the modules of Sport Safety and Advanced Exercise Physiology. Jaron is completing his PhD research on firefighters, with special focus on cardiovascular disease risk factors and health metrics, musculoskeletal health, physical fitness and occupational performance. In addition, he is supervising multiple studies investigating different aspect of firefighter health and wellness, such as psychological health, social behaviour, health-risk behaviours, occupational stress, technology use as health monitoring systems, and health knowledge and attitudes toward musculoskeletal health in firefighters. Moreover, he also supervises Honours and Master's students in the areas of chronic diseases, exercise rehabilitation, sports injuries and all firefighter related studies. During his academic career, Jaron has been awarded the Academic Achievers Award for the best Honours student (2017), awarded as the best Honours student in biokinetics by the Biokinetics Association of South Africa (BASA) (2017), has been nominated as the best Master's student in the Faculty of Community and Health Sciences (2021) and has been awarded the Ryoichi Sasakawa Young Leaders Fund Fellowship (SLYFF) (2021) for his leadership skills and focus on social transformation. He has received multiple scholarships for his academic achievements, such as the NRF Honours Scholarship (2017), DAAD-NRF Scholarship for Masters (2019-2020), and is currently the holder of the NRF Innovation Doctoral Scholarship (2022). Jaron has several publications on firefighters and their health. He strives to advance this scarcely studied research field in occupational health in the emergency services with a particular focus on firefighters. Jaron has a passion for research and teaching, while using his positive work attitude and energy to encourage others to work hard and succeed.

**Christyn Rayford** has been Library Director of South Holland Public Library since August 2020. As a Chicago native raised in the South Suburbs, she attended schools throughout South Holland in her youth and feels deeply connected to the values of Faith, Family, Future that the community promotes. Christyn graduated from Dominican University in 2016 with a Masters in Library Science. As a librarian with over 8 years of experience in Illinois Libraries, she discovered her passion for community service and youth librarianship early in her career. Working with teenagers and helping them on their journey of self-discovery, gave her a purpose and an unwavering commitment to offering the best services and opportunities available in a public space, namely the local library. As a woman of color, Christyn experienced the disadvantages of growing up in an area where everyone wasn't afforded the same opportunities to grow because of their economic or social backgrounds. Thus, as a Library Director, her goal is to remove barriers and help everyone gain exposure to new opportunities and services that will meet people's needs.

**Jason D. Reid**, MA, currently serves as a doctoral researcher in the Spirituality and Psychology Lab at Teachers College. Jason is an alumnus of the Teachers College Master of Arts Psychology in Education degree with areas of focus in Spirituality and Mind-Body Practices and Clinical Psychology and Technology. Jason also holds a Masters in Management Studies degree from the Fuqua School of Business at Duke University and a Bachelor of Arts degree in Psychology from the University of North Carolina at Chapel Hill. Jason's current research interests include Spirituality as a protective factor against Depression and Innovation in Psychological Service delivery. Jason has received prior accolades for his work in innovation, most notably receiving the "People's Choice Award" for the 2020 Columbia University Innovation Award Program (INA) for his work on Virtual Reality (VR) game design.

**José A. Ruipérez-Valiente** received the Engineering degree in Telecommunications from Universidad Católica de San Antonio de Murcia, and the M. Engineering degree in Telecommunications and the M.Sc. and Ph.D. degrees in Telematics from Universidad Carlos III of Madrid while conducting research with Institute IMDEA Networks in the areas of learning analytics and educational data mining. His MEng and PhD theses at UC3M have received three national awards related to educational technologies. Dr. Rupierez-Valiente was also awarded the BBVA-SCIE Award for Young Computer Science Researchers for exceptional Spanish researchers. He has received more than 20 academic/research awards and fellowships and has published more than 90 scientific publications in high impact publications, as well as participated in over 18 funded projects. He currently holds the prestigious Spanish Fellowship Juan de la Cierva with the University of Murcia. José is currently an Associate Professor (Profesor Contratado Doctor) at the Complutense University of Madrid, within the department of Software Engineering and Artificial Intelligence. He was previously a Juan de la Cierva fellow at the University of Murcia and completed a postdoc with the MIT Teaching Systems Lab and MIT Playful Journey Lab. His work focuses on Educational Technology, and he specializes in applying data science to large scale free online courses and to game-based environments to enhance human knowledge on how we learn. He is passionate about how learning occurs, solving data-based problems, teaching, and sharing knowledge.

***Füsun Şahin*** is a researcher at American Institutes for Research (AIR). Dr. Sahin has been contributing to the National Assessment of Educational Progress (NAEP) work in assessment operations, research, and reporting teams. She contributes to the NAEP project with her expertise in process data (i.e., log data that include record of examinees' interactions within the digitally based assessments), where she investigates data quality, different ways to benefit from process data for operational decisions, and various research projects on response time and response behaviors of examinees. In her current role, Dr. *Şahin* is also involved in research on the digitally based NAEP assessment especially for using process data to inform operational decisions such as design of the items, features, and system tools. She also examines the content and structure of the process data files and evaluates their usefulness for informing about valuable student actions. In addition, she leads various research activities using process data. She presented research in various conferences on topics including examinees' testing behaviors and modeling response time. Alongside her expertise in process data, Dr. *Şahin* contributes to the NAEP project with her experience in operational testing and psychometrics. She participates in reviewing deliverables for various operational stages of the NAEP assessment including assembly, administration, and reporting of the NAEP assessment. In addition, she reviews psychometric qualities of the assessments as well as various NAEP score and survey data files, technical reports, and white papers. Dr. *Şahin* has extensive expertise in process data, psychometrics, and statistical analysis in the context of large-scale assessments. Her experiences prior to joining AIR include working with the log data files from the computer-based Programme for International Students Assessment (PISA), working with a high-stakes medical certification program, and various high-stakes assessments administered at the state and district levels. Dr. *Şahin*'s statistical experience includes finite mixture modeling, structural equation modeling, hierarchical linear modeling, propensity score analysis, and regression models. Dr. *Şahin* has also authored three book chapters on using mobile phones for assessment.

**Sofia Strukova** received the B.Sc. degree in computer science from Moscow Power Engineering Institute, Russia and M.Sc. degree in Big Data from the University of Murcia, Spain where she is currently pursuing the Ph.D. degree with the Department of Information and Communications Engineering.

**Keying Wang** does research in Cognitive Science in Education at Teachers College, Columbia University in New York City. She is currently the research assistant for the Education for Persistence and Innovation Center (EPIC) at Teachers College. She helps with several research projects on high schoolers' failure stories in STEM, reactions to failure, and definitions of failure. Before EPIC, she received a degree in Psychology from Occidental College in 2020 and worked in the Behavioral Medicine Lab and Developmental Psychology Lab at Occidental College where she assisted with multiple studies investigating emerging adults' loneliness, popularity, and health-risk behaviors. Keying's current research projects is on educational media with special foci on character development, attention, and comprehension. She is passionate about applying learning theories to the development of educational media products that enhance children's academic achievement and health outcomes.

# Index

## F



## G



## H



## I



## J



## K



## L



## M