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Analyzing Multidisciplinary Uses and Impact of Innovative Technologies

Emiliano Marchisio

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Emiliano Marchisio
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the use of AT-based programs for ALS people. Empirical data have demonstrated the effectiveness and adequacy of AT interventions. In conclusion, AT-based rehabilitation programs can be useful to promote the independence and quality of life of individuals with ALS.

Chapter 5

Neurological disorders are one of the most common causes of motor/cognitive impairments leading to adult disability. Neurorehabilitation is defined as a complex rehabilitation process directed to recovery from a nervous system injury, and to minimize or compensate the associated functional limitations. The frequent incomplete recovery of the neurological patients induces to the introduction of novel neurorehabilitative treatments, tailored to the patients, targeting the specific motor or cognitive disorders. The aim of this chapter is to bring together the latest findings on new technologies including virtual reality across the multiple research fields of rehabilitation in neurological disorders, mapping key developments and innovations such as telerehabilitation systems.

Chapter 6

The spread of the internet has had important consequences in all economic sectors, including tourism. The chapter analyzes the role of the museum in the recovery, management, and enhancement of the local cultural heritage as a tool capable of promoting the development of sustainable tourism in a region with evident infrastructural problems located in the south of Italy. In particular, the following work focuses on the management dynamics of two museums—the Amarelli Company Museum and the MUSABA Museum Park—and their relationship with new technologies. The aim is to demonstrate how an adequate museum management activity through an innovative and integrated organization of tangible and intangible resources, an efficient use of resources and effective communication, can significantly contribute to its growth by attracting the attention of sustainable tourism.

Earthquakes are one of the most difficult natural phenomena in human history to predict. Today, despite very advanced technologies, earthquake predictions still have not been conclusive. It is especially known that the trilogy of location, time, and magnitude is quite difficult to predict at the same time. In order to discover this powerful natural phenomenon, scientists are trying to collect and make sense of the parameters affecting the earthquake and the earthquake results. In general, their goal is to determine the characteristics that have an impact on earthquakes, to perform classifications thanks to various artificial intelligence algorithms, and to predict future earthquakes. The aim of this study is to compile, examine, and analyze earthquake risk prediction researches or applications carried out using artificial intelligence methods. The studies obtained as a result of the literature review were grouped according to the metrics used, data sets, features, and models used and evaluated according to the success rates obtained.

Today, data is generated continuously by millions of data sources, which send in the records simultaneously, in small to large sizes. The rapid growth of data in velocity, volume, value, variety, and veracity has presented big challenges for businesses of all types. This type of data is called streaming data. Streaming data includes a variety of data such as mobile application notifications, e-commerce purchases, sensors in transportation vehicles, information from social applications, IoT sensors. This data is required to be processed sequentially and incrementally on record by record and used for a wide variety of analytics including correlations, filtering, and sampling. Information derived from such analysis gives visibility into many aspects such as customer activity, website clicks, geo-location of devices. There has been a great interest in developing systems for processing continuous data streams. This chapter aims to design a scalable system that can instantly analyze the data using machine learning algorithms.

Preface

This book follows after the International Conference on "Technology and Innovation: New Ways to Perform Known Activities" held in Benevento on 15-16 December 2020 and organized by the Online University Giustino Fortunato of Benevento (Italy), the University Isabel I of Burgos (Spain) and IRCCS Mondino Foundation of Pavia (Italy).

Over seventy scholars from numerous disciplines (from law to psychology, from philosophy to engineering) contributed on the topics covered by the conference. The fields of study have ranged from the applications of artificial intelligence in the psychological field to the use of digitization to combat COVID-19; from smart contracts to the use of algorithms in museums; from digital education to the banking and financial applications of the blockchain; from cognitive rehabilitation using virtual reality to algorithm civil liability; from the problems of ethical limits to technological progress to digital citizenship.

The proposal behind the conference was that of inviting academics and researchers to reflect on new technologies currently available on the market; on the possibilities offered by them to respond to the needs of individuals and communities; on the opportunities and risks resulting from their use; on the different harmonization strategies of new technologies within the other scientific and humanistic disciplines.

This book contains some of the papers discussed within the conference and some more submitted for publication pursuant to an *ad hoc* call for papers. Other papers, either discussed within the conference or submitted pursuant to the call, will be published in a following, different book: splitting of chapters into two different books was suggested by the need to maintain a certain consistency within each publication.

This book is addressed to a wide target audience. First of all, academics, researchers and scholars (including PhD students) are likely to appreciate the wide and problematic approach adopted within this volume. The first scope of the following chapters is to open debate for further discussion and raise problems and issues not settled, yet. Professionals and businessmen would also find it useful insofar as several chapters also provide practical and operative suggestions, paths of action and strategies to develop organizations into future technologies and take

advantage of them. Journalists and other professionals of the media could benefit from up-to-date information on several topics much relevant for society. More in general, all people interested in new technologies could profitably read this volume, to increase their knowledge of the issue, deepen connected problems and develop a systematic and rigorous approach thereto.

The importance of each of the chapter submissions requires a brief presentation of each of them. This book opens with a first set of chapters relating to management and business issues.

The first chapter deals with "Technological Variants and Invariants: Qualitative Analysis of a Basic Training Module for Media Education." In this chapter a qualitative analysis of a good teaching practice is examined with respect to a specific teaching experience. The results of the research consists in re-elaboration of written conversational exchanges on the platform between tutors and students in five of the six overall academic years of delivery of the training module described in the chapter in e-learning mode. The training module described in this chapter was initially proposed in presence for seven years within the Image Didactics Training Unit in the master's degree course in Primary Education Sciences. Comparison is made with the proposed six-years training module delivered in e-learning mode.

The second chapter relates to "Mediatization of Musical and Theatrical Practice on the Moodle Platform." The background to this chapter is that degree courses (with specific reference to those aimed at the training of professional profiles) have experimented with new e-learning design solutions to make students exercise in experiential practices during the pandemic period. In this contribution two solutions for university professional practice in an e-learning environment are proposed, after a virtual internship at the Giustino Fortunato Telematic University within the 'Educational Sciences' course; online music performance lessons at the Kazan Federal within the 'Teacher Education' course. A related comparative investigation is also brought. Results allow to assume video lessons as more effect than webinars, beyond geographical context and specific competence profile.

Within the same field, in "A Comprehensive Review of Data Mining Usage in Education," data mining method in the field of education is examined. Here studies conducted since 2011 using data mining method are examined in order to promote its success in education. What kind of data has been used in data mining application in the field of education, which algorithms have been used to analyze these data and the success cases obtained from these algorithms will be examined. The aim of this study is that of being a guide in determining the work to be done to increase the success in the education sector and in determining the algorithms that can be preferred in order to achieve more successful results in these studies.

The fourth chapter is titled "Assistive Technology to promote the independence and quality of life of people with Amyotrophic Lateral Sclerosis". As we all sadly

know, amyotrophic lateral sclerosis (ALS) is a progressive neurodegenerative disease that selectively affects motor neurons. To date, there is no cure for ALS. It is shared that the use of AT can increase the independence and safety of patients of ALS improving their quality of life. In this chapter interventions based on the use of AT are examined, with reference to aids to support residual capacities, increase autonomy and control of oneself and one's life, increase interactivity with the surrounding environment, increase participation in family and social life, maintain a dignified standard of living and at the same time decrease the workload of the caregiver. The aim of the chapter is to provide, an overview of the latest empirical evidence available on the use of AT-based programs for ALS people.

Matamala-Gomez, Malighetti, Mancuso, Bernini and Bottiroli, in their chapter, deal with "Non-Invasive Technologies in Neurorehabilitation: Novel Neurorehabilitative Treatments for Motor and Cognitive Disorders." The background to this chapter is that neurological disorders are one of the most common causes of motor/cognitive impairments leading to adult- disability. Recovery from nervous system injuries is possible and consists in neurorehabilitation, which is a field in continuous growing and enrichment. The aim of this chapter is to bring together the latest findings on new technologies including virtual reality across the multiple research fields of rehabilitation in neurological disorders, mapping key developments and innovations such as telerehabilitation systems.

Also museal activity may have overlaps with technology. "The Role of Museums in the Development of Sustainable Tourism in Calabria Between Infrastructural Deficiencies and New Communication Technologies" is a chapter dedicated to the role of museums in the recovery, management and enhancement of the local cultural heritage as a tool capable of promoting the development of sustainable tourism in a region with evident infrastructural problems located in the south of Italy. In particular, this chapter focuses on of two Italian museums: the Amarelli company museum and the MUSABA museum park and their relationship with new technologies. The aim is to demonstrate how an adequate museum management activity through an innovative and integrated organization of tangible and intangible resources, an efficient use of resources and effective communication, can significantly contribute to its growth by attracting the attention of sustainable tourism.

AI may have many different applications. "Earthquake Risk Prediction With Artificial Intelligence Methods" show how earthquakes and technology may overlap. Earthquakes are most difficult to predict, despite very advanced technologies. Scientists are trying to collect and make sense of the parameters affecting the earthquake and the earthquake results. The scope of this article is to contribute in determining the characteristics that have an impact on earthquakes, to perform classifications thanks to various artificial intelligence algorithms, and to predict future earthquakes using artificial intelligence methods.

"Scaling of Streaming Data Using Machine Learning Algorithms" is an article where it is considered what is called Streaming Data, i.e.: that today data is generated continuously by millions of data sources, which send in the records simultaneously, in small to large sizes. Streaming data includes many kind of data such as mobile application notifications, e-commerce purchases, sensors in transportation vehicles, information from social applications, IoT sensors. The rapid growth of data in velocity, volume, value, variety, and veracity has presented big challenges for businesses of all types. Information derived from analysis of such data allows us to explore many aspects such as customer activity, website clicks, geo-location of devices. This chapter aims to design a scalable system that can instantly analyze the data using machine learning algorithms.

It is somehow unavoidable to deal with innovative technologies without taking into consideration the law. One of the first fields called to head technological evolutions was, and is, financial law. In this ninth chapter, moving from some brief general considerations on different types (or models) of "active" (or "activist") institutional investors, the birth of the "impact investing" phenomenon is examined. The role of the Covid-19 pandemic crisis in accelerating the rise of the so-called sustainable finance is also dealt with. Within this framework are identified those institutional investors which effectively invest their assets according to the "ESG" criteria, highlighting that the post millennials, or generation Z, are - at least apparently - the chosen beneficiaries of this new financial investment model.

Artificial Intelligence may pose peculiar problems also to private international law, which is commonly referred to also as conflict of laws – i.e.: the set of rules or laws a jurisdiction applies to a case, transaction, or other occurrence that has connections to more than one jurisdiction. In fact, as the Internet becomes part of everyday life, the need arises to study the adaptation of private international law systems to the new requirements, as it happens with reference to the Blockchain. This is a decentralized technology, which carries with it some legal uncertainties, such as its legal nature and shared digital records. In view of this, the chapter on "Blockchain and Artificial Intelligence: Reflections Seen From Private International Law" provides some reflections on whether the legal criteria currently applicable, from the point of view of private international law, are sufficiently clear.

The last chapter of this book deals with "Digital Resources for the Preparation of a Thesis in Roman Law Studies." This may appear a rather peculiar subject but it clearly shows as technology may well operate in support of all cultural needs and activities. More in particular, in this chapter it is noted that, because of the recent pandemic, most of the students discovered several difficulties in traditional research concerning sources connected to literature for the elaboration of their final thesis, especially with respect to Roman law studies. Here the Author refers to his experience in helping students in developing and completing their works through the use of

digital resources. The chapter is arranged as a "short digital guide". The specific purpose of the investigation is to highlight the impact of technology on scientific research in particular for what concerns Roman studies. More in general, it clearly shows how technology may be adapted to any cultural or practical need, insofar as adaptation is sought with appropriate skills.

Conclusively, it is likely that this book will bring an impact on the field of new technologies and contributes to the subject matter by raising problems, ideas and proposals for future regulation, exploitation, and research.

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Chapter 1
Technological Variants and Invariants:
Qualitative Analysis of a Basic Training Module for Media Education

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ABSTRACT

This scientific contribution aims to propose a qualitative analysis of a good teaching practice conducted personally by the authors. The results of the research were obtained thanks to a longitudinal textual analysis with manual coding of all the written conversational exchanges that took place on the platform between tutors and students in five of the six overall academic years of delivery of this training module in e-learning mode. This idiographic research is part of the methodology of observational research. This training module was initially proposed in the presence for seven years within the Image Didactics Training Unit in the master's degree course in Primary Education Sciences. Then it was proposed for six years as a training module delivered in e-learning mode. Subsequently, in presence, the contents of the module were proposed until last year in the university teaching of technologies of teaching and learning and for the current year in the Laboratory of Didactic Technologies, both belonging to the master's degree course in Primary Education Sciences of the University of L'Aquila.

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ABOUT TECHNOLOGICAL VARIANTS AND INVARIANTS IN RELATION TO EDUCATION TO AND WITH THE MEDIA

Since the advent of the first non-open source communication platforms for e-learning, in the late nineties, it was already evident to many pedagogical scholars that the economic-commercial structure on which they were based was in contrast to education understood as a public good to be shared as freely and equally as possible (Galliani, 2002; Manfredi & De Waal, 2005). Since then, the giants of digital technology that have established themselves and succeeded up to the present day have taken an interest and are increasingly interested in education and its institutions. Currently, many practices and discourses on 'digital education' are supporting a broad process of reconfiguring education that is increasingly at risk of greater adaptations in relation to the market. Through their presence in schools, even when philanthropic and free, they affect the tools used by teachers (Carlotto, 2017; Massou, L., Juanals, B., Bonfils, P. & Dumas, P., 2019; Palareti, 2020). And this condition then inevitably leads to repercussions on the learning models adopted.

With regard to media education, both in terms of educations to the media and with the media (Galliani, 2000a, 2000b; Rivoltella, 2017), one of the most recurrent reasons used by teachers to justify the non-activation of media training courses is the obsolescence of technical equipment in schools. This perception derives from at least two conditions regarding the technological knowledge and skills in which teachers often find themselves. On the one hand we are witnessing a lack of technological knowledge and skills in relation to their use, on the other hand a lack of knowledge and skills that allow the teacher to manage critically the innovative push of a commercial matrix coming from the technical instrumentation market. If on the one hand certain technical tools are still essential to be able to implement any path of media education, on the other hand this lack of knowledge and skills means that the technologies already present in schools are not able to be evaluated with technical and didactic precision, and at the same time that we do not know how to evaluate the additional technologies actually needed. A 2018 Organisation for Economic Co-operation and Development (OECD) study (2019) found that on average less than 40% of educators across the EU felt ready to use digital technologies in teaching, with divergences between EU Member States.

In the formative perspective of media education we have begun to respond to this constant and verified through the experiences (Luciani, 2014) lack of knowledge and skills on the part of teachers, activating this training module initially in presence for seven academic years (2001-2008) in the context of the Seminar introducing the Media Laboratories of the Image Didactics Training Unit pertaining to the Master's Degree Course in Primary Education Sciences of the University of Padua. Subsequently, again at the University of Padua, but in e-learning mode, we proposed this training module

between the academic years 2008-2011 as part of the training familiarization Desk to various teachings and various media laboratories, to then continue until 2014 as module inserted in the teaching of Theories and techniques of radio and television language with video-filmic and radio analysis and writing laboratories: courses both pertaining to the blended master's degree course in Theories and Methodologies of Media Education and E-Learning. Subsequently, at the University of L'Aquila and a new time in presence, the contents of the module were inserted between the academic years 2014-2020 in the teaching of Technologies of teaching and learning and to date (2021) in the Laboratory of didactic technologies: both courses related to the Course of Studies in Primary Education Sciences.

TEACHING STRUCTURE OF THE EDUCATIONAL MODULE

Starting from the previously stated assumptions, which have also been constantly verified in the field over the twenty years or more of our teaching activity, we have designed and developed over time the training module called 'Technological variants and invariants' (Luciani, 2014). This module aims to be a first, fundamental and basic approach to media technologies with the didactic-training objective of allowing a balanced relativization with respect to the frequent excessive push towards technological evolution, substantially supported by economic reasons, placing it in relation to real needs didactics of media education in the different contexts of training and referring to the different possible training objectives. The knowledge and skills acquired thanks to this training module also make it possible to face with awareness the relationship between the previous analogue technical instruments and the new digital equipment, also triggering insights drawn from the history of media technologies, as well as accurately identifying and starting to define 'technological convergence' as a fundamental construct for this digital communication era.

The training module in the time period in which it was delivered in e-learning mode was structured in an introductory video-pill created by the teacher, entitled "Technological variants and invariants for a contextualized approach to technologies", and by a related specific forum animated by a disciplinary tutor, also an expert in interactive online communication, in constant contact with the teacher. From the 2011-2012 academic year, a complementary wiki activity was also proposed in order to allow participants to collaborate in drafting a table in which to try to distinguish the technological variants and invariants in relation to each media technology. The goal was to further refine technological awareness to manage the creation and portability of content that the digital age allows with effective operational possibilities and successfully.

Although there has always been the awareness that addressing this topic means reasoning about concepts that encounter a significant margin of interpretative relativity and that for this reason it is difficult to propose a distinctive *taxonomy* between variants and technological invariants that is precise, unequivocal, certain, and stable over time, the video-pill, through a series of possible concrete examples[1], stimulated reflection, debate and in-depth analysis in the forum. These examples were particularly focused on those aspects of media technologies whose knowledge allows the creation (writing) of a media text. The training stimulus video-pill corresponded to a reflection on technological evolution through an attempt to constantly distinguish between the two opposing categories represented by the technological *variants* and *invariants*. These categories of investigation had a mainly theoretical purpose and, once considered in relation to the various technical aspects of the technologies, they should have made it possible to reach a more conscious and contextualized approach to communication technologies. Starting with the reasoning from these somehow open categories can allow the development of a reflection on the evolution of technology. It can be said that these are didactically instrumental in order to allow us to understand our degree of awareness as users of technological devices. It is a possible interpretation through which to evaluate the technological objects that constantly enter our daily life as well as permeate that of schools. This allows us to pause reflexively on the distinction between *constant* technical elements and *innovative* technical elements to then arrive at being able to choose technologies with greater awareness according to their context of use.

The primary didactic objective of this initial incipit, in addition to that of triggering the online debate as best as possible, was to stimulate reflection on one of the possible interpretations in relation to the contemporary uses of the various media technological tools (camera, camera, digital audio recorder, software inside digital equipment, video-editing software, digital photographic development software, audio editing software, etc.). This collective reflection has allowed students over time to begin to distinguish more clearly between the more constant and changing aspects of a technical tool, and, thanks to the acquisition of this new awareness, to learn how to direct the choice of a given object. technological in relation to the actual didactic-communicative objectives that we intend to achieve in a training course, and not on the basis of the latest fashion news suggested by the market.

This online training proposal was part of a larger didactic unit (Luciani, 2014) and was related to other modules which together defined the basic technical dimension of the digital media communication approach together with the dimension of the distinct media languages scanned at starting from the codes of their linguistic structure on the syntactic communicative level[2]. The provision of the online module provided that the sequence of topics relating to the technological area, and, subsequently, fifteen days after the activation of the first, that relating to languages, rather than in a

progressively consequential and cadenced manner as occurs in face-to-face training courses, they were jointly proposed as a whole from the moment in which the distinct thematic areas of study online were made visible and active for the collaborative and cooperative use by the students. The *asynchronous* and *recursive* training method typical of collaborative and cooperative delivery in e-learning mode, together with the diversity of teaching typologies in which this online training module has been placed over time between the academic years 2008-2014, has meant that the its overall temporal duration was significantly variable: from fifteen days in some editions to four months in others.

RESEARCH METHODOLOGY AND ITS CONTOURS

The characteristics highlighted by Ferrari and Rivoltella (2010) regarding computer-mediated communication (CMC: from now on in the text only the acronym will be used), especially in the educational field, are the basis of the scientific significance of discursive analysis forums as a qualitative and quantitative tool for the validation of training courses. In fact, CMC is characterized above all by a centrality of 'written orality' (say-writing) which associates the immediacy of orality with the persistence of writing: "any interaction on the network, if possible even more than other situations, does not it can only take place within language. The online interaction consists exclusively of communicative acts: only the one who communicates exists and is recognized. For this reason, the development processes of a specific language are particularly important, which takes into account the limits and possibilities offered by the medium and which makes the actors capable of sharing the meaning and significance of what they do within virtual environments"[3] (Galimberti & Riva, 1997, p. 54). Within the CMC there is also a continuous availability of discursive exchanges which constantly allows us to return to the discursive proposals of others, thus ending up expanding metacognitive and metariflexive processes (Garavaglia, 2006). Furthermore, especially in the asynchronous interactions typical of forums, the asymmetry of the process of construction of meanings should be highlighted where it is the receiver who decides whether or not to continue the discursive interaction. Regarding the relevance of the discursive analysis of forums in the validation of online training courses, an important indication also comes from one of the most recent psychosocial models in relation to CMC: the Positioning Theory (Ferrari & Rivoltella, 2010). In this theoretical perspective, the role of an interlocutor as a stable and defined category is replaced by the concept of 'positioning' as a dynamic process resulting from communicative activity: the conversation is therefore fundamental because it is within it that most of the mental phenomena take place.

The development of the formative discourse and its significance are strongly correlated to the social dimension of the forum as an online interactive multimedia environment, and are also directly supported by this. This aspect is especially important in our case relating to a forum related to one of the blended courses provided by the Faculty of Education and then, for a few more years, by the FISPPA Department of the University of Padua, specifically designed, focused, and managed, precisely on the cooperative and collaborative dimension of training. In strongly and constantly supporting these training dynamics it has always been clear to the designers as to the actors in the field of these training courses as the CMC not only structures social relationships, but is the space in which relationships take place and the tool that individuals use to entering space, and consequently it is more than just the context in which social relations are built. (Jones, 1998). Through a constant process of negotiation by the actors, communication becomes the space for the construction of shared meanings. Communication then is no longer just a textual act but also a social process: "The social actors exchange meanings, not pieces of information. More precisely, they exchange interpretations of the situations in which they are involved. In this sense, the key element in the disambiguation of messages is their reference to a common meaningful context"[4] (Mantovani, 1995, pp. 94-95). The subjects are therefore the active builders of situations and of the environment as a product of social processes and this implies that in the online dimension, the discursive exchanges that take place in the forums are the basis of the evaluation analysis of a training course.

In order to support the validation of the efficiency and effectiveness of what we are proposing as a *good training practice* in the field of media technologies oriented to media education, we have developed a qualitative longitudinal research focused on the discursive exchanges of five academic years of this training module delivered in e-learning mode (from the 2008-2009 academic year to the 2012-2013 academic year). This is an observational analysis of the contents flanked by the adoption[5] of the psycho-pedagogical proposal of evaluative reading of the forums outlined by Ferrari and Piccardi (2010). We conducted the textual analysis using an exclusively manual approach unlike other possible computer-based or mixed approaches (Massaro & Gon, 2018). The proposal by Ferrari and Piccardi (2010), in addition to a series of forum 'quality indices', which allow a quantitative analysis[6] (Ferrari & Garavaglia, 2006, 2011), is based on an observation grid of the forum articulated on three levels which allows to conduct a qualitative micro analysis. According to the indications of the authors (Ferrari & Piccardi, 2010) the 'quality indices' can also be applied separately. As for the second and third level, in order to better understand what happens from a communicative point of view between subjects who relate, the proposal in question recovers contributions from transactional analysis (Berne, 2003). The latter is a theory based on the two key concepts of 'ego

states' and 'transactions'. Transactions are a kind of rules, independent of the nature and content of a communicative act, which are based only on the directions of the vectors in question (Berne, 2003). In this theory, communication is understood as the moment in which the transaction occurs between the mental states and attitudes of the speaker and the listener. In order to be able to analyze transactional exchanges, Berne (2003) introduces the concept of 'ego state' "defined phenomenologically as a coherent system of feelings, and operationally as a set of coherent types of behavior"[7] (p. 25) . Below are the three levels from which this psycho-pedagogical proposal for evaluative reading of the forums is composed (Ferrari & Piccardi, 2010):

1. **Pragmatic-communicative**: it concerns the plan of adequacy to the learning context in relation to the 'media competence' related to the tool (knowledge of the tool, its relevant use, compliance with the implicit and explicit rules of the socializing dimension).
2. **Structural-procedural**: it concerns the use of online time by the actors involved in the forum (its distribution and symbolic and psychological values).
3. **Functional-transactional**: it implies a timely decoding of the transactions concerning the communication of the tutor in the forum (delineation of a taxonomy of the positive symbolic values of the tutor role starting from the ego state). In this regard, Ferrari (2010) recalling Kahler (De Martino & Novellino & Vicinanza, 1990) reminds us that "a communicative position allows communication to reach the recipient, directly activating the state of the involved ego. If [therefore] the position of the tutor is positive, it becomes the student's responsibility to activate the state of the requested ego"[8] (p. 194).

As regards the 'pragmatic-communicative' level, and therefore the analysis of the communicative dimensions with pragmatic value, the scope of 'communicative relevance' is outlined. This is consisting of the thematic dimension with the thematic coherence as an indicator, from the formal dimension, and therefore from the way in which the various interventions are formulated, from the procedural dimension, and therefore from how the interventions are inserted. About this level is outlined also the scope of the 'communicative openness' with the dimension relating to the level of communication whose indicator is the direction they take communicative exchanges. There are also a number of descriptors in the model for each indicator.

The 'structural-procedural' level focuses on the ways in which time is used online, and therefore on its segmentation, and on the symbolic and psychological values of the communication that emerges from the transactions involved in the messages. Even in the case of the segmentation of time, we start from Berne's proposal (1964) which was punctually adapted to the online communication of the forums (Ferrari & Piccardi, 2010): 'Ritual and procedure' (relating to the opening and closing moments

Table 1. Schematic summary of the level of analysis pragmatic-communicative

Dimension		Indicator	Descriptor
Communicative relevance	Thematic	Thematic coherence	• Micro (3d) and macro connection to the forum. • Connection with the forum but not with 3d. • Connection with 3d but not with the forum. • Not connection.
	Formal	How it is formulated	• Respect netiquette. • Doesn't respect netiquette.
	Procedural	How it is inserted	• Reply to a specific message. • Retrieval of various textual contributions. • A new thread is missing.
Communicative openness	Level	Direction of Communication	• Direct. • Triangulation. • Towards the subgroup. • Towards the group. • Indefinite.

of the communicative discussion threads. The reference is therefore to necessary moments codified both from an institutional point of view and from that of social practice in presence and online); 'Pastimes' (pastimes include all transactions that do not concern the specific theme of the forum, but they end up constituting its informal plot); 'Activity' (this is the communicative activity that in a thematic forum or group work should involve the maximum amount of communication traffic. This includes all the discursive exchanges and related transactions centered on the topic under discussion and on the objective of the group work of the forum); 'Intimacy' (in the online dimension we find intimacy in all transactions that highlight strong affinities and alliances between the subjects); 'Games' (these are psychological games triggered by cross and further transactions that can compromise the search for a positive solution); 'Script' (it completely concerns the communicative style of the subject, which reflects a rigid script).

Table 2. Schematic summary of the level of analysis structural-procedural

Use of Time	Tipologies of Segmentation of Time
Ritual and procedure	Opening and closing of threads
Pastimes	Socialization transactions or certification of presence
Activity	Discursive exchanges and related transactions centered on the topic under discussion and the goal of forum group work
Intimacy	Strong affinities and / or alliances between forum participants
Games	Problem solving, conflict and negotiation
Script	Distributed throughout the forum

The functional-transactional level concerns the tutor's communication and related transactions. In relation to each function performed by the tutor, the ideal communicative position of the tutor was identified in order to activate the 'corresponding ego state' in the interlocutors. The tutorship functions are: 'Information' (providing information); 'Directive' (orienting speeches); 'Normative' (making the forum secure); 'Relational' (taking care of the participants); 'Expressive' (allowing the direct expression of emotions).

As for the textual analysis, this was conducted through a manual identification of information. The processing basis involved all the online discourse exchanges of five academic years relating to the 'Technological variants and invariants' training module delivered in e-learning mode. The analysis of the content was carried out on each post of the various annual discursive concatenations with the aim of detecting its communicative 'Relevance' in relation to the proposed training theme, any 'Cognitive increase' made, the level of 'Reflective deepening' possibly carried out and solicited, the proposed 'Content significance', as well as the argumentative 'Incisiveness' achieved. In relation to the proposed training contents, the most representative thematic co-occurrences were then identified which allow to detect the degree of conceptual adhesion of the participants to the training proposal.

DATA ANALYSIS AND INTERPRETATION

The total number of tutors' interventions in the five years that we were able to take into consideration were 28 with the following annual chronological division: 8 / 3 / 4 / 4 / 9. Instead the total number of interventions by the participants in the five years was 177 with the following annual chronological division: 20 / 6 / 74 / 56 / 21. The difference in the number of interventions by the participants between the different academic years is substantially due to the very different overall numbers from year to year of enrollments in the course of study. The diversity of the relationship between tutor interventions and participants interventions over the various years is due instead to the fact that the tutors, constantly coordinated by the teacher, were experienced professionals both in online edu-communicative methods on interactive multimedia platforms and in relation to disciplinary contents. For this reason, the number of interventions was always functional to the actual educational-communicative needs related to the natural evolution of the specific discursive concatenation. In addition to the fact that in the cases we have taken into consideration, these have always been fully developed environments such as communities of practices and online learning where "the group is a place of 'pedagogical self-management' and learning in which to work in an active, cooperative and collaborative. In this perspective, the activities carried out in the community are always aimed at a conscious purpose, where theory

and practice are always seen 'in action'"[9] (Galliani, 2004, p. 36). In these cases the collaborative and cooperative dimension pushes the discursive evolution often without the tutor's need for pressing corrective, directive, informative, expressive or relational interventions allowing instead interventions of synthesis, connection, systematization, clarification, communicatively appropriately positioned in the process constructive of the formative discourse. In any case, the participation rate, which makes it possible to quantitatively distinguish the weight of the tutor's communication from that of the participants, is significantly high in three editions and appears sufficient in two editions, especially in relation to the aforementioned.

Before continuing with the data relating to the three levels of the psycho-pedagogical proposal of evaluative reading, it is important to introduce this part of the analysis with a fundamental observation that indicates that "in terms of evaluation, the most interesting evidence relates to the need for the forum, to be a co-constructed social environment, to support on the one hand all the different types of time segmentation and on the other hand to see all the tutoring functions put into effect by the model"[10] (Ferrari & Piccardi, 2010, p. 195).

At the level of pragmatic-communicative analysis it is detected, in the five years of discursive concatenations a full communicative relevance close to 100% of the interventions. This communicative relevance turned out to be both thematic in connection with the forum, and formal in compliance with the netiquette, and also procedural with responses to specific messages, links to other contributions, reflective insights around the theme and the contents proposed by the introductory video-pill. It also showed with a coherent opening in the direction of communication, used by the various posts mainly directly, with some triangulation, with some posts partially directed to the group and none indefinite. On the other hand, there were no openings of new threads of discussion due to the fact that in relation to the specificity of the training topic addressed, the opening of a new thread of discussion would have involved a training dispersion, in addition to the fact that participants were asked explicitly not to proceed with the opening of new threads of discussion with respect to those already started and each related to specific contents.

As regards the level of structural-procedural analysis, a use of time was found almost completely correlated to the temporal segmentation of the 'activity', which from this model of evaluative reading of the forums is precisely envisaged as the method of use of the time that should convey the maximum of communication traffic. The dimension of use of time called 'script', which concerns the communicative style of a subject and permeates and structures its entire communication activity, therefore requires an evaluation of the entire span of its communication on multiple threads. Since our analysis focuses on a single thread, this dimension cannot be analyzed. With the exception of 'pastime' and 'games', which are not present, the remaining dimensions of use of time, i.e. those relating to the dimensions of 'ritual'

and 'intimacy' are occasionally present, but when present, they are however included in all cases as marginal parts of the main 'activity' dimension. Also at this level of the analysis it emerges that the groups that have happened over the years, and that have followed a significantly collaboratively and cooperatively well structured e-learning training model, have reached and developed a learning situation fully immersed in a community of practical (Wenger, 1998) although virtual. "Learning in virtual communities takes place through cooperative and collaborative activities, in the acquisition of knowledge based on texts / products negotiated with all group members"[11] (Galliani, 2004, p.p. 37-38).

The functional-transactional analysis level highlighted how the main functions performed by the tutor were 'informative' and 'directive', therefore focused on providing complementary reflective information on the training topic covered by the thread and on the orientation of discursive exchanges always starting from the specific training contents proposed by the participants. The need to secure the forum has never emerged and therefore the 'normative' function has never been used. The other functions, namely the 'relational' and the 'expressive' ones, when present, correspond to textual portions on the sidelines of those mainly performed. A first confirmation of the quality of this training proposal in e-learning mode therefore also derives from the variety of tutoring functions performed compared to those provided by this model of evaluative reading. At the same time, the predominantly informative and managerial role played by the tutors, certainly not for lack of specific communication knowledge and skills, provides us with a further indication of the overall design quality of the e-learning training model of which this forum was part.

The textual analysis made it possible to detect full discursive relevance in all posts of the five years considered. The communicative trend of the thread in the various years analyzed showed overall a good cognitive increase with respect to the training objectives set. At the same time there was a general good personal reflective deepening in most of the participants, which then became a common heritage thanks to the collaborative and cooperative dimension in the construction of a common sense. The discursive significance has on the whole, from year to year, constantly verified, obviously with variously different outcomes depending on the individual post authors. The same situation just described, with a greater degree in the variety of outcomes according to the various authors, it is possible to detect it also with regard to the general argumentative incisiveness of the interventions. Numerically irrelevant, however, in the five years observed, although always with a certain discursive relevance, were the more superficial posts, less thematically contextualized and not very elaborate.

From the set of contents exposed at a general level it is clear that the theoretical-operational problem that was wanted to be solicited with this training module, focused in particular on the development of knowledge and skills for a more objective

evaluation of the technical instruments in relation to media education, and in the light of the technological convergence brought about by the digital revolution, it was well framed in each of the years analyzed.

Below is a selection from the 2009-2010 academic year forum of the various possible examples[12] of significant discursive concatenations developed over the years that allow us to detect the degree of general classification of the proposed training topic:

"[...] Choosing technology in a contextualized and profitable way to the situation and the objectives to be achieved, in my opinion, means reflecting on the use of technologies, their function and their more or less sophisticated technical characteristics. If in a first class of primary school the goal is to learn how to read and write, at the beginning I can also use an old typewriter (if I can recover some copies) and then move on to the computer [...]" (Anna); "[...] Even at school, it seems that nothing can be done except with the latest digital camera or multimedia computer. Perhaps instead with a little more creativity and in-depth knowledge of the medium, its potential could be exploited more. After all, you can take a computer lesson even with a dated computer if it works [...]" (Gianio); "[…] At school we often have tools whose potential we do not fully know, and with the drive to update technologies we think we can solve the situation. In my school there is a video camera; the other day a colleague suggested that we could buy a new one because it's a little dated, but it's not really necessary! what we have is sufficient for the purpose of documenting the experiences of the school [...] we can introduce the photographic language through the old machines and / or devices that allow framing (a cardboard frame, a box with a hole ...) [...]" (Cecilia); "[…] Even in the school where I work, the tools available such as video projectors, video recorders… have been used very little and have been completely neglected because they are classified as old and outdated; not to mention the hundreds of video cassettes enclosed in dusty shelves that now look like part of a museum ... Now we use CD / DVDs with the students [it was 2010], but they too will, in some time, do the same also because it will be increasingly difficult to find a device that reproduces them. But, despite the scarce finances, even at school people prefer to buy new objects with a thousand functions that, as there are no expert teachers, no one will ever be able to fully exploit "(Adalgisa); "[...] I agree that creativity and planning must prevail over the technical peculiarities of the media tools used ... sometimes superficial with respect to the purposes and orienting towards product approval. This without underestimating the attention to innovation. It requires constant ability to relate to ever new skills. Skills that are still required even if you want to exploit the existing one by combining it with new

needs [...]" (Emanuela); "[...] Just today a colleague (who has never even tried to use a PC and has never adhered to the updating proposals relating to information technology) said that the computer room of our school is equipped with machines old and therefore the students are better not to bring them ... according to her it would be necessary to have a laboratory equipped with PCs with more up-to-date operating systems. Perhaps it would be necessary for everyone to reflect on the importance of increasing and improving knowledge also and above all in this teaching area by providing a compulsory refresher plan for teachers [...]" (Antonella); "[...] I believe that it is important to know how to make the best use of what we have available, but with our eyes wide open to innovations, in order to understand when the time has come to abandon obsolete and unusable technologies [...]" (Laura); "[…] The concept of old or obsolete is very subjective. Often the two terms are not synonymous with really old machines, but of little knowledge. A colleague of mine said that the pc she had in class was old only because she hadn't found Office Word, but Open Office ... as if one was older than the other and with the idea that what is open source it's just what has already passed. In fact, up to four years ago, for various reasons, I did computer science in my school with really old computers and nevertheless I did it. I do not think that at an educational level it is only the aspect of advanced technology that keeps you going. Rather, I believe that language is important, the new way in which you approach knowledge. […]" (Lidia).

CONCLUSION

The results of the qualitative analysis conducted by us following the pedagogical model of evaluative reading of the forums adopted (Ferrari & Piccardi, 2010), with the addition of the textual analysis of the discursive concatenations of five years of e-learning delivery of the module subject of the research, we believe that it allows to further validate this didactic proposal as a good basic training practice in the field of media education. This is a further and more specific validation with respect to that already proposed by us based on the training outcomes and to the realization ones of the 'Taxonomic media familiarization educational module' of which this training proposal is part (Luciani, 2014). We believe that the didactic validity of this training proposal is still congenial today, in its e-learning version and also in its content proposition in presence, as a basic reflection on the media in the perspective of media education in the digital age.

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ENDNOTES

1 The examples of triggers for the development of formative discourse were different and concerned various technical aspects of media technologies including both originally analogical instruments and their digital evolution. One above all was the example relating to the lens as a technological invariant regardless of the type and from which technical equipment it uses (video cameras, photographic cameras, smartphone, tablet, personal computer): to date, particular technical-scientific experiments apart, each technical equipment designed to create still or moving images taken from reality uses a lens capable of concentrating the light reflected from natural elements, things and people on the focal plane.

2 The other modules in the field related to technologies were 'Audiovisual codecs, digital audiovisual formats', 'Digital and analogue still and moving images', 'Digital audiovisual compression', 'The photographic digital camera', 'Microphones', 'The audio recorder', 'The digital video camera'. Instead, the field relating to media languages consisted of the modules 'Of media languages' and 'The codes of the syntactic communication plan of the distinct media languages'.

3 The original text is in Italian. The translation is ours.

4 The original text is in Italian. The translation is ours.

5 The adoption of the forum evaluation model took place only for those dimensions and indices that can actually be analyzed today starting from the data we collected in the past. In fact, we based our analysis not directly on the online spaces of the courses on the moodle platform, which are no longer available today, but on the complete printout of the forums that we had run before their deletion or archiving.

6 Of these indices that allow us to establish a first level of forum quality at the level of quantitative and macro analysis, we will only detect the 'participation rate'. This index concerns the activity of the moderator and is defined as the ratio between the number of messages written by the tutor and the total number of messages posted in the online forum. It makes it possible to distinguish the weight of the tutor's communication from that of the participants. The other indices, that of 'depth' of a forum (the average of the depth of discussions contained in a forum), that of 'density' (the calculation of the ratio between the total of messages entered as replies and the total of discussions and therefore of the messages inserted as initial posts), that of 'success' (comparison of the densities of multiple forums with different depths), and that of 'lurking' (passive use of the forum compared to the active one based on writing), due to the uniqueness of the thread we analyzed longitudinally, which implies the

lack of multiple threads, of the numerical variability of students between the different academic years, which necessarily implies a priori of the different depths, and due to our necessarily offline analysis condition that, not knowing the total number of students enrolled in the various academic years taken into consideration for the analysis, implies the impossibility of verifying the percentage of passive use of the forum.

7 The text we have consulted is in Italian. The translation is ours.

8 The original text is in Italian. The translation is ours.

9 The original text is in Italian. The translation is ours.

10 The original text is in Italian. The translation is ours.

11 The original text is in Italian. The translation is ours.

12 All the examples shown are taken from Italian texts. The translation is ours.

Chapter 2
Mediatization of Musical and Theatrical Practice on the Moodle Platform:
Investigation of Online Resources

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ABSTRACT

Degree courses, specifically aimed at the training of professional profiles, have experimented with new e-learning design solutions to make students exercise in experiential practices (internships, practical exercises, laboratories) during the pandemic period. The contribution presents two ad hoc solutions for university professional practice in an e-learning environment (virtual internship at the Giustino Fortunato Telematic University within the Educational Sciences course; online music performance lessons at the Kazan Federal within the Teacher Education course) and the related comparative investigation. Which Moodle resources are the most effective in training performance skills? A cross analysis is done between the averages of students' access to Moodle resource and the grade obtained at the final project works. Results allow the authors to assume video lessons as more effective than webinars, beyond geographical context and specific competence profiles.

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INTRODUCTION

The pandemic crisis has forced many countries around the world to change people's habits and the way they manage their internal sectors of life (United Nations – Secretary-General, 2020; Alwan et al., 2020). University-level training processes were not exempt. Many universities in the world have had to adopt urgent measures for the reorganization of training processes, both in management and learning design level (Gaebel et al., 2021; EUA, 2020), in order to avoid the negative effects of the so called 'coronateaching' (UNESCO-IESALC, 2020) - that is the adaptation of face-to-face classes into a virtual mode, without changing the curriculum and methodology, i.e. poor quality of training provision and inefficiency with respect to skills output. The use of digital technology in universities involves the transformation of teaching and learning practices in relation to student access and the expansion of individualized and adaptive education. For this to be possible, higher education institutions should invest in the development of learning environments through update of hardware and software and training for teaching staff able to adapting pedagogical and assessment approaches.

The COVID-19 crisis stimulated an acceleration of digitalization in teaching by touching on aspects such as the design of courses, the methods of instruction and assessment, the analysis of learning (Crawford et al., 2020). However, the OECD underlined 'how poorly prepared universities in most countries were for a rapid shift to online provision (…) they often struggled with insufficient experience and time for conceiving new formats of instructional delivery and assignments' (OECD, 2021, p. 3). This imply relationship with the suppliers of educational technologies and online learning platforms and with the designers of virtual learning environments, so that it is not competitive with respect to the control over the development, design and evaluation of courses. Specifically, the adaptation of courses due to the pandemic crisis has affected the disciplines or courses that required practice-based learning resources (e.g. laboratories, fine arts studios, clinics, work-based), as faculties where practical apprenticeship is required (Rose, 2020; Mapletoft & Price, 2020).

Degree courses, specifically aimed at training professional profiles, have had to ensure online methods consistent with expected outgoing skills and are still experimenting with new e-learning solutions to make students exercise in experiential practice - virtual internships, online practical exercises, remote laboratories, etc. - no longer feasible in the face-to-face mode but to be carried out in the remote mode (Gamage et al., 2020; Hora et al., 2020). The document 'The impact of COVID-19 on Higher Education in Apprenticeships: An Overview of the Challenges facing Higher Education Providers' (2021), which takes into account approaches to higher education in apprenticeships across the UK, notes three key elements that higher education institutions should consider regarding their support for higher education

apprenticeships: ability to adapt training to different circumstances; ability of the work context to continue to provide an adequate environment for work-based learning; apprenticeship requirements to be guaranteed despite being in remote mode. In addition to compliance with financial, regulatory and reporting requirements, in terms of educational organization, higher education institution have had challenges such as:

- *Impact on work-based learning* – related to the 'integrity' of the apprenticeship and its roots in work-based learning - the possibility for apprentices to be able to acquire the required experience through additional equipment, access to online sources, setting up of an appropriate study environment, methods of assessing the tasks of the courses, observations and exams, which are not always available online.
- *Digital technology and communication strategies* – regarding the need to mitigate any potential 'digital fatigue' (Gaudioso et al., 2017), both for apprentices and staff, through appropriate supports (i.e., scheduling of meetings, personalization of meetings, proactively offering support and encouragement, etc.) in the interest of the well-being of both.
- *Forward planning* – related to the flexible rescheduling of teaching blocks or the replacement of certain activities, rather than traditional terms or semesters.

The contribution presents two 'ad hoc' solutions for university professional practice in e-learning environment (virtual internship at the Giustino Fortunato Telematic University within the 'Educational Sciences' course; online music performance lessons at the Kazan Federal within the 'Teacher Education' course) and the related comparative study. It supports the debate on the adaptation of degree courses in a pandemic period, especially regarding the 'integrity' of experiential practice, delivered through the flexible rescheduling of teaching blocks and online resources, and invites reflection on the mediatization of practical learning for expressive skills.

BACKGROUND

The research literature had already analyzed the quality of experiential practice - such as virtual internships – on the design and consistency with the curriculum levels: instructional design of a three-year course in accounting (Bayerlein, 2015), learning design of an international master's course in Great Britain (Ruggiero & Boehm, 2016), pedagogical skills of middle school music teachers (Pike, 2015), design skills of future engineers (Chesler et al., 2015), mentoring support in the development of the trainee's practical knowledge (Mullen & Tallent-Runnels, 2006). Beyond

the specific professional profiles, in the previous studies there are some constants referring to two levels: a. system - the structuring of diversified training modules, with a specific function to the knowledge and skills to be stimulated, but organic to each other (Bayerlein, 2015; Ruggiero & Boehem, 2016), which make it possible to create an individualized program; b. specific skills - practical skills are exercised through simulation activities that recreate real conditions and which are achieved by means of 'online mediators' (Pike, 2015; Chesler et al., 2015) - e.g. interactive software specifically developed and adapted in the graphic interface. Chesler et al. (2015) investigated the simulated nature of the experience, made possible for students through the design of 'fictitious' interventions, through interactive software. The virtual internship is assumed as a 'professional practice simulator' (Chesler et al., 2015, p. 78; Herzog, 2013), in which students practice solving 'authentic' problems (open structure, with multiple variables, within a realistic working context), through the exchange of knowledge with colleagues-companions.

The online adaptation experiences of several professional qualification courses are today animating the discussion on higher education (UNESCO-IESALC, 2020; Alwan et al., 2020; Gamage et al., 2020) and focusing the interest of scholars on theoretical (training e-learning environment - Rapanta et al., 2020; Crawford et al., 2020, Huang et al., 2020) and practical (the preparation of functional e-tivities for specific skills - Hora et al., 2020; Author1, 2021) aspects. In refers to the emergency adaptation of university courses in online delivery, the lack of link between pedagogical contents, setting up differentiated learning environments, by means of digital technologies and organization of learning experiences (Rapanta et al., 2020) has been recognized as specific limit. This limitation would concern both the design of the instructional design (ID) and the choice of learning tools (learning design - LD) (Bates, 2019; Carr-Chellman 2016; Goodyear, 2015). Rapanta et al. (2020) offered a descriptive model of the multiple aspects from several perspectives: the point of view of the student, the learning context, the task and the tools. The study by Bryson and Andres (2020) on 'support packages' for students through practical exercises shifts the focus on the restructuring of LMS resources (Roy & Sykes, 2017). The choice of LMS resources becomes important, also in terms of visual design, according to the knowledge processes to be activated in the learning path of the students, as already suggested by Vai & Sosulsky (2015).

The instructional design research and the investigations on simulated activities through LMS resources allow questions to be posed from the perspective of teachers' pedagogical knowledge - as online-learning-related PCK ('Pedagogical Content Knowledge' - Shulman, 2005; Kali et al. 2011) - and the relationship between pedagogical knowledge to be developed and activities/tools that favor it in an on-line environment. In refers to the didactic theory of mediation (Damiano, 2013; Perla, 2016; Author1, 2020), virtual practice adapted for university courses has been framed

in the broader model of 'professional practice simulation' (Chesler et al., 2015) and described through 'analogue mediators', capable of reproducing a working reality, alternative to that of real experience on the basis of the criterion of verisimilitude (*simulation*) not of adequacy (*representation*) (Rézeau, 2002; Author1, 2021).

The research works in the mediatization of expressive and performance practice covered main scholar issues on the design and implementation digital tools for improvement performance skills: psychological changes in listener`s reception of performance in comparison to a live and recording music (Boudreau, 2018), computer hardware and software platforms engineering in order to create an online art performance network environment (Prior et al., 2017), designing a curriculum based on a conceptual model called Technological Pedagogical and Content Knowledge (TPACK), and consideration learning outcomes through the educational process using technology for creating, performing, and responding to activity in arts (Bauer, 2014), pedagogical methods in delivering training art performance skills by the means of online resources (King et al., 2019; Lee et al., 2018; Pike, 2017). Due to the pandemic crisis COVID-19 which has disrupted art education across the world (Camlin and Lisboa, 2021) the analysis of radical changes toward online digital musical practice consequences found the increasing of local artists` popularity using music streaming (Danielsen and Kjus, 2019).

Regarding the emergency adaptation of expressive and performance skills training in online teaching, the creation of a specific artistic community (Lee et al., 2018) that allows students to collaborate beyond distances through telematic performance (Rofe, 2017) provides integration of two or more arts, such as music with dance or other (Levens, 2021) has been recognized as a pivotal part of the educational process. Despite several benefits of video conferencing in the music learning delivering include the high degree focus increasing (Dye, 2016), availability of musical lessons, and direct control of students` eyes from the screen (Pike, 2017), the deficiency of teacher` instructions and self-practice were discussed. Pointed the internet resources provided musical libraries, records, and teaching instructions Price emphasizes opportunities for self-learning in the musical field, exchange of ideas and information through open off-line way (Price, 2013).

ONLINE ADAPTATION OF UNIVERSITY COURSES: TWO 'AD HOC' SOLUTIONS

The support for practical knowledge carried out by mediators in an online environment was investigated, ie the verbal, analogical and symbolic means that reproduced the professional reality. The study focused on professional practice - assumed as an 'active

mediation device' (Damiano, 2013) - rendered in virtual form, that is 'mediated' (Rézeau, 2002) - and set the following investigation objectives:

- General, how useful are LMS resources (Vai & Sosulsky, 2015) - interactive web seminars held within e-tivity facilities (Salmon, 2002) - in building practical skills of the educating profession?;
- Specific, which Moodle resources are the most effective in training performance skills – such as creation of the ensemble compositions and set up theatrical rehearsals in childcare services?

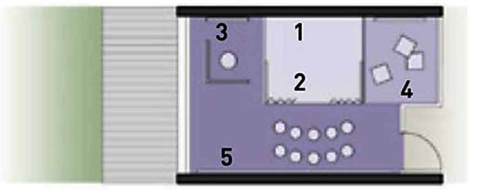
The study refers to two 'ad hoc' adaptations of professional practice on Moodle platform due to COVID pandemic emergency, respectively: a. the virtual internship carried out at the Giustino Fortunato Telematic University to guarantee 10 ECTS provided for in the 'Educational Sciences' L-19 course; b. the online music performance lessons carried out at the Kazan Federal University to guarantee 15 ECTS provided for in the Educational Program of the 'Teacher Education' Б1.О.03.22 course. Didactic models that inspired such solutions (remodeling of delivery and interactive teaching) are described, as well as the e-learning design adaptation (articulation of e-tivity - Salmon, 2002 - in using webinars, videos, forums, etc.; redefinition of roles and skills) to train specific performing arts skills in online environment: a. design theatrical and expressive activities at the childhood services for children aged 0-6; b. design a virtual learning environment based on Moodle for future music teachers` performance practice.

Mediatization of Theatrical and Expressive Skills of Educator/Teachers

Theatrical expressiveness is widespread in Italy as a training method for all ages (Buccolo, Mongili, Tonon, 2012; Cassinelli & Castiglia, 2020) also thanks to the national dramaturgical tradition - from ancient Rome, to the Commedia dell'arte to the strehlerian theater (Molinari, 2004). Theatrical activities in the nursery and in childcare services, specifically, are widespread also thanks to the formalization of methods aimed at specific skills – see 'Theatre for very little' (Festa, 2020), for symbolic ability and knowledge of the self; 'Theatrical games' (Dentale, 2018), for motor skills, sensory listening, relationship with oneself and the other; 'mimicry of relationships' (Bricco, 2007), for expressiveness and social relationship.

As stated in the dm 378/2018 and decree n. 65/2017 the nursery school educator in Italy must have: 'knowledge and skills relating to the design and organization (...) of educational contexts and activities for early childhood', especially with respect to the educational proposals and methodologies of play and expressiveness. The

Figure 1. Theatrical workshops space in the nursery: an iconic support
Source: DPF & IIF, 2020



'Manual of educational services for children' (DPF & IIF, 2020), also, focuses on the educator's ability to design and set up the 'educating space', such as - for example - the theatrical workshops in the nursery having: platform, seats, disguise corner, reading corner, display panels.

The 'ad hoc' solution at the UniFortunato has been adopted to train future educators capable, among others, of setting up spaces for expressive and theatrical activities in nurseries, involving children. It followed the pedagogical model of Bayerlein (2015 – see fig. 2) based on the exchange of real-fictitious roles between students-workers, classmates-colleagues and teacher-mentors and, above all, the 'material situational resources'. It has been inspired to the study of Chesler (Chesler et al. 2015) on 'virtual internship' as 'professional practice simulation', described as 'simulates authentic and practical problems (...) and provides students with the opportunity to turn to realistic professional work' and is focused on a team work related to a virtual 'fictitious' project under the control of an expert.

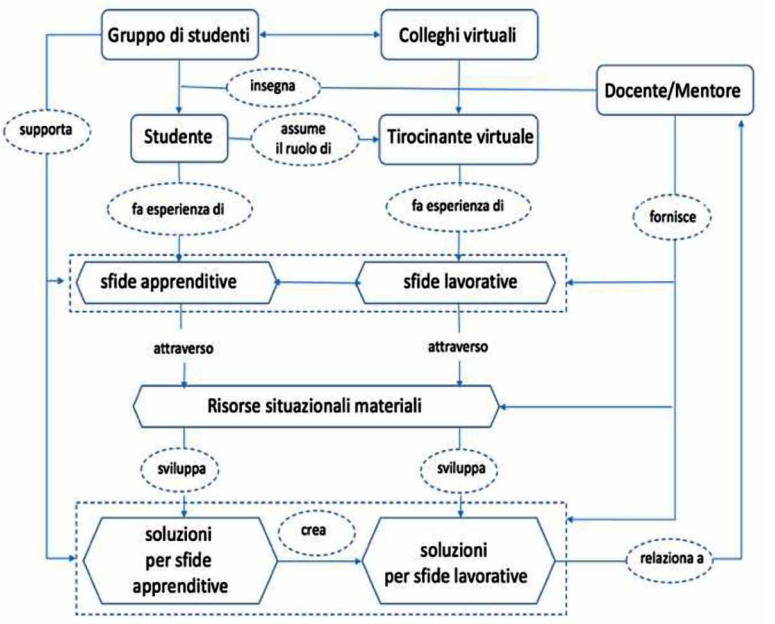
Such 'ad hoc' solution allowed to articulate the Learning Management System resources (webinars, videos, forums, task etc. – Vai & Sosulski, 2015) with reference to the specific practical skills to be trained. For what concern the skill of designing theatrical and expressive activities at the childhood services, the related e-tivity was articulated as follows (Tab. 1): activity (focus on the activity to be carried out), web seminar with expert (in-depth description of the activity), task (description of the case/problem to be solved), thematic forum (discussion among peers and with the expert on how to solve the case/problem), web seminar with moderator/tutor (reflection on the solution process carried out).

Above all, a temporal flow of the Moodle resources was articulated in order to observe the type and frequency of access of the students to the platform (see Figure 3).

Mediatization of Performance Skills of Teachers

Training performance skills is an essential part of aesthetic education in Russia for all ages (Akhmetshina, & Kadyjrova, 2017; Author2, 2019) which is based

Figure 2. Virtual internship process
Source: Bayerlein, 2015, p. 676

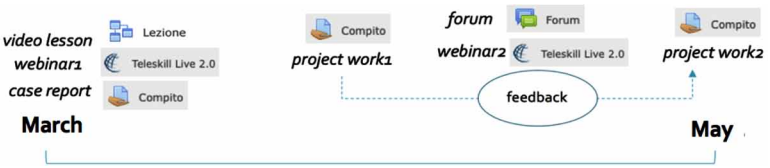


on rich national cultural traditions in music, dance, and theatre (Orlov, 1992), and were establishing world-leading artistic trends. Artistic activities in general school organized by music teacher include playing musical instruments, choral and vocal singing, musical and rhythmic poly-artistic and creation of unique art pieces' (Abdullin and Nikolayeva, 2006). The Federal State Educational Standard

Table 1. Elements of e-tivity in Moodle resources – UniFortunato

Elements of e-Tivity	Moodle Resources
Title: designing the space in the nursery of theatrical and expressive	Activity
Purpose: arrange the furniture in order to: a. support interaction between 5 children during the dramatization activity; b. support everyone's participation	Webinar (expert)
Brief summary of the task: educator's space is 5x8 meters, there are 4 movable low-tables, 3 puffs, 3 hypoallergenic carpets	Task
Spark: what should be excluded/included, based on type of activity and numbers of children?	Forum (question)
Individual contribution: *I would eliminate the poofs because they are not functional for manual work. I'd rather arrange the tables …*	Forum (post)
Moderator's interventions	Webinar (moderator)

Figure 3. Temporal flow process of Moodle resources - UniFortunato



Secondary General Education approved by the order 413/2012 emphasizes the high priority of training performance skills during the school education process aimed at personal improvement, which involved, particularly, 'aesthetic attitude to the world, including the aesthetics of everyday life, scientific and technical creativity', and aimed at developing the ability to use artistic way of mind and creative approach means 'production of relevant and effective novelty' (Cropley, 2011) widely in daily routine.

According to 'Methods of music education' (Abdullin and Nikolayeva, 2006) the musical composition activity includes artistic skills in improvisation using musical means, such as sound, and non-musical, poetry or elements of dance, in order to implement figurative content by images. Due to the technical progress, the mediatization in the field of art increases and offers opportunities to use digital resources for composing artistic images by means of electronic instruments, computer tools, telematic ensembles (Shirieva & Dyganova, 2020).

The 'ad hoc' solution at the Kazan Federal University has been adopted to train future educators capable to teach children of general school how to play musical instruments and to sing in ensemble. It followed the model of Shulman` signature pedagogy (2005) to figure out the teaching of professional habits of mind through the educational process and preparation of students for future professional activity using the set of specific methods. The solution has been inspired by the research on 'teaching piano online' where author demonstrates the way how to eliminate time, location, or social limits in teaching musical education (Pike, 2017), and studying online courses provided by Coursera (2014) which offer the training musical performance skills by the empowering students delivering unlimited access for self-activization for fruitful performance practice.

This 'ad hoc' solution delivers the same links as 'ad hoc' solution at theatrical activity between Learning Management System resources with reference to the specific practical skills to be trained. Table 2 demonstrated the students` e-tivity elements content.

A temporal flow of the Moodle resources was organized in the same way as 'ad hoc' solution at theatrical activity articulated in order to observe the type and frequency of access of the students to the platform (see Figure 4).

Table 2. Elements of e-tivity in Moodle resources – KFU

Elements of e-Tivity	Moodle Resources
Title: creation of the musical ensemble composition	Activity
Purpose: perform the musical piece in ensemble of 5 and more students, add one or more voices according to own and use several musical instruments	Webinar
Brief summary of the task: educator can offer to choose a musical piece from the two list – songs wrote by G. Tukay and songs dedicated to the memory of historical event (victory in WWII)	Task
Spark: how many voices/instruments/performers should be added, according the style of music?	Forum (question)
Individual contribution: I would add the violin rather than flute because its timbre more soft and expressive for this music	Forum (post)
Moderator's interventions	Webinar

COMPARATIVE STUDY ON MEDIATIZATION OF PERFORMANCE SKILLS

In the pandemic period, from May 2020 to February 2021, a comparative study on training of professional practice in higher education was conducted with the aim of knowing which Moodle resources are the most effective in training performance skills - such as creation of the ensemble compositions at school and set up theatrical rehearsals in childcare services. A comparative design, in the perspective of the educational knowledge (Kazamias, 2009), was adopted. A total of 30 students - 12 future educators of childcare services, 18 future music teachers - were involved: these presented the following socio-professional characteristics (see Table 3).

Based on the Kirkatrick model, adapted to the e-learning environment - which replaces four (reaction, learning, behavior, results) with three (interaction, learning, results) tips - (Hamtini, 2008), attention was focused on level 2 of learnings with reference to a project work, developed by students at the end of the course, as documentary evidence of performance skills (outcome).

Figure 4. Temporal flow process of Moodle resources - KFU

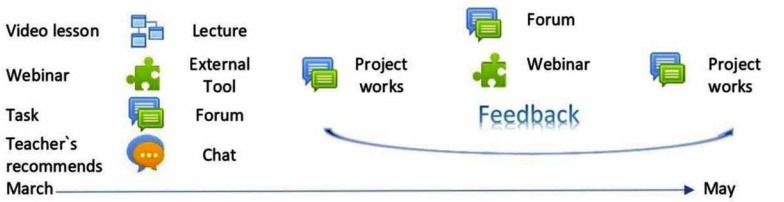


Table 3. Socio-professional characteristics of students involved

	UniFortunato – n.	Kazan Federal Univ. – n.	Tot.
n.	12	18	30
Gender	Female (n.12)	Male (n.3) Female (n.15)	Male (n.3) Female (n.27)
Age average	28	22	25
Qualification	Secondary school (n.9) First degree (n.3)	Secondary school (n.18)	Secondary school (n.28) First degree (n.3)
Seniority of service	0-1 year (n.7) 2-5 year (n.2) >5 year (n.3)	0-1 year (n.15) 2-5 year (n.3)	0-1 year (n.22) 2-5 year (n.5) >5 year (n.3)

Data Collection and Data Analysis

The data analysis took place in four phases: a. first the number and types of Moodle resources used for setting up the two e-learning environments (interactive webinars, discussion forums, recorded video lessons) were mapped. Then b. data concerning the average student access to Moodle resources and c. the average rating of the project works, were obtained. Finally, data relating to the rating-votes of the project work were crossed with accesses to the webinars and video lessons.

The average access of students to Moodle resources was calculated via learning analytics through automatic extraction of data from the platform. The average rating of the project works was obtained with reference to an independent three-level scale, established at the time of designing the course and agreed upon during the survey.

Data Sources

Phase B. data concerning the average student access to Moodle resources (see Table 4).

Phase C. data related to the average rating of the project works (see Table 5).

Table 4. Average student access to Moodle resources (n., %)

Skill	Ensemble Compositions		Theatrical Rehearsals		Tot.	
Resources	**n.**	*%*	**n.**	*%*	**n.**	*%*
Webinar	42	33,07	27	33,75	69	33,33
Video lesson	68	53,54	40	50	108	52,17
Forum	17	13,38	13	16,25	30	14,49
Tot. access	127	100,00	80	100,00	207	100,00

Table 5. Average rating of project works (n., %)

Skill	Ensemble Compositions		Theatrical Rehearsals		Tot.	
Project Work	**n.**	**%**	**n.**	**%**	**n.**	**%**
Level A	9	50,00	5	41,69	14	46,66
Level B	6	33,33	3	25,00	9	30,00
Level C	3	16,66	4	33,31	7	23,33
Tot. student	18	100,00	12	100,00	30	100,00

Phase D. data concerning rating-votes of the project work crossed with accesses to the webinars and video lessons (see Table 6).

Results

The data concerning the average student access to Moodle resources (see Table 4) show a similar distribution of access between the two groups of students: half (52.17%) of the students involved in the training path both in the ensemble composition (53,54%) at the theatrical rehearsal (50%) had access to the video lesson; a third (33,33%) of both group - the first (33.07%) and the second (33,75%) - had access to the interactive webinar. Less than a fifth (14,49%) of both groups - the first (13,38%) and second (16,25%) - had access to the discussion forums.

The data related to the average rating of the project works (see Table 5) shows, overall, a progressive distribution according to the levels: half of the students involved (46,66%) obtained the highest grade; 30% obtained the average mark, 23,33% the lowest mark. Specifically, it is possible to note a dissimilar trend between the two groups of students: those in training for the ensemble compositions show the progressive distribution - level A: 50%, level B 33,33%, level C 16,66%; those

Table 6. Average n. student access

Skill	Ensemble Compositions		Theatrical Rehearsals		Tot.	
Project Work	**Webinar**	**Lesson**	**Webinar**	**Lesson**	**Webinar**	**Lesson**
Level A	2,67	**4,67**	2,60	**3,60**	2,64	**4,28**
Level B	2,33	3,33	1,67	3,33	2,11	3,33
Level C	1,33	2,00	2,25	3,00	1,85	2,57
All students	2,33	3,77	2,25	3,33	2,3	3,6

in training for theatrical rehearsal show a tending polarization between Level A (41,69%) and Level B (33,31%).

Table 6 reports data concerning rating-votes of the project work crossed with accesses to the webinars and video lessons. In total, it can be noted that students with the highest average grade in project works also had more access to video lessons on average (4,28). This trend is also found within the two groups - more in students in training for the ensemble compositions (4,67), significantly less in students in training for theatrical rehearsal (3,60).

The descriptive analysis highlighted that, in reference to the theatrical rehearsal skill, the vote-rating of the project work has more relation with the access to the video lessons (3,60) than with to the webinars (2,60). Using the descriptive analysis of musical performance practice were established the vote-rating of the ensemble compositions has more relation with students` watching the video lessons (3,22) than participation in the webinars (2,67).

SOLUTIONS AND RECOMMENDATIONS

Research question - Results allow to assume that students' access to the video lessons have more effect (4,28) on the increase of expressive skills than webinars (2,64), beyond geographical context and specific skill. In reference to the specific skill, the access to the video lessons seems to be slightly more effective in ensemble compositions (4,67) than in theatrical rehearsal (3,60).

This result leads us to reflect once again on the usefulness of video lessons in online training, in general, and in the training of expressive skills, specifically. The video lesson is assumed as training activity through which certain knowledge, techniques, skills are imparted and as an instructive strategy of a receptive-transmissive type characterized by the organization, management and presentation of contents according to adequate times and rhythms, by the teacher (Bonaiuti, 2014). Beyond the delivery methods (in presence or mediated, in real time or deferred), the forms (traditional lesson, seminar, conference, e-learning webinar, etc.) research has already highlighted what makes the main types effective of lesson (see Table 7; Author1, 2019):

Unlike previous studies (Zhang et al., 2006), which demonstrated the effectiveness of interactive video lessons compared to non-interactive videos in e-learning systems, the presented study highlights that, for the training of expressive skills, students made more use of static video lessons less interactive webinars.

As supported by other studies (Ou et al., 2019; Kim et al., 2014), in fact, the effectiveness and consistency of video lessons, as the main method for providing instructions in online courses, would not depend on interaction but on pedagogical

Table 7. Effective lessons: summary of studies

Types	Description	Evidence
Traditional lesson	'Provision of content in a more or less articulated form, without specific moments of interaction, with or without the support of multimedia tools'	Effective if equipped with: to. clarification of objectives/purposes to direct the energies (Hattie, 2009 - ES = 0.56), b. anticipators that favor the connection between old and new information (ES = 0.41) (Hattie, 2009), c. conceptual maps/graphic organizers for synthesis/identification/organization of information (ES = 0.57) (Marzano, 2000), d. procedural examples of problem solving (ES = 0.53) (Marzano, 2007).
Multimodal lesson	'Adaptation of the channel/ method of communication of the contents based on the characteristics of the students'	Effective in general (Hattie, 2009 - ES = 0.41), especially in relation to specific learning domains (van der Meij & de Jong, 2006 - eg effectiveness of the diagram in representing qualitative contents).

Source: Author1, 2019

methods of the course (online discussions, assignments and quizzes etc.). Furthermore, as stated by Hansch et al. (2015), analyzing click-flow data and viewing access statistics is indicative of student engagement but is not an effective proxy for measuring learning. For this reason, in the study presented, the access data to the platform were integrated with those associated with student learning (Hamtini, 2008), explained through the evaluation of the final project works.

Referring to the didactic theory of mediation (Damiano, 2013; Perla, 2016; Author1, 2020), the study would also invite to deepen the reflection on the virtual mediation: it would not necessarily imply the active involvement of students but - on the basis of the effective listening/viewing of multimedia materials, as suggested by the principles of multimedia learning (Mayer, 2005; Ganino, 2018) -, it would suppose the learning of the contents and the mental representation of the actions to be carried out by virtue of the criterion of verisimilitude (simulation) and not of adequacy (representation) (Rézeau, 2002; Author1, 2021).

FUTURE RESEARCH DIRECTIONS

The work therefore allows to offer investigation solicitations:

- to research on higher education, in relation to the use of online resources e and virtual learning environment to support the training of expressive skills, as theatrical and musical practice (ensemble compositions, theatrical rehearsals.

The effectiveness of video lessons is highlighted within courses that include simulation activities, 'online mediators', such as project work (Pike, 2015; Chesler et al., 2015);

- to research on educational technologies, given that the comparison of the practice of theatrical and musical performance has shown that the e-tivities (see Table 1 & 2) and the virtual learning environment (appropriate choice and integration of Moodle resources) allow to organize the practice of the theatrical and musical performance of the students. The study, indeed, highlights the need to make the most of the link between the individual LMS resources and the respective learning processes activated (Vai & Sosulsky, 2015);
- to research on didactic theoretical models, especially on updating of well-established explanatory theoretical models, such as 'Pedagogical Content Knowledge' (PCK- Shulman, 2005) and 'Technological Pedagogical Content Knowledge' (TPCK- Mishra & Koehler, 2006), as at the moment they exclude specifically artistic components. The model of Shulmans` Signature Pedagogy was adapted for the musical education field as an approach for productive training of students` performing skills; The model of Technological Pedagogical Content Knowledge' was adapted for design of theatrical and expressive activities at the Childhood Services.

CONCLUSION

Due to the pandemic crisis emergency, a lot of people from all over the world had to change their routine habits and working activity management. Teachers from schools and universities have met unexpected difficulties when the education process was shifted online totally. They all had to figure out teaching methods in order to adapt the educational process to the online environment, while the lack of experience in the implementation of students` practical work, such as artistic performance or engineering laboratory. Despite before the crisis some researchers stated the possibility to teach music online (Pike, 2017), the lack of link between pedagogical content, specific teacher`s instructions, organization of learning experiences, and support of students' motivation has been recognized.

Theatre and music are very close to each other from the point of views such as musical theatre or theatrical genre in music like opera. The musical pedagogy follows theatrical methods trying to adapt them, and the most famous example of such adaptation was the world-known singer in the past Fedor Shalyapin`s artistic career, who implemented in his performance practice the theatrical pedagogy of Stanislavsky (Shalyapin, 1997). This research work results confirm the identical

in essence of theatrical and musical performance skills through demonstrating the effectiveness of video lessons in comparing with webinars in both cases.

These are some of the considerations emerged from recent adaptation experiences at Kazan Federal University and Giustino Fortunato University but they are not finished. The mediatization increasing offer new possibilities to organize student-centered educational process featured unlimited access to web-resources, teachers` instructions and students` own practice. Besides we can assume appearing new digital tools in the future will replace regular artistic functions such as composing, performance, and any other (Shirieva & Dyganova, 2020), that will stimulate improvement pedagogical approaches in training expressive and performance skills in the university educational process. In-depth study and scientific comparison new data and conditions will allow to verify the effectiveness of the devices and improve knowledge. In-depth study and scientific comparison will allow to verify the effectiveness of the devices and improve knowledge.

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KEY TERMS AND DEFINITIONS

Mediatization: Transformation process of the means of communication that also modifies content.

Moodle Platform: Acronym for Modular Object-Oriented Dynamic Learning Environment; training course management environment.

Online Training: A form of instruction that takes place entirely via web.

Performance Skills: abilities that an individual demonstrates in the actions they perform (sensorimotor, sensory-perceptual skills, emotional regulation, cognition, communication, and social skills) with expressive and artistic purposes.

Teaching Mediation: Process of transforming learning content within teaching contexts.

Chapter 3
A Comprehensive Review of Data Mining Usage in Education

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ABSTRACT

In this chapter, the data mining method in the field of education will be examined, an emerging technology. In this study, studies conducted since 2011 using data mining method, one of the developing technologies, and the results obtained from these studies will be examined in order to increase the success in the field of education. What kind of data has been used in data mining application in the field of education, which algorithms have been used to analyze these data and the success cases obtained from these algorithms will be examined. By examining the results obtained from these studies, it will be examined which algorithms are more successful in the analysis to be obtained. It is aimed to identify the deficiencies that affect the success in the field of education. This study is aimed to be a guide in determining the work to be done to increase the success in the education sector and in determining the algorithms that can be preferred in order to achieve more successful results in these studies.

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INTRODUCTION

In order to achieve social success, educational success and quality should also be increased.

Education has an important role in forming the future of societies. In order to create a successful society, the importance of education should be increased and it should be aimed to raise individuals with a high level of education. With the regulations in the field of education, a more conscious society can be created by raising more conscious individuals.

In the literature various training methods have been tried in order to increase the quality of education and to reduce the failures. Education methods are changed according to students' success in learning methods. In addition, educational methods also change with the change in the ways people access information.

With the development of technology, emerging technologies are used in education. This situation provides easier access to information. With the wide emerging technology opportunities, an education method is used for students to learn more by research. In addition, it enabled the training to be done in a more visual way. Instead of rote learning system, education methods that enable students to think more, question events and get to know themselves better are preferred.

Emerging technologies are used to increase the quality of education and to find the causes of failures. By using these technologies, factors that cause failure can be identified and necessary arrangements can be made to increase success. In addition, following the current success rate with emerging technologies can be done more easily. Technologies such as artificial intelligence, robotics, deep learning, cloud computing, big data, and data mining can be considered as emerging technologies.

In this chapter, data mining methods in the field of education will be examined an emerging technology. It is possible to convert data that does not make any sense to meaningful information by processing it with data mining. With data mining, seemingly meaningless data is transformed into information, so that the missing parts are detected and the correct solution methods are found more easily. By using data mining in the field of education, the causes of failures will be determined more easily and what needs to be done to increase success will be examined.

In this study, studies since 2011 using data mining method, one of the developing technologies, and the results obtained from these studies will be examined in order to increase the success in the field of education. The answers of the questions of what kind of data has been used in data mining application in the field of education, which algorithms have been used to analyze these data and the success cases obtained from these algorithms will be examined. By examining the results obtained from these studies, it will be examined which algorithms are more successful in the analysis to be obtained. It is aimed to identify the deficiencies that affect the success in the field

of education. This study is aimed to be a guide in determining the work to be done to increase the success in the education sector and in determining the algorithms that can be preferred in order to achieve more successful results in these studies.

2011

In Baradwaj & Pal (2011), it is aimed to evaluate student performance by using Decision Tree (DT) method. In Pandey & Pal (2011a), it is aimed to analyze the performance of the student by using Bayes algorithm. While Microsoft SQL 2005 is used in database management, MATLAB is used for programming. In Pandey & Pal, (2011b) an analysis was made with the association rule since the study aimed to find the relationship between the items and show the relationship between them. In (Sarıman, 2011), the clustering algorithms were compared and a better evaluation was observed even if the k-medoids clustering algorithm worked in a scattered cluster compared to k-means algorithm.

In Aher & L.M.R.J., (2011) ZeroR algorithm was used in classification and density-based spatial clustering of applications with noise (DBSCAN) clustering algorithm was used in the clustering of the students. In Baradwaj & Pal, (2011), Naive Bayes (NB) algorithm was used to select the best subset of variables. In (Sarıman, 2011b), "Flags" data set from UCI Machine Learning Repository database was used. In Aher & L.M.R.J., (2011b), the data of the students in the database of the last year students were used for the Information Technologies UG course. Data were collected on a variety of subjects, including his university exam achievements. In (Baradwaj & Pal, 2011), the data set was created with the information obtained from the questionnaire and university database of 300 students from five different universities.

2012

In Kumaret al., (2012), DT method is investigated, ID3, C4.5 and Classification And Regression Tree (CART) were used, and CART was found to be the most successful. In Osmanbegovic & Suljic, (2012), NB, Multilayer Perceptron (MLP) and C4.5 were used in Weka. Better results were obtained with NB algorithm. In Baha, Uçar & Delen, (2012) Artificial Neural Networks (ANN), Support Vector Machine (SVM), DT and Logistic Regression (LR) were used. The accuracy was obtained with the highest DT with the data from Information Services Department of General Directorate of Educational Technologies of Ministry of National Education in Turkey. Yadav & Pal, (2012) used Weka. ID3, C4.5 and CART were used for classification. The highest accuracy rate was obtained with C4.5. In Agarwal et al., (2012), it is aimed to analyze the performance of classification algorithms in Weka.

At the end of the study, it was concluded that the best classifier with maximum accuracy and minimum root mean square error (RMSE) was in SVM. In Bayer et al., (2012), ZeroR, NB, SMO, IB1, PART, OneR and C4.5 were used. Accuracy and True Positive were used as performance criteria. Obtained with the highest accuracy and TP C4.5 algorithm without knowledge of students' social behavior. Higher results were obtained by using student data and student behaviors. In Kumar & Chadha, (2012), Apriori algorithm, one of the association rules, was used and the application was done with Tanagra. Different association rules with different supporting factors were examined. In López et al., (2012), the clustering method for the classification process is examined. Expectation-Maximisation (EM), FarthestFirst, HierarchicalClusterer, sIB, SimpleKMeans and XMeans clustering algorithms were examined using Weka. It has been observed that EM clustering algorithm gives the best results when all or some of the selected features were applied. In Hung et al., (2012), a combination of two different classification methods was applied in the development of the K-12 education program. The common characteristics of the students were tried to be determined by using cluster analysis. DT was used to determine the performance of the students.

2013

In Sundar, (2013), NB, HNB, WAODE, AODEsr were examined, as a result, AODEsr algorithm has the highest correct classification rate for the data from First Year students of MCA Hindusthan College of Arts and Sciences Coimbatore. In Ramesh et al., (2013), NB, MLP, SMO, C4.5 and REPTree in Weka were used. The best results were obtained with MLP algorithm to predict students' grades. In Priyama et al., (2013), ID3, C4.5, CART, SPRINT and SLIQ were used. ID3, C4.5 and CART were applied to similar datasets and the highest result is obtained with C4.5 algorithm in the small dataset. SPRINT and SLIQ can be used for big data set. In Priya & Kumar, (2013), classification and DT algorithm (ID3) were combined and used. It is aimed to create a DT using ID3 algorithm. Entropy, gain, split value and gain ratio values were calculated for the specified attributes, and the root attribute was determined according to these values. In Bhise, Thorat & Supekar, (2013), k-means algorithm, one of the clustering algorithms, was examined with the data provided by Ale B.J. Obtained from College Computer Application Bachelor. In Borkar & Rajeswari, (2013), Apriori algorithm, one of the association rules, was used with Weka for the data of students who want to get a computer application master's degree from Pune University were used. Tiwari et al., 2013), used classification, clustering and association rules. The association rule was used to determine grade values. Classification rules were used to predict students' performance. Students were divided into groups using k-means clustering algorithm.

A questionnaire was used to collect the data in this study. In AlHammadi & Aksoy, (2013), C4.5, k-Means, K*, NB, Simple Logistics, RULES-3 EXT were used with Weka. The highest accuracy rate was obtained with the C4.5 algorithm. In Nagy et al., (2013), classification and clustering algorithms were used with Tanagra. C4.5 algorithm was used to divide students into appropriate departments. Students were divided into groups using k-means algorithm, one of the clustering algorithms. Then, the results obtained from both algorithms were used together. Data from the Cairo Higher Institute of Engineering, Computer Science and Management for the years 2010-2012 were used. In Adhatrao et al., (2013), ID3 and C4.5 classification algorithms were examined with Rapid Miner for the data of students enrolled in the first year of engineering were used. In Lakshmanan et al., (2013), the gain rate was used instead of the information gain in order to compensate for the lack of using ID3 algorithm with multi-valued attributes. Many other algorithms such as C4.5 and NB algorithm were applied to the data with Weka tool. With the new ID3 algorithm, the previous problem was solved and more efficient results were obtained than NB and C4.5.

2014

In Elakia et al., (2014), ID3, C4.5 and CHAID were used with Rapid Miner and were compared according to accuracy, precision, recall, sensitivity and F-measure. The best performance was achieved with ID3 algorithm. In Lakshmi et al., (2014), DT were applied. It is seen that the classification method and ID3 method among this method will give better results in data mining studies in the field of education. In, Yukselturk et al., (2014), k-nearest neighbour (kNN), DT, NB and ANN were used to classify school dropouts. MATLAB was used to implement these algorithms. The highest success rate was obtained from ANN algorithm. The data used in this study were obtained through a questionnaire from students enrolled in the Online Information Technologies Certificate Program. In Lotsari et al., (2014), R and Weka tools were used, text mining and social network analysis techniques were used in addition to classification and clustering techniques. The data examined in this study were obtained from the Hellenic Open University online forums. In Sharabiani et al., (2014), a prediction model was created according to BN to promote the academic success of engineering students, the accuracy of the model was investigated by using DT, NB and kNN. The highest accuracy has been achieved with BN algorithm developed for General Physics and Calculus II. The data in this study came from a database of undergraduate students at the University of Illinois at Chicago. In Isljamovic & Suknovic, (2014), different ANN algorithms were used. The results obtained from Quick, Dynamic, Multiple, Prune, RBFN and Exhaustive Prune were compared according to Absolute Average Error, Standard Deviation and Linear

Correlation criteria. Exhaustive Prune algorithm produced the best results according to all criteria. The necessary data for this study were collected from the graduates of the Faculty of Organizational Sciences of Belgrade University. In Chen et al., (2014), NB and SVM were used on data on Twitter. The most successful results were obtained using NB. In Hu et al., (2014), C4.5, CART and LR classification algorithms were used with Weka. In Abeer Badr El Din Ahmed & Elaraby, (2014), ID3 is used for classification. Informatin Gain was used to determine the best attribute. The data used in this study were obtained from the student database of one of the educational institutions with the Information System Department between 2005-2010. In Belsis et al., (2014), the analysis process for the extraction of clustering and association rules was performed. In Chalaris et al., (2014), k-means algorithm from clustering algorithms and FP-Growth algorithm from Ward's algorithm association rules were used.

2015

In Oyedotun et al., (2015) Back propagation ANN (BP-ANN) and radial basis function ANN (RBF-ANN) were used and cross validation technique was done in the training phase. It has been observed that the BP-ANN performs better and is trained in a shorter time. The data for this study were obtained through a questionnaire from students at Gazi University in Turkey. In Strecht, et al., (2015) classification and regression algorithms as kNN, RF, AdaBoost, CART, SVM and NB were used.

The results estimated by the regression algorithms were not very successful, but successful results were obtained with the classification algorithms. In Zhou et al., (2015), NB algorithm was used and according to the results obtained, it was concluded that it is a usable method for estimating students' performance. In Harwati et al., (2015), the student performance pattern was examined using k-means clustering algorithm. The number of clusters is set to 3. Data from approximately 300 students were used in this study. In Shahiri et al., (2015), data mining studies between 2002 and 2015 were examined and the success of DT, ANN, NB, kNN and SVM were compared. When the obtained results were examined, it was seen that the highest success was achieved with ANN algorithm. In Ahmad et al., (2015), DT, NB and Rule-based classification techniques were applied. The most successful results were obtained with rule-based classification. The data were obtained from Universiti Sultan Zainal Abidin University's Software Development Specialization and Computer Science Bachelor's Degree students. In Yehuala, (2015) Weka was used for CRISP-DM, C4.5 and NB. The data used in this study were collected through a questionnaire and saved in Excel. Data were obtained from 11,873 undergraduate students. In

Al-Saleem et al., (2015), ID3 and C4.5 were used with Weka. More successful results were obtained with C4.5 algorithm. The data used in this study were obtained

from students of King Saud University (KSU) Computer Science Department. In Abu-Oda, & El-Halees, (2015), DT and NB algorithms were used. As a result of the study, it was observed that the DT algorithm was more successful. In addition, in this study, the relationship between students' dropout and enrollment continuity was examined by using the FP-growth algorithm, one of the association rules. In Ruby & David, (2015), Weka was used. This study was conducted to prove that MLP algorithm achieves successful results compared to other algorithms. In Abu-Naser et al., (2015), ANN algorithm was used. The BP-ANN was used for this study. 80% success was achieved. This study was done with data from students in the Engineering Department of Al-Azhar University in Gaza. In Jishan et al., (2015), Weka was used for NB, ANN and DT were applied. The data used in this study were taken from a course titled "Numerical Analysis", which is a core course for EEE student at North South University in Dhaka, Bangladesh. In Pradeep et al., (2015) Weka was used for JRip, ADTree, SimpleCart, C4.5 and OneR. The dataset used in this study was composed of data from 57 students in a school in Kerala, India between 2011 and 2013. In Navamani & Kannammal, (2015) Rapid Miner was used. In this study, algorithms such as NB, RF and kNN were used. In this study, the highest accuracy rate was obtained by using NB algorithm, which has the lowest accuracy, and the Adaboost algorithm. In Amaya et al., (2015), C4.5 and ID3 were examined using Weka. It has been observed that more sensitive results were obtained with ID3 algorithm.

2016

In Mishra et al., (2016), C4.5, NB, SMO, Random Tree (RT), RF and MLP were used with Weka and the highest accuracy rate was achieved with RF. In Amrieh et al., (2016), a new model was proposed for the prediction of students' performance. In order to increase the performance of algorithms such as ANN, NB and DT, ensemble methods called bagging, boosting and RF were used in addition to these algorithms. In Saa, (2016), Rapid Miner and Weka used for C4.5, ID3, CART and CHAID. In Singh et al., (2016), Weka used. The prediction model was created using DT, NB and ZeroR. The accuracy rate of the model was found to be 85.53%. In Devasia et al., (2016), a web-based application using NB technique with Weka was proposed. It has been seen that NB algorithm provides higher accuracy when compared to algorithms such as Regression, DT and ANN. In Altujjar et al., (2016), ID3 algorithm was used with Rapid Miner. The data in this study were obtained from the records of students who graduated from the Undergraduate Program in the Department of Information Technology at King Saud University in the 2013-2014 academic year. In Hamsa et al., (2016), DT algorithm and Fuzzy Genetic Algorithm (FGA) were used. According to DT algorithm, more students were in the risky class, while more

students were in the reliable group with the FGA. In Meedech et al., (2016), Weka was used for JRip, OneR, Ridor, C4.5, SimpleCart, ADTree, RT and REPTree. In Kaur & Singh, (2016), NB and C4.5 in Weka were used. With NB, 63.59% accuracy was obtained, with C4.5 algorithm 61.53% accuracy. In Livieris et al., (2016), a new decision support tool was presented with Weka.

NB, BP-ANN, RIPPER, C4.5, 3NN and SMO were used. The highest accuracy rate was achieved with voting. In Rubiano & Duarte, (2016), Weka was used for implementing C4.5, RIDOR and PART and the best results were obtained with RIDOR. The data used in this study were obtained from the data of Systems Engineering students at the University of El Bosque in Colombia. In Mueen et al., (2016), NB, MLP and C4.5 were examined using Weka. It has been observed that higher accuracy is obtained with NB. In Mundada, (2016), Weka was used and a 72% correct prediction was obtained by applying NB. This study used data from a coaching class for Grade 11 and Grade 12 students preparing for the Indian Institute of Technology entrance exams. In Sumitha & Vinothkumar, (2016), Weka was used for NB, MLP, SMO, Decision Table, C4.5 and REPTree, the highest accuracy rate was obtained with C4.5.

In Velmurugan & Anuradha, (2016), C4.5, NB, BN, IBk, OneR and JRip were examined using Weka. In addition, Correlation-based Feature Selection, Best First Search Algorithm, Wrapper Feature Selection, CfsSubset Evaluator were used for feature selection. The highest accuracy rate was obtained with kNN. In Agaoglu, (2016), DT, SVM, ANN and Discriminant Analysis (DA) classification techniques were used. The data were collected through questionnaires from students at a department of Marmara University in Istanbul.

2017

In Gowri et al., (2017), Weka was used for Apriori algorithm. It was used to group students according to similar characteristics with k-means algorithm. The data in this study were obtained from students in 4 public schools in the Vellore district of Tamil Nadu, India. In Asif et al., (2017), Rapid Miner was used for DT, NB, ANN and RF. The highest accuracy was achieved with NB. In Khasanah & Harwati, (2017), BN and DT were used and higher accuracy rate was achieved with BN.

In Veena & Guruprasad, (2017), NB, SVM and kNN were examined using Weka. The highest performance was achieved with kNN. The data in this study were taken from the SIU database of the students who graduated from the Information Informatics department. In Mehboob et al., (2017), DT, ID3, CHAID, Decision Stump (DS), RT and RF were used. The highest accuracy was obtained from ID3. Data provided by the Department of Electrical and Mechanical Engineering at the National University of Sciences & Technology in Pakistan. In Mhetre & Nagar,

(2017), NB, C4.5, ZeroR and RT were used by using Weka. The highest accuracy rate was obtained with RT algorithm. In Govindasamy & Velmurugan, (2017), C4.5, NB, kNN, k-means and EM were examined by MATLAB and Weka. The highest accuracy rate among the classification algorithms was obtained with C4.5 algorithm with 62.7%. In Amra & Maghari, (2017), kNN and NB were applied and a higher accuracy was obtained with NB. In Wati et al., (2017), NB and C4.5 were compared using Rapid Miner. The data used were obtained from interviews with students and student organizations at Mulawarman University in Indonesia.

In Costa et al., (2017), SVM, C4.5, ANN and NB were applied, DT has the highest efficiency.

In Fernández & Luján-Mora, (2017), the results of Rapid Miner, Knime and Weka were compared.

The data were taken from the academic database of the university and saved in Excel. Areas studied were Network and Telecommunications Engineering, Computer and Information Systems Engineering, and Electronics and Information Networks Engineering. In Sivasakthi, (2017), MLP, NB, SMO, C4.5 and REPTree were examined using Weka. The highest performance accuracy rate was achieved with MLP. In Athani et al., (2017), Weka was used. NB algorithm was used and the accuracy rate was 87% using the confusion matrix. In Al-Shehri et al., (2017), SVM and kNN were applied. The correlation coefficient was found to be 0.96 with SVM algorithm and 0.95 with kNN algorithm. In Utomo, et al., (2017), Gaussian NB, Multinomial NB, Bernoulli NB, DT and SVM were used. The highest accuracy value was obtained with SVM. The highest average accuracy value was obtained with DT. The data used in this study were obtained from new students enrolled in the State Polytechnic of Ujung Pandang University in Indonesia.

2018

In Funcion, (2018), J48 (C4.5) was used to predict the academic performance of students using Weka. A 10-fold Cross Validation and Receiving Operating Characteristics Curve (ROC) were applied to test the success of the system. As a result of this study, it was observed that the accuracy rates were 89.0% for the successful attribute, 92.60% for the unsuccessful attribute, and 74.90% for the conditional attribute. In Soni et al., (2018), DT, NB and SVM were used. SVM was the algorithm that showed the best success with an accuracy rate of 83.33%. In Ajibade et al., (2018), NB, DT, kNN, DA and Pairwise Coupling (PWC) were used. In addition, methods such as AdaBoost, Bag and RUSBoost were used. MATLAB was used during this study. Considering the behavioral model with DT model, the highest accuracy rates were obtained as 84.2% and without the behavioral feature as 72.6%. In Sugiyarti et al., (2018), C4.5 with Weka was used. The data used in this

study were collected through observation at the end of interviews with scholarship officials. In Mishra & Mishra, (2018), RF, C4.5 and CART were used. In this study, Oracle database, Weka and MATLAB were used. Tthe highest accuracy rate was obtained with RF algorithm as 92.7%. In Hegde & Prageeth, (2018), it was made using NB algorithm in R and Weka. The correct classification rate was found to be 72%. In Burgos et al., (2018), LR was used. Feed Forward Artificial Neural Network (FF-ANN), SVM, Educational Data Mining (SEDM), Adaptive Resonance Theory Mapping (PESFAM) methods were applied. In Tegegne & Alemu, (2018), Phyton and Weka were used to organize and process the data. An accuracy rate of 81.4% was obtained in the study performed by applying C4.5. In Sivakumar & Selvaraj, (2018), DT, SVM, kNN, NB and improved DT were applied to the data. With the developed DT method, the best accuracy rate was obtained with an accuracy rate of 98.56%. In Hussain et al., (2018), C4.5, PART, RF and BN Classifiers were examined using Weka. It has been found that RF algorithm is the algorithm that gives the best result with an accuracy rate of 99%. In Kiu, (2018), NB, MLP, C4.5 and RF were examined using Weka. In Al-Noshan et al., (2018), ANN, kNN, RF, DT, AdaBoost and MLP were compared using Rapid Miner. With ANN, the highest accuracy rate was obtained with an accuracy rate of 84.8%. In de Sousa, de Oliveira & Borges, (2018), One R, kNN and NB were examined by applying 5-fold cross validation. The highest accuracy rate was found to be 86% using NB. In Miguéis et al., (2018), DT, SVM, NB, RF, Bagging–DT and Adaptive Boosting–DT were examined. The highest accuracy rate was found to be 96.1% with RF algorithm. In Chanlekha & Niramitranon, (2018), DT, NB, RF, SVM and ANN were applied. In Kasthuriarachchi & Liyanage, (2018), NB, RF and DT were used. A 10-fold cross validation method was used and the highest accuracy rate was 98.9% with DT. In Polyzou & Karypis, (2018), DT, Linear SVM, RF and Gradient Boosting were used. According to the F1-score and ROC value, the algorithm that gave the best results was GB. In Shingari & Kumar, (2018), DT, RF, Linear Model and ANN were compared using R. It was concluded that the most suitable classification algorithm is the DT. In Kaunang & Rotikan, (2018), DT and RF were compared. The highest accuracy rate of 66.9% was obtained with DT. In Ashaduzzaman et al., (2018), DT, NB and SVM were compared. The highest accuracy rate was obtained as 87.8187% as a result of the NB algorithm with 10-fold cross validation.

2019

In Widyaningsih et al., (2019), k-means clustering divided students into three clusters. Then it is classified using by NB. The data were divided into 80% training and 20% testing, and the accuracy rate was found to be 96%. In Tasnim et al., (2019), C4.5, RT, RF, Logistic Model Tree (LMT), DS, Hoeffding Tree (HT) and their reinforced

forms were used. Better results were obtained with enhanced DT algorithms. In Santoso, (2019), DT and NB were used. When the test data and estimation results were examined, it was observed that better results were obtained with NB compared to the AUC value. The data used in this study were obtained from the database of the university.

In Saa et al., (2019), DT, RF, Gradient Boosted Trees (GBT), Deep Learning, NB, LR and Generalized Linear Model were applied. The highest accuracy rate was found to be 75.52% with RF algorithm.

In Moscoso-Zea et al., (2019) Weka, RT, C4.5, OneR, NB and staking were examined. The precision obtained from C4.5 and RT was found to be close. In Adekitan & Salau, (2019), the results were compared with Probabilistic ANN, RF, DT, NB, LR and Tree Ensemble using Knime. The highest accuracy rate was obtained with LR as 89.15%. In Yusuf & John, (2019), C4.5, IBK, SMO were examined using Weka. The highest accuracy rate was obtained as 95.1923% using C4.5. In Ghazzawi & Salama, (2019), DT, kNN, RF and NB were compared. According to results, the highest accuracy was found with RF as 97.86%. In Lenin & Chandrasekaran, (2019), RF, NB and kNN were compared. The highest accuracy rate was 95.45% with RF. In Imran et al., (2019), C4.5, NNge and MLP were compared. The highest accuracy rate was found to be 95.78% with C4.5. The data used in this study were obtained from the CI Machine Learning Repository of Portugal's Alentejo region. In Amirhajlou et al., (2019), MLP, SVM and Linear Regression were compared. The lowest error rate was obtained with MLP. In Chango et al., (2019), C4.5, REPTree, RT, JRIP, Nnge and PART were compared. The highest accuracy rate obtained from categorical data was found to be 82.4561% with PART algorithm. In Ketui et al., (2019), DT, DT Weight-based, ID3, RT and GBT were compared. The highest accuracy rate was found to be 92.41% with GBT. In Aziz & Awlla, (2019), C4.5 and NB were compared using Weka. The highest accuracy rate was obtained as 48.1 with C4.5 algorithm using Hold out (60%).

In Kumar et al., (2019), NB, ID3, C4.5 and RT were examined. Of these algorithms, the full accuracy rate was found to be 85% with NB the highest. In Salal et al., (2019), NB, C4.5, RF, RT, REPTree, JRip, OneR, SimpleLogistic and ZeroR were compared using Weka. Using the default parameters, the highest accuracy rate was found to be 76.7334% with OneR algorithm. In Jalota & Agrawal, (2019), C4.5, SVM, NB, RF and MLP were used by using Weka. The highest accuracy rate was found to be 76.07% with MLP. In Mohammadi et al., (2019), kNN, NB and DT were compared. The highest accuracy rate was found to be 0.5464% with kNN. In Yaacob et al., (2019), kNN, NB, DT and LR were used. The highest accuracy rate was found with NB as 89.26%.

2020

In Walia et al., (2020), NB, DT, RF, JRip, and ZeroR were compared by using Weka. The highest accuracy rates were found to be 85.31% with Jrip algorithm and 85.06% with DT algorithm. In Rimi et al., (2020), DT, NB, ANN, SVM and kNN were compared using Weka. The highest accuracy rate of 85% was obtained with NB. The data were obtained from the characteristics of the students collected from different sources. In Nemomsa et al., (2020), C4.5, RF, NB, BN, JRip and PART were compared using Weka. The highest accuracy rate was obtained with C4.5 and JRip. In Budiman et al., (2020),

NB and C4.5 were compared using Weka. The highest accuracy rate was obtained with NB as 71.4%. In El Aissaoui et al., (2020), NB, CART, ID3 and C4.5 were compared using Weka. In AlHakami et al., (2020), C4.5 algorithm was used using Weka. The data were obtained from Umm Al-Qura University in Makkah. In Medina et al., (2020), BN and DT algorithms were compared. The highest accuracy rate was obtained with BN as 67.1%. In Ndou et al., (2020), RF, Logistic Model Trees, C4.5, Multinominal Logistic, NB and SMO algorithms were compared. The highest accuracy rate was obtained with RF.

In Yulianto et al., (2020), kNN and C4.5 were compared. The highest accuracy value was found as 59.32% with kNN. In Mengash, (2020), DT, SVM, NB and ANN algorithms were compared.

The highest accuracy rate was found to be 79% with ANN algorithm. In La Ode Mohamad Zulfiqar et al., (2020), a hybrid method consisting of DT and NB algorithms was examined. The best result was found to be 72.73% with 90% accuracy. In Sasikala et al., (2020), NB and ID3 algorithms were examined using Weka and R. The highest accuracy rate obtained with R using all features was found to be 96.8% with NB. In Thant et al., (2020), NB was used. More than 90% accuracy was achieved with NB. The data used in this study was created from student records collected from departments. In Tun & Htay, (2020), C4.5 was examined using Weka. With C4.5, 78.2% accuracy was achieved. In Koyuncu & Gelbal, (2020), NB, kNN, ANN and LR were compared. In Sanlı et al., (2020), kNN, C4.5, SMO, NB, NBM, BAGGING and JRIP algorithms were compared. The most successful algorithms were found to be kNN, SMO and C4.5, respectively. In Dewantoro & Ardisa, (2020), kNN, ANN, and NB algorithms were compared. The best accuracy for estimating GPA was 92% with ANN. In Yaacob et al., (2020), DT, LR, RF, kNN and ANN algorithms were compared. It was observed that LR produced the best estimates with 0.908.

2021

In Nedeva & Pehlivanova, (2021), BN, MLP, SMO and C4.5 algorithms were compared. The best accuracy results were obtained with MLP. The data used in this study were obtained through a questionnaire from students at Trakia University. In Nahar et al., (2021), DT, NB, PART, Bagging, Boosting and RF algorithms were compared. Two different data sets were used in this study. In the first dataset, the highest accuracy with the test data was found to be 67.8571% with Bagging. In the second dataset, the highest accuracy with the test data was found to be 75.3846% with Boosting and RF.

The data used in this study were obtained through a questionnaire to students and from student grades in the CSE department. In Triayudi & Widyarto, (2021), C4.5 and NB algorithms were compared using Weka. While the obtained accuracy rates were 73.8% with NB algorithm, it was 73.6% with C4.5 algorithm. The data used in this study were obtained from the learning management system of a private university in Jakarta, Indonesia. In Kiffen et al., (2021), MLP, RF and SVM algorithms were compared. The highest accuracy was obtained with MLP algorithm as 73%. The data used in this study were obtained from the university's learning management system. In Verma et al., (2021), kNN, ANN, SVM, RF and NB algorithms were compared. The highest accuracy rate was obtained with kNN. However, successful results were obtained with the ANN algorithm by combining different variables. The data in this study was obtained from the Open University data site Kaggle in the United Kingdom.

CONCLUSION

In this study, various studies conducted with the data mining method in the field of education between the years 2011-2021 were examined. 6 studies from 2011, 9 studies from 2012, 11 studies from 2013, 11 studies from 2014, 15 studies from 2015, 16 studies from 2016, 15 studies from 2017, 20 studies from 2018, 2019 146 studies, including 19 studies belonging to the year 2020, 18 studies belonging to the year 2020, and 6 studies belonging to the year 2021 were examined.

The data mining tools and algorithms used in these studies were determined and the successes obtained from these algorithms were compared. The algorithm with which the highest success rates were obtained in the studies examined was examined. In addition, the data used in these studies were also examined, and how the data used was obtained and what kind of data these data consisted of were examined.

When the studies between the years 2011-2021 were examined, it was seen that although Rapid Miner and Knime were used while analyzing with the data mining

method, studies were generally conducted with Weka. Although different algorithms were used in the studies examined, the generally used algorithms are; ANN, BN, BP-ANN, CART, DA, DS, DT, EM, FGA, GBT,, KNN, LMT, LR, MLP, NB, RBF-ANN, RF, RT, SMO, SVM and k-means. Although the data used in the studies examined were collected in different ways, they were generally obtained from the databases of universities or various schools. In addition, some studies also collected data by questionnaire method.

When the studies conducted in 2011 were examined, DT, Associsted Rule, k-means, ZeroR, NB algorithms were used in general. It is aimed to achieve successful results by using the algorithms determined in these studies. When the studies conducted in 2012 were examined, it was seen that the algorithms ID3, C4.5, CART, NB, MLP, PART, ANN, SVM, DT, LR, ZeroR, PART, SMO, BN were used. It has been observed that more accurate predictions are obtained with different algorithms in different studies. When the studies conducted in 2013 were examined, it was observed that BN, MLP, SMO, C4.5, REPTree, ID3, C4.5, CART, k-means and NB algorithms were preferred. It has been observed that more accurate predictions are obtained with MLP, C4.5, ID3 algorithms. When the studies conducted in 2014 are examined, generally, ID3, C4.5, CHAID, DT, NB, ANN, kNN, BN, CART, RF, SVM and LR algorithms were used. It has been observed that more accurate predictions are obtained by using the ID3, ANN, BN, NB and C4.5 algorithms. When the studies conducted in 2015 are examined, ANN, kNN, RF, CART, SVM, NB, DT, C4.5, ID3 and MLP were used in general. It has been observed that more accurate predictions are obtained by using SVM, ANN, DT, C4.5, NB and ID3 algorithms. When the studies conducted in 2016 are examined, generally C4.5, NB, SMO, RT, RF, MLP, ANN, DT, C4.5, ID3, CART and CHAID were used. It has been observed that more accurate predictions are obtained by using RF, CART, NB, C4.5 and kNN algorithms. When the studies conducted in 2017 are examined, generally DT, NB, ANN, RF, BN, SVM, kNN, ID3, RT, C4.5 and REPTree algorithms were used. It has been observed that more accurate estimations are obtained by using NB, BN, ID3, RT, C4.5, DT, MLP and SVM. When the studies conducted in 2018 were examined, C4.5, DT, NB, SVM, CART, RF, NN, kNN, PART and MLP were used in general. It has been observed that more accurate predictions are obtained by using SVM, DT, RF, C4.5, ANN, RF and NB algorithms. When the studies conducted in 2019 are examined, generally k-means, NB, C4.5, RT, RF, DT, ANN, LR, SMO, IBK, MLP, ID3, REPTree and SVM algorithms were used. It was observed that more accurate estimations were obtained by using k-means, DT, NB, C4.5, LR, RF, C4.5 and MLP. When the studies conducted in 2020 are examined, generally NB, DT, RF, JRip, ZeroR, ANN, SVM, kNN, C4.5, BN, PART, CART, ID3, BN, SMO and LR were used. It has been observed that more accurate predictions are obtained by using DT, NB, C4.5, ID3, RF and ANN. When the studies conducted

in 2021 are examined, generally BN, MLP, SMO, C4.5, DT, NB, RF, C.4., SVM, kNN and ANN were used. It has been observed that more accurate predictions are obtained by using MLP, NB, C4.5 and kNN algorithms. As a result of the studies examined, it was observed that higher accuracy results were obtained by using C4.5, ID3, ANN, NB, SVM and CART.

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Chapter 4
Assistive Technology to Promote the Independence and Quality of Life of People With Amyotrophic Lateral Sclerosis:
A Selective Review

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ABSTRACT

Amyotrophic lateral sclerosis (ALS) is a progressive neurodegenerative disease that selectively affects motor neurons. To date, there is no cure for ALS. It has been widely demonstrated how the use of AT can increase the independence and safety of patients improving their quality of life. Interventions based on the use of AT consist of aids to support residual capacities, increased autonomy and control of oneself and one's life, increased interactivity with the surrounding environment, increased participation in family and social life, maintaining a dignified standard of living, and at the same time decreasing the workload of the caregiver. The aim of the chapter is to provide an overview of the latest empirical evidence available on the use of AT-based programs for ALS people. Empirical data have demonstrated the effectiveness and adequacy of AT interventions. In conclusion, AT-based rehabilitation programs can be useful to promote the independence and quality of life of individuals with ALS.

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INTRODUCTION

Amyotrophic lateral sclerosis (ALS) is a neurodegenerative disease characterised by progressive muscular paralysis reflecting degeneration of motor neurones in the primary motor cortex, corticospinal tracts, brainstem and spinal cord (Wijesekera & Leigh, 2009). Upper motor neurons degeneration leads to an increased muscle stiffness (spasticity) and impaired fine movements. Lower motor neurons degeneration leads to wasting and weakness, often with prominent muscle twitching (fasciculations) and reduced or absent deep tendon reflexes (Andersen, Borasio, & Dengler, 2007). In ALS, motor neurons innervating all the voluntary muscles are affected, with the exception of eye muscles, which are seldom involved, and the bladder, which may be affected late in the illness. Involvement of lower cranial nerves, innervating the tongue and swallowing apparatus leads to difficulty with speech and in swallowing. When the disease affects this region, it is considered to be 'bulbar' in onset. Spinal onset disease refers to development of the first symptoms in the arms or legs (Meireles & Al-Chalabi, 2009). Therefore, ALS has a rapidly progressing that (a) typically strikes people between 40 and 60 years of age and (b) causes muscle atrophy, spasticity, dysarthria (anarthria), and respiratory problems (failure), and, eventually, death (Ahmed & Wicklund, 2011; Chio` et al., 2011). Death generally occurs 3–6 years after the diagnosis of the disease and is primarily brought about by infections and respiratory failures (Carlesi et al., 2011). Pharmacological interventions to improve this condition or slow down its progression seem to be limited to the use of anti-excitotoxic compounds such as riluzole (Carlesi et al., 2011; Cifra, Nani, & Nistri, 2011) and possibly the use of antioxidants (Bach, Gonzalez, Sharma, Swan, & Patel, 2010).

Persons with extensive neuro-motor impairments and lack of speech, following severe neurological damages, remain largely dependent on caregivers for all daily functions including leisure, occupation, and communication (Aoun, McConingley, Abernethy, & Currow, 2010). Any effort to help individuals with ASL to acquire some level of independent functioning requires the support of specific technology (Bauer & Elsaesser, 2012; Borg, Larson, & Ostergren, 2011). Behavioral interventions are considered to be critical to avoid isolation, lack of environmental engagement, and of communication activity (Brownlee & Palovcak, 2007; Gruis, Wren, & Huggins, 2011). Among behavioral interventions, assistive technology-based programs (AT) are increasingly conceived crucial to support independent leisure engagement and communication opportunities (Beukelman, Ball, & Fager, 2007). AT options are broadly recognized as essential means of support for individuals with neurodegenerative diseases, acquired brain injuries, and multiple disabilities (Mishra & Banerjea, 2020). Thus, AT-based programs are commonly planned to favourably fill the gap between behavioral/cognitive skills and environmental requests

(Bertelli, et al., 2016). That is, an AT setup is conceived to build functional bridges between users, environment, and technology. Essentially, it ensures that a helpful interaction (i.e., purposeful behavior and goal-oriented) is achieved for persons with extensive motor delays (Papais, et al., 2020). That interaction is critical to enhance personal fulfilment, social image, active role, satisfaction, and improving quality of life accordingly (Troncoso-Escudero, 2020).

For example, a computer-aided program presenting brief samples of environmental and social stimuli might be used together with a microswitch device to enable passive/isolated persons with extensive neuro-motor impairment and lack of speech to manage positive leisure engagement (Lancioni, Singh, O'Reilly, Sigafoos, Buonocunto, et al., 2011). Indeed, they could trigger the microswitch through a minimal response (e.g., minimal head movement) and, through this response, choose among the aforementioned stimuli and activate those that they prefer. Computer-aided telephone technology operated via a microswitch might enable persons with minimal response repertoire and lack of speech to place phone calls to relevant partners and have a basic contact and communication with distant persons. The availability of a series of words and phrases that the persons could activate via the microswitch to ask the partners about specific topics (e.g., activities performed during the day) or answer their questions could largely improve the communication value of the call (Lancioni, Singh, O'Reilly, Sigafoos, Ricciuti, et al., 2013).

A quarter of century ago, Farwell and Donchin (1988) described their mental prosthesis for "talking off the top of your head." This innovative communication system, later named P3-speller, has been the most investigated and tested brain–computer interface (BCI) system, to date. A main goal of the research on P3-spellers was the development of an effective assistive device for patients with severe motor diseases. Among these patients are those affected by amyotrophic lateral sclerosis (ALS). ALS patients have become a target population in P3-speller (and more generally in BCI) research. The P3-speller relies on the visual sensory modality, and it can be controlled by requiring users to actively move their eyes. Unfortunately, eye-movement control is usually not spared in the last stages of ALS, and, then, it is definitively lost in the case of complete paralysis.

Calligari et al. (2019) designed a new sensor, the Lever Magnetic-spring Mechanical Switch (LeMMS), allowing repeated activation/release cycles requiring a very small activation force. The LeMMS was applied and validated in a group of 20 patients with ALS in an advanced stage of disease. All the participants were regular users of communication aids employing other sensors, but which they could no longer operate their sensors (different from LeMMS). Patients were assessed at baseline (T0) and after one (T1), 6 (T2) and 12 (T3) months. Assessment at T0 included administration of standardized clinical scales, the Click-Test-30 counting the maximum number of LeMMS activations in 30 s, and thumb/fingers

strength assessment with the Kendall scale. The QUEST 2.0-Dev questionnaire was administered at T1. Some use-related information and the Click-Test-30 were collected at T1, T2 and T3. After one training session, all patients could operate the LeMMS with minimal residual movement of one finger. At T1, they used it on average 5.45 h/day. The mean score of the QUEST 2.0-Dev was 4.63, and suggested strong satisfaction with the LeMMS. Regarding Click-Test-30 scores, no significant difference was found between T0 and T1, but performance at T2 and T3 declined significantly ($p < 0.005$ vs. T0). At T3, 9/20 patients were still able to use their communication aid. This new switch sensor can enable patients with ALS to use their communication aids for a prolonged time even in the advanced phase of disease. It is easy to use, reliable and cheap, thus representing an intermediate alternative to more sophisticated and expensive devices.

Early research has found that there are few literature reviews based on AT interventions for people with SLA. In light of the above, the chapter included a selective review of the last two decades categorizing the use and effectiveness of AT-based programs for people with SLA. Finally, the implications of the findings have been critically argued and some useful insights for future directions in both research and practice have been highlighted.

BACKGROUND

For people with disabilities, computers, smartphones, the Internet and the multimedia world have the potential to unleash creativity, increase personal autonomy, make leisure activities available, allow work and social participation. However, this is only if the peripherals and services are designed to be accessible (De Nicolò & Lanubile; 2020). AT includes any item, part of equipment or product that is commercially acquired, modified, or customized, useful to increase, maintain, or improve the functional capabilities of people with disabilities (United Nation, 2019). The purpose of assistive technologies is to eliminate differences in performance between two individuals by means of a series of solutions which can be summarized as follows: (a) restoring a-function; (b) overcome a barrier; (c) remove a barrier; (d) amplify a stimulus; (c) pass a interrupted function; (f) convert and re-direct a stimulus (De Nicolò & Lanubile; 2020).

ALS initially leads to muscle weakness, causing mild problems that can initially be unnoticed; then we arrive at the progressive loss of voluntary control of the arms, legs, speech, breathing, swallowing mechanism. As the disease progresses, the strength and ability to move is completely lost; once the thoracic muscles are affected, breathing can also become difficult first and progressively impossible (independently) making indispensable the respiratory support provided by special

machines Technological research today makes available to the patient with SLA aids that, although in a different way than before, allow him to continue to move, feed, breathe and communicate maintaining an acceptable quality of life. The type, severity and frequency of symptoms determine the progression of ALS and the potential need for AT. The possibility of losing the ability to walk increases stress and psychological aspects of MS diagnosis. Therefore, relying on a mobility assistance device becomes very important for all people with ALS. One of the biggest challenges for rehabilitation professionals and people with ALS is finding a mobility device that meets users' needs and maintains or increases participation in social life. Be able to stay active in the community and also keep their work are some of the biggest challenges for people with ALS (Souza et al., 2010). The ultimate goal of the AT award process is to improve the functioning and quality of life of a person with disabilities and many other individuals. Quality of Life means well-being and, in a general sense, "the whole universe of the domains of human life, including physical, mental, and social aspects, which constitute what can be called a "good life"' (WHO, 2002).

METHOD

A computer search was carried out in Scopus, ResearchGate, and PubMed databases. Amyotrophic Lateral Sclerosis, Assistive Technologies, Positive Participation, quality of life, constructive engagement, communication skills, leisure, and occupation were merged as keywords. The eligibility criteria were (a) an empirical, evidence-based study including an AT-based intervention, (b) persons with ALS as participants; (c) last two decades of publication interval (i.e., 2000-2020), and (d) English as language of the paper. Consequently, twenty-two studies were reviewed with 233 participants included and grouped according to four main categories, namely: (a) communication, (b) daily activities, (c) assessment, and (d) locomotion (see Table 1). In the following section, the retained studies were concisely described and a synoptic table (i.e., Table 1) summarized the main findings.

LITERATURE OVERVIEW

The reviewed studies were arranged in an alphabetic order and summarized in Table 1. The reader may note that reviews or theoretical papers were not included because their inclusion would exceed the aim and scope of the current chapter (see above the eligibility criteria in the Method section).

Communication

The irreversible progression of the disease, causes a serious weakness that can evolve into complete immobility and consequent impossibility of speaking. Most ALS patients tend to have no intellectual impairment, although they gradually lose the ability to move and talk. Dysarthria is probably the most devastating symptom related to ALS, as it results in loss of the ability to communicate and prevents affected patients from participating in many activities, leading to social isolation. Dysarthria affects 80% of ALS patients throughout their history, causing large disabilities, with earlier onset in bulbous onset patients, some of whom arrive at anarthria in a few months (Casillo, 2016). In this group, 8 empirical studies were reviewed with a total of 71 participants involved.

Chung-Min et al. (2020), highlighted how a lot of people with severe disabilities such as amyotrophic lateral sclerosis, motor neuron diseases, cerebral palsy, stroke, and spinal cord injury with intubation always have different degrees of communication problems. Therefore, it is very important to develop an effective and easy use assistive communication system for persons with extensive motor impairments. In this study, a wireless home assistive system (WHAS) with different types of assistive input accessories sensors, Morse code translator, and human machine interface was developed and tested to help people with severe disabilities communicate with people and machines. A Morse code translator was implemented as an assistive communication core device to facilitate the input of people with severe disabilities. For the proposed human–machine interfaces, personal computer-based alternative augmentative communication was developed for patients to communicate with other people easily. To promote the quality of life, the home appliance control interface was developed for the people with severe disabilities to directly control the functions of home appliances by their own. The experimental results showed that the proposed WHAS was practical and feasible. Therefore, the proposed approach could help people with severe disabilities individuals to effectively interact with their surroundings.

Donated et al. (2019) measured the EEG signal of 12 subjects, 6 men and 6 women, of average age (25 ± 3) years, using a 64-channel actiCAP headset of brain product, while participants performed the expected tasks (think about producing /a/ or /i/) following a precise protocol. The Independent Component Analysis (ICA) technique has been applied for the purpose of detecting muscle artifacts and, in particular, those due to eye movements, and other possible sources of disturbance (e. g., 50Hz noise). This was followed by the calculation of discriminating features, obtained by the common spatial model method (CSP) and by time-frequency analysis. The results were variable but interesting, with high area values below the ROC curve, and classification errors often well below 10%.

Kathner et al. (2015), evaluated electrooculography (EOG), an eye tracker and an auditory brain-computer interface (BCI) as access methods to augmentative and alternative communication (AAC). The participant of the study was diagnosed in the locked-in state (LIS) for 6 years due to amyotrophic lateral sclerosis. He was able to communicate with slow residual eye movements, but had no means of partner independent communication. They discussed the usability of all tested access methods and the prospects of using BCIs as an assistive technology. Within four days, we tested whether EOG, eye tracking and a BCI would allow the participant in LIS to make simple selections. They optimized the parameters in an iterative procedure for all systems. The participant was able to gain control over all three systems. Nonetheless, due to the level of proficiency previously achieved with his low-tech AAC method, he did not consider using any of the tested systems as an additional communication channel. However, he would consider using the BCI once control over his eye muscles would no longer be possible. He rated the ease of use of the BCI as the highest among the tested systems, because no precise eye movements were required but also as the most tiring, due to the high level of attention needed to operate the BCI. In this case-study, the partner-based communication was possible due to the adequate care provided and the proficiency achieved by the interlocutors. To enhance the transition from a low-tech AAC method to a BCI once control over all muscles was lost. For persons, who rely on AAC and were affected by a progressive neuromuscular disease, they argued that a complementary approach, combining BCIs and standard assistive technology, could prove valuable to achieve partner independent communication and promote the transition to a purely BCI based approach.

Laffont et al. (2007), have evaluated a speech synthesizer with respect to patterns of use and satisfaction, during a 2-month trial at home, and the usefulness of the word prediction function, through a prospective study. Initially, 24 patients with severe dysarthria were recruited although 10 completed the study. Five patients had cerebral palsy, 3 amyotrophic lateral sclerosis, one locked-in syndrome, and one anoxic brain damage. Mean age was 32 (standard deviation 21) years (range 9–66 years). Each participant received 10 hours of training with the device and then used it at home for 2 months. The main outcome measures were the level of use recorded by the device, Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST), satisfaction score (maximum = 5), time needed to take dictations of a standard dictionary, and personal-dictionary words with and without word prediction. Level of use varied widely across participants. Overall satisfaction at the end of the home trial was high, with a mean QUEST score of 3.4 (SD 1) and was related to the level of use of the device. Level of satisfaction at the end of the training session could not predict the level of use at home. No significant differences were found in dictation-taking times with and without word prediction. However, 6 of the 10

patients took dictation faster with than without word prediction. This study provided the first evidence supporting the benefits of a speech synthesizer used at home for several weeks. Word prediction was useful for some patients even if increase in dictation speed did not reach significance.

Lancioni et al. (2012), have implemented a technology assistance program to promote communication and commitment to leisure. Study I involved a 51-year-old man with a virtually total loss of his motor repertoire and assessed a technology-aided program aimed at enabling him to (a) write and send out text messages and have incoming messages read to him and (b) establish videophone connections with his children (i.e., establish video contact and communicate with them). Study II involved a 66-year-old man with virtually no motor behavior and apparent depression and assessed a technology-aided program aimed at enabling the participant to (a) engage in leisure activities and make requests for basic needs and (b) use a low-demand messaging system. The results of both studies were highly encouraging. The participant of Study I could use the technology-aided program for effective communication and social interaction with multiple partners as well as for family interaction. The participant of Study II could use the technology-aided program for leisure engagement, requests, and basic family contacts/communication.

Pandarinath et al. (2016), pointed out that brain-computer interfaces (BCI) have the potential to restore communication for people with tetraplegia and anarthria by translating neural activity into control signals for assistive communication devices. While previous clinical and clinical pre-cycle studies have shown promising proofs of concept, the performance of human clinical BCI systems was still not high enough to support widespread adoption by people with physical limits of speech. In this study, however, an intracortical BCI with a high performance (IBCI) was used for communication, which was tested by three participants in the clinical trial with paralysis. The system had leveraged advances in decoder design developed in previous pre-clinical and clinical studies. For all the participants, performance exceeded previous IBCI measured by typing speed (by a factor of 1.4-4.2) and information throughput (by a factor of 2.2–2.4).

Soriani et al. (2017), evaluated a visual BCI device in a clinical study to test if patients with disability with multiple deficiencies related to ALS would be able to use BCI to communicate in a daily environment. After clinical evaluation of physical, cognitive and language capacities, 20 patients with ALS were included. The BCI P300 speller system consisted of an EEG acquisition connected to real-time processing software, and separate keyboard display control software. It was equipped with original features such as optimal stopping of flashes and word prediction. The study consisted of two 3-block sessions (copy spelling, free spelling and free use) using the system in several modes of operation in view of evaluating its usability through its effectiveness, efficiency and satisfaction. Effectiveness is evidenced as

100% of participants successfully achieved all spelling tasks. Efficiency is supported considering over 95% of correct symbols were selected by 65% of participants. The average number of correct symbols/min ranged from 3.6 (without word prediction) to 5.04 (with word prediction). Participants expressed satisfaction with an average score of 8.7/10 on a Visual Analog Scale assessing comfort, ease of use and utility. Patients quickly learned how to operate this system which did not require much learning effort. Word prediction and optimal stopping of flashes improved information transfer rate and made BCI competitive with alternative communication systems such as eye trackers. Remaining requirements to improve the device for a suitable ergonomic use were currently in progress.

Wilson and Lovely (2012), evidenced to a small potential difference of between 1 and several mV exists between the cornea (+) and the retina (-) of the eye which was dependent on the ambient light level. This phenomenon, known as the resting potential or corneal-retinal potential (CRP), has been known for over 150 years, and had led to the eye being model as an electrical dipole. The measurement of this signal, electrooculography (EOG), was used not only for diagnostic studies in clinical settings, but also for use in assistive technology (AT) as a control input for external devices for the people with disability. A large percentage of end users of EOG in AT were patients who have developed amyotrophic lateral sclerosis (ALS) and that use bi-level positive airway pressure (BiPAP) devices for breathing assistance. These devices covered a large portion of the face, especially the area most commonly used for EOG signal acquisition (area surrounding the eyes). This paper served to present alternative locations for EOG acquisition through the use of electrode facial mapping. A high-density electrode array system was used to gather information on the signal integrity on the face and surrounding area and was weighed against the apparent benefits with respect to BiPAP mask obstruction and general aesthetics. These results were used as a stepping stone towards the development of a new low powered, portable EOG device that will be applicable to any user, despite possible facial obstructions or aesthetic concerns.

Daily Activities

Environmental control units (ECU), integrated into communicators, can be very useful in maintaining the patient's sense of autonomy. With these remote-controlled devices, one can control lights, air conditioning, television and other appliances. Electronic control units, which can be activated with voice, eyes or switches, also reduce service requests. It is possible to start telephone calls and video calls, open and close doors or simply adjust a bed. Some people with ALS paint, write autobiographies, are an inspiration to their communities. Eye-tracking technology allows full control of computers and internet access. They can improve education,

find support groups online, and stay in touch with family and friends via email or social media, maintaining their autonomy and limiting isolation. In accordance with this definition, BCI should be considered as it supports the daily activities of people with ALS precisely and of such importance in fact be able to perform a right assignment of the technology in order to avoid dissatisfaction or the abandonment. It is now widely recognized that personal factors can prove both as important barriers and as facilitators in the use of AT. According to this point of view, AT are not considered as deficit compensation systems but involve personal well-being and social participation. Only once technologies are considered within a real-world context of use AT can meet the needs of users and involve broad-spectrum considerations of functional attributes and it does not work (Federici & Scherer, 2013). In this group, 6 empirical studies were reviewed with a total of 60 participants involved.

Carpinella et al. (2012), compared two protocols for robot-based rehabilitation. They used the *Braccio di Ferro* robot for a reaching task. A splint in which the people would suspend arm was added to the end effector for use in reaching and manipulation tasks. PwMS recruited for this study had EDSS score < 9 with a mean EDSS score of 6.7. For the reaching task, the participants used a cursor and target setup as described above, and for the manipulation task they were asked to manipulate real objects like LEGOs, bottles and jars. Two types of forces were applied by the robot: perturbing forces that acted in the perpendicular direction to the movement and resistive forces that opposed the movement. Kinematic assessments like reaching duration, manipulation duration, jerk index, mean and maximum lateral duration, normalized path length and learning index and also clinical assessments like the NHPT and ARAT were recorded. The authors found that the proposed robotic therapy approach reduced arm tremor and improved arm kinematics and functional ability. They also found that MS people had the ability to adapt to the perturbing forces generated by the robot, which suggests that the PwMS were able to learn an internal model to account for these forces. While prior to the treatment the MS people had difficulty counteracting resistive forces, this ability improved when tested post treatment.

Kather (2017) designed and implemented BCIs a multifunctional P300 BCI with a graphical user interface intended for non-expert setup and control, because current brain-computer interface (BCIs) software was often tailored to the needs of scientists and technicians and therefore complex to allow for versatile use. The system included applications for spelling, web access, entertainment, artistic expression and environmental control. In addition to new software, it also included new hardware for the recording of electroencephalogram (EEG) signals. The EEG system consisted of a small and wireless amplifier attached to a cap that can be equipped with gel-based or dry contact electrodes. The system was systematically evaluated with a healthy sample, and targeted end users of BCI technology, (i.e.,

people with a varying degree of motor impairment tested the BCI in a series of individual case studies). Usability was assessed in terms of effectiveness, efficiency and satisfaction. Feedback of users was gathered with structured questionnaires. Two groups of healthy participants completed an experimental protocol with the gel-based and the dry contact electrodes (N = 10 each). The results demonstrated that all healthy participants gained control over the system and achieved satisfactory to high accuracies with both gel-based and dry electrodes (average error rates of 6 and 13%). Average satisfaction ratings were high, but certain aspects of the system such as the wearing comfort of the dry electrodes and design of the cap, and speed (in both groups) were criticized by some participants. Six potential end users tested the system during supervised sessions. The achieved accuracies varied greatly from no control to high control with accuracies comparable to that of healthy volunteers. Satisfaction ratings of the two end-users that gained control of the system were lower as compared to healthy participants. The advantages and disadvantages of the BCI and its applications were discussed and suggestions are presented for improvements to pave the way for user friendly BCIs intended to be used as assistive technology by persons with severe paralysis.

Lancioni et al. (2014) extended the assessment of technology-aided programs to enhance leisure occupation in persons with extensive neuromotor impairment and lack of speech. Specifically, the study implemented the program for leisure occupation with two post-stroke patients. A computer system presented the participants with a variety of stimuli. The participants could select/access those stimuli by microswitch activation or could bypass them by abstaining from microswitch responses. Data were largely positive. The patients showed high levels of stimulus selection (access) and extended engagement.

Lievesley et al. (2011) assessed the use of an EPOC neuroheadset, a commercially available device that allowed game players to control a computer using their facial expressions or their thoughts. This paper aimed to examine whether the developed device had the potential to be used as an input for assistive technology (AT) devices. Two experiments were conducted. First, 12 non-impaired people used the neuroheadset to control a computer with their facial expressions. They also used a simple system of two head switches for comparison. Secondly, three non-impaired people were trained to use the neuroheadset to control a computer with their thoughts. Findings Data evidenced that the neuroheadset was slower and less accurate than the head switches ($p<0.05$), and it was also harder to use. It was unlikely to be preferred to existing methods of accessing AT for those that retained a small amount of head movement. Furthermore, by the end of the week, all three subjects achieved accuracy rates greater than chance. All subjects were non-impaired, and the sample size in the second experiment was small. Further research should concentrate on the second experiment, using larger sample sizes and impaired subjects. The EPOC neuroheadset

was substantially cheaper than similar specialist devices, and had the potential to allow those with no voluntary muscle control to access AT with their thoughts. The results of these two experiments showed that the Emotive EPOC neuroheadset could be used as an interface for non-impaired users to transfer information to a computer, which could in turn be used to control AT.

Rudigkeit and Marion (2020), evaluated AMiCUS, a human–robot interface that enabled tetraplegics to control an assistive robotic arm in real-time using only head motion, allowing them to perform simple manipulation tasks independently. The interface could be used as a standalone system or to provide direct control as part of a semi-autonomous system. Within this work, they presented our new gesture-free prototype AMiCUS 2.0, which has been designed with special attention to accessibility and ergonomics. As such, AMiCUS 2.0 addresses the needs of tetraplegics with additional impairments that may come along with multiple sclerosis. In an experimental setup, both AMiCUS 1.0 and 2.0 were compared with each other, showing higher accessibility and usability for AMiCUS 2.0. Moreover, in an activity of daily living, a proof-of-concept is provided that an individual with progressed multiple sclerosis was able to operate the robotic arm in a temporal and functional scope, as would be necessary to perform direct control tasks for use in a commercial semi-autonomous system. The results indicated that AMiCUS 2.0 made an important forward step towards closing the gaps of assistive technology, being accessible to those who rely on such technology the most of the time.

Schettini et al. (2015), evaluated the feasibility and usability of an assistive technology (AT) prototype designed to be operated with conventional/ alternative input channels and a P300-based brain-computer interface (BCI) in order to provide users who had different degrees of muscular impairment resulting from amyotrophic lateral sclerosis (ALS) with communication and environmental control application. End-users with ALS (NZ8; 5 men, 3 women; mean age _ SD, 60_12y) were recruited by a clinical team from an ALS center. Three experimental conditions based on (1) a widely validated P300-based BCI alone; (2) the AT prototype operated by a conventional/alternative input device tailored to the specific end-user's residual motor abilities; and (3) the AT prototype accessed by a P300- based BCI were assessed. These 3 conditions were presented to all participants in 3 different sessions. Main Outcome System usability was evaluated in terms of effectiveness (accuracy), efficiency (written symbol rate, time for correct selection, workload), and end-user satisfaction (overall satisfaction) domains. A comparison of the data collected in the 3 conditions was performed. Effectiveness and end-user satisfaction did not significantly differ among the 3 experimental conditions. Condition III was less efficient than condition II as expressed by the longer time for correct selection. A BCI could be used as an input channel to access an AT by persons with ALS, with no significant reduction of usability.

Assessment

Many patients with ALS experience a rapid evolution of symptoms related to a progressive decline in movement function that affects different systems. Clinical assessment is based on measures of progression for identifying the need and the pace of medical decisions, and to measure also the effects of novel therapies. However, assessment is limited to the periodicity of clinical appointments that are increasingly difficult for patients due to progressive mobility impairments. In this group, 1 empirical study was reviewed with a total of 8 participants involved.

Londral et al. (2018), proposed studying the AKV as a marker of neurodegenerative progression in ALS. They were interested in evaluating current speech that could be recorded via a current mobile device to be used in remote monitoring, outside the clinical facilities. In particular for ALS, for which standard clinical assessments were spaced of 3 to 6 months, this would facilitate: 1. A continuous evaluation of progression that could be sent to the clinician. 2. Novel markers to study the impact of new therapies. 3. The remote assessment, in particular when patient had mobility impairments and the transportation for the clinical facilities became difficult. Have used a database containing sound samples that were recorded from a mobile phone or a laptop computer. These samples contained the same common 20-words sentence in Portuguese. For the severity of ALS disease, a short sentence could be an important requisite of methodology, to make it valid for these patients' context. In fact, as speech became Biomarkers of Neurodegenerative Progression from Spontaneous Speech Recorded in Mobile Devices: An Approach based on Articulation Speed Estimation - A Study of Patients Suffering from Amyotrophic Lateral Sclerosis 273difficult to produce, the more complex is the sample collection, and the more dropouts will take place. The results described in previous sections demonstrate that the KLD from a healthy control was sensitive to neurodegeneration progression in ALS. For all ALS people, except one, the AKV model emphasized progression of neurodegenerative symptoms in speech, by increase of KLD, for both the younger and the older models.

Locomotion

Serious injuries to the motor system lead patients with ASL to complete paralysis of the limbs. BCI can be used to activate motion support devices, as well as the ability to use celebratory signals for control, such as wheelchairs that can allow movement (Federici & Scherer, 2013). In this group, 7 empirical studies were reviewed with a total of 104 participants involved.

Alboré et al. (2013) conducted a pilot study using an electronic board that, connected to the control system of an electric wheelchair, from one end and a pc,

on the other (by interfacing with a card), and consented to the patient with an eye-tracker and the ISA communicator, to physically drive the movement of the single chair movement of the pupils, through special visual triggers shown on the screen. The problem was addressed from a software point of view, creating two modules (for the person with ALS and for PC), to obtain serial communication via USB port, and from a hardware point of view, creating two ad hoc electronic circuits, namely a relay board and an additional circuit to drive the electric motors of the wheelchair. The PC could therefore be increasingly able to place the following commands in the chair: (a) insane; b) forward (slow or fast); (c) reversing; and (d) right or left rotation.

Beer et al. (2008) evaluated the effect of a robot-assisted gait training in 35 PwMS. The participants were divided into two groups, one of which performed rehabilitation using a robot (19) and the other without (16). PwMS recruited for each group had severe walking disabilities with a EDSS score between 6 and 7.5 while the median EDSS score was 6.5. The people in both groups underwent a treatment session of one hour daily for five days per week, over a period of three weeks. Walking velocity, walking distance, stride length and knee-extensor strength were recorded, as well as clinical measures like activities of daily living and Extended Barthel Index were measured. T Findings indicated the feasibility of a robot-assisted gait training for PwMS, although the authors noted that a larger people were required for significant effect.

Caligari et al (2019) highlighted how scanning access-based on the patient's interaction with a sensor (or switch) that intercepts even a weak body movement was a valid communication aid. However, its use became limited with the progressive decline of residual movements. To overcome this problem, the authors designed a new sensor, the Lever Magnetic-spring Mechanical Switch (LeMMS), allowing repeated activation/release cycles requiring a very small activation force. The LeMMS was applied and validated in a group of 20 PwALS in an advanced stage of disease. All subjects were regular users of communication aids employing other sensors, but which they could no longer operate their sensors (different from LeMMS). Patients were assessed at baseline (t0) and after one (t1), 6 (t2) and 12 (t3) months. Assessment at t0 included administration of standardized clinical scales, the Click-Test-30 counting the maximum number of LeMMS activations in 30 s, and thumb/fingers strength assessment with the Kendall scale. The QUEST 2.0-Dev questionnaire was administered at t1. Some use-related information and the Click-Test-30 were collected at t1, t2 and t3. After one training session, all patients could operate the LeMMS with minimal residual movement of one finger. At t1, they used it on average 5.45 h/day. The mean score of the QUEST 2.0-Dev was 4.63, suggesting strong satisfaction with the LeMMS. Regarding Click-Test-30 scores, no significant difference was found between t0 and t1, but performance at t2 and t3 declined significantly ($p < 0.005$ vs. t0). At t3, 9/20 patients were still able to use

their communication aid. This new switch sensor can enable PwALS to use their communication aids for a prolonged time even in the advanced phase of disease. It is easy to use, reliable and cheap, thus representing an intermediate alternative to more sophisticated and costly devices.

Michael et al (2019) tested the feasibility and performance of an eye-controlled power wheelchair for amyotrophic lateral sclerosis (ALS) patients. In this prospective pilot study, participants drove the wheelchair three times around an indoor course. Was evaluated the time to complete the course; starting and stopping on command; turning 90, 135, and 180 degrees; time to backup; and obstacle negotiation. Following their use of the wheelchair, people filleda questionnaire to assess user experience. Twelve patients participated, and all were able to complete three trials without difficulty. Eight participants completed all of the individual tasks (e.g., turning, stopping,) without any errors. Overall performance ratings were high across all participants (4.6/5-excellent). Our eye-controlled power wheelchair prototype was feasible and has a very favorable user experience. This system had the potential to improve the mobility and independence of ALS patients, and other groups with motor impairments.

Puanhvuan et al (2017), pointed out how electronic wheelchairs were commonly used to improve mobility in people with disabilities. In severe cases, the user was unable to control the wheelchair by themselves because his/her motor functions were minimum. To restore mobility function, a brain-controlled wheelchair (BCW) would be a promising system that would allow the patient to control the wheelchair by their thoughts. P300 was a reliable brain electrical signal, a component of visual event-related potentials (ERPs), that could be used for interpreting user commands. This research aimed to propose a prototype BCW to allowed severe motor disabled patients to practically control a wheelchair for use in their home environment. The users were able to select from 9 possible destination commands in the automatic mode and from 4 directional commands (forward, backward, turn left and right) in the shared-control mode. These commands were selected via the designed P300 processing system. The wheelchair was steered to the desired location by the implemented navigation system. Safety of the user was ensured during wheelchair navigation due to the included obstacle detection and avoidance features. A combination of P300 and EOG was used as a hybrid BCW system. The user could fully operate the system such as enabling P300 detection system, mode shifting and stop/cancelation command by performing a different consecutive blink to generate eye blinking patterns. The results revealed that the prototype BCW could be operated in either of the proposed modes. With the new design of the LED-based P300 stimulator, the average accuracies of the P300 detection algorithm in the shared-control and automatic modes were 95.31 and 83.42% with 3.09 and 3.79 bits/min, respectively. The P300 classification error was acceptable, as the user could cancel an incorrect

command by blinking 2 times. Moreover, the proposed navigation system had a flexible design that could be interfaced with other assistive technologies. This research developed 3 alternative input modules: (a) an eye tracker module, (b)chin, and (c) hand controller modules. The user could select the most suitable assistive technology based on his/her level of disability. Other existing assistive technologies could also be connected to the proposed system in the future using the same protocol.

Subhadra et al. (2007) sought to qualitatively examine the older EPIOC users' satisfaction with the chair and service providers. Eight women and nine men aged between 60 and 81 (mean 69) years were recruited through a specialist wheelchair service database. All had severe mobility disabilities. Analysis was performed using a qualitative framework approach. Participants reported a variety of EPIOC uses, including shopping and some social contact. Moderate satisfaction with the chair was reported. Use was compromised by indoor and outdoor environmental barriers; and the chair not meeting users' needs. Accidents were rare, but many users still experienced insecurity in the chair. High levels of satisfaction with the service were reported, although concern was expressed over length of waiting times. EPIOCs proved useful to most older people with disabilities. However, even those who were satisfied reported only moderate use of the chair outdoors. Service providers should be aware that older EPIOC users may require extra support and the provision of timely adjustments to increase chair use.

Sun et al. (2018), planned a static balance assessment measuring the postural sway by using lightweight inertial sensors and accurately measuring sway metrics like sway area, sway path length, root mean square (RMS) sway amplitude along the anterior-posterior and medial-lateral axis, mean velocity and jerk (an indicator of the smoothness of postural sway). Postural sway referred to the horizontal movement around the center of gravity of the human body. The balance assessment consisted of two 30 s quiet standing trials in three different conditions: eyes open on a firm surface, eyes closed on a firm surface, and eyes open on a foam surface. Statistical analysis of sway metrics from BioStamp inertial sensors showed a strong correlation with MTx sensor data and its capability to distinguish PwMS from healthy subjects. This study considered PwMs with mild MS who had EDSS score between 2 and 4 and severe MS with EDSS score ^{3}6.

DISCUSSION

This review demonstrated the validity, suitability, and effectiveness of using AT-based programs for persons with ALS to enable self-determined pleasurable stimuli and increase their independence by addressing problems in locomotion, communication, daily activities and to facilitate the continuous monitoring of the disease even at

Table 1. Reviewed studies arranged in alphabetic order

Authors	N° Participants	Groups	Outcomes
Alborè et al (2013)	1	Locomotion	Positive
Beer et al. (2008)	35	Locomotion	Positive
Caligari et al. (2019)	20	Locomotion	Positive
Carpinella et al. (2012)	22	Daily Activities	72,7% Positive
Chung-Min et al. (2020)	8	Communication	Positive
Donativi et al. (2019)	12	Communication	Positive
Kathner et al. (2015)	1	Communication	Positive
Kathner et al. (2017)	6	Daily Activities	Positive
Laffont et al. (2007)	24	Communication	41,6% Positive
Lancioni et al. (2012)	2	Communication	Positive
Lancioni et al. (2014)	2	Daily Activities	Positive
Lievesley et al. (2011)	15	Daily Activities	Positive
Londral et al. (2018)	8	Valutation	Positive
Michael et al (2019)	12	Locomotion	Positive
Pandarinath et al. (2016)	3	Communication	Positive
Puanhvuan et al. (2017)	4	Locomotion	Positive
Rudig Keit & Marian (2020)	7	Daily Activities	Positive
Schettini et al. (2015)	8	Daily Activities	Positive
Soriani et al. (2017)	20	Communication	Positive
Subhara et al. (2007)	17	Locomotion	Positive
Sun et al (2018)	15	Locomotion	Positive
Wilson et al. (2012)	1	Communication	Positive

a distance. Whenever available, social validation procedures, preference checks, maintenance or follow-up phases confirmed social and clinical validities of the adopted programs, which were consolidated over the time. Essentially, AT-based programs functionally filled the existing gap between the individual skills and the environmental requests. Individuals with ALS and multiple disabilities will be ensured with an independent access to positive stimulation. A beneficial coping will be outlined with positive outcomes on the participants' quality of life (Amoako & Hare, 2020). The findings suggested the following considerations.

First, communication skills were promoted through the use of technological equipment, fostering social interactions and enhancing participants' constructive engagement. Consequently, caregivers' burden was reduced. The positive participation to social life was additionally consolidate. BCI, are indispensable in the end to allow

people with ALS to interact both with people close to it and with people who are not in the same environment. Individuals with progressive neuromuscular disease often develop complex communication needs and consequently find that interaction using their natural speech may not sufficiently meet their daily needs. Increasingly, assistive technology advances provide accommodations for and/or access to communication. Although research evaluating the use of AAC across all neuromuscular disease is severely lacking, studies in ALS suggest that use of an AAC is generally well accepted and improves quality of life. AAC systems continue to be designed and implemented to provide targeted assistance based on an individual's changing needs. Advanced technologies using BCI are becoming more readily available and have the potential to extend access to communication to even the most severely disabled patient with neuromuscular disease (Ball, Fager, & Oken, 2012).

Second, AT-based interventions may be viewed as great educational, psychological, and rehabilitative resources. In fact, they prevent isolation, withdrawal, and passivity. The AT-based programs were helpful for promoting the independence and an active role of the participants involved in the selected studies. Furthermore, their challenging behaviors were relevantly reduced. One may argue that the AT-based strategies may have beneficial effects on the participants' quality of life (Span et al., 2018; Zellefrow et al., 2017). Daily activities are easy to perform thanks to the implementation of programs based on AT, integrating equipment capable of improving autonomy in the performance of simple daily activities (Gobeil et al., 2019). The type of loaned device and diagnosis can act as a possible moderator for the positive impact of AT on the lives of people with rare neurodegenerative diseases. These aspects have to be taken into account in the process of prescription to get the maximum benefit and utility for the affected person and his/her family. The results of the research noted the importance of assessing the needs, demands, and contexts of people with rare neurodegenerative diseases to prescribe the best AT and to get a high and positive impact of the device on the life of the user (Pousada et al., 2021).

Third, AT is also important in the medical field, in order to be able to keep under constant control the degeneration of the disease in cases where the movement of people with ALS is impossible. Early involvement of palliative care as part of the multidisciplinary team ensures an integrated approach across the spectrum of the illness that includes multimodal symptom management, advanced planning of end-of-life care, and timely utilization of hospice. Patients with advanced disease and their caregivers face increasing physical, financial, and emotional demands. Adequate social support is associated with reduced burden and continued engagement with the multidisciplinary team assists patients and their caregivers in coping with worsening functional status. Home visits and telemedicine visits reduce the need for logistically difficult trips to the ALS clinic. The main focus of palliative care for people with advanced ALS is proactive management of symptoms such as pain and shortness of

breath, which can be effectively managed with a variety of medications including opioids and benzodiazepines, coordination of home care services, and caregiver support (Paganoni, Karam, Joyce, Bedlack, & Carter, 2015).

Finally, locomotion aspects. The AT for assistive mobility refers to a wide range of assistive interventions designed to maintain, facilitate and improve independent mobility, including manual and powered wheelchairs, electric scooters, crutches, walking sticks, walking frames, adapted shoes and vegetable gardens, pliers and prosthetics. Although there are many other forms of mobility enhancement interventions, including physical and occupational therapy and surgeries such as arthroplasty, assistive mobility technology interventions are some of the most commonly used approaches to improve and facilitate mobility for people with long-term motor disabilities.

CONCLUSION

Assistive technologies provide people with ALS with the ability to self-determine their favourite stimuli and increase their independence by avoiding social isolation. Various categories of assistive technologies have been examined to help and manage some of the symptoms of ALS.

The current chapter identified fourth different groups of studies (communication, daily activities, diagnosis and locomotion) for patients with ALS. In this systematic review it was found that few studies focused on AT for diagnosis and day-to-day activities. The synoptic picture of AT for patients with ALS is very limited. New technological and sophisticated options should be designed and implemented to meet both human expertise and financial resources. Both qualitative and quantitative analyses should be considered in the future

FUTURE RESEARCH

In the light of the above, future research should extend the number of samples examined in empirical contributions, include additional technological and individualised solutions to meet more complex needs of the participants involved by considering (where possible) more sophisticated targeted behaviors. Whenever available, virtual reality technologies (e. g., serious games) could be used. Wearable technologies focused on promoting locomotion, posture, and gait might additionally be adopted. Telerehabilitation should be widely implemented to allow patients to remain in a highly comfortable and safe environment. Communication with distant partners could

also have a positive impact on people with RTT, who could easily communicate in the Covid-19 pandemic era.

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KEY TERMS AND DEFINITIONS

Amyotrophic Lateral Sclerosis: Amyotrophic lateral sclerosis is a rapidly progressing neurodegenerative disease that (a) typically strikes people between 40 and 60 years of age and (b) causes muscle atrophy, spasticity, dysarthria (anarthria), and respiratory problems (failure), and, eventually, death.

Assistive Technologies: Assistive Technology (AT) is a technology that includes assistive, adaptive and rehabilitation devices for people with disabilities, including the process used in the selection, detection and use of them. Assistive technology promotes greater independence by allowing people to perform tasks that they were previously unable to accomplish, or who had great difficulty in accomplishing, by providing improvements or by changing the methods of interaction with the technology needed to perform those tasks. Assistive technology products are designed to provide additional accessibility to people with physical or cognitive difficulties, impairments, and disabilities.

Positive Participation: In order to participate a person needs to be an active part of their own life, being able to decide how and what type of activity they wish to participate in and to be given the opportunity to take part in desired activities. Participation can be considered part of a healthy life and thus as a human right. Participation is important for optimal development and learning.

Quality of Life: Complex psychological construct which includes pleasure, satisfaction, fulfilment, well-being, and happiness.

Chapter 5
Non-Invasive Technologies in Neurorehabilitation:
Novel Neurorehabilitative Treatments for Motor and Cognitive Disorders

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ABSTRACT

Neurological disorders are one of the most common causes of motor/cognitive impairments leading to adult disability. Neurorehabilitation is defined as a complex rehabilitation process directed to recovery from a nervous system injury, and to minimize or compensate the associated functional limitations. The frequent incomplete recovery of the neurological patients induces to the introduction of novel neurorehabilitative treatments, tailored to the patients, targeting the specific motor or cognitive disorders. The aim of this chapter is to bring together the latest findings on new technologies including virtual reality across the multiple research fields of rehabilitation in neurological disorders, mapping key developments and innovations such as telerehabilitation systems.

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INTRODUCTION

Neurological diseases account for a wide and expanding health burden around the world: among them, dementias like Alzheimer's disease, headache (migraine and tension-type headache), epilepsy, multiple sclerosis, brain cancer, Parkinson's disease, motor neuron diseases, neuroinfectious diseases, and stroke (Whiteford et al., 2015). The most recent estimates, nowadays, come from the Global Burden of Disease Study 2017 showing that neurological illnesses are the third most common cause of disability and premature death, after cardiovascular diseases and cancers, within the EU, and their predominance and burden will likely increment with age growing of the European population (Bikbov et al., 2020). Particularly, neurological disorders caused 41.1 million deaths and 21.0 million of disability-adjusted life years (DALYs). Specifically, stroke, dementias, and headache accounted for the three commonest causes of DALYs in the EU (Deuschl et al., 2020). Moreover, this burden is higher through men than in women, with a peak between 80–84 years (Deuschl et al., 2020). The increase in the absolute numbers of people—including incident and prevalent cases—who died or remained disabled from non-communicable neurological disorders suggests that the advances in prevention and management of these disorders have not been sufficiently effective to counterbalance ongoing population growth and ageing. In this regard, the proposed advances in the management of neurological disorders are not keeping up with the increasing burden of neurological disorders. From a public health point of view, this is upsetting because people with neurological disorders require adequate and accurate care in both hospital and community settings, although currently health-care resources are still limited. Besides dramatically affecting health and wellbeing, neurological disorders cause a negative balance even in countries with best economies. In fact, the European Brain Council proposed the Value of Treatment for Brain Disorders Project, focusing on the benefits of improving healthcare, the identification of possible treatment gaps in the patients care system, and associated cost savings (Di Luca et al., 2019). Given the limited resources and competing health issues all policy makers are facing around the globe, coordinated advocacy efforts are required at the individual, institutional, local, and national government levels, with support from relevant non-governmental and patient organizations (Di Luca et al., 2019). Such efforts should encourage prioritization and promote the funding and implementation of strategies to reduce the burden of neurological disorders. Overall, this data underlies the necessity to provide early, effective and efficient interventions to prevent both health and economic burden.

Neurorehabilitation is defined as a complex medical process directed to aid recovery from a nervous system injury, and to minimize or compensate for the associated functional limitations. According to this, scientific evidence has demonstrated the

capacity of the central nervous system to structurally and functionally adapt in response to an event or experience (Albert & Kesselring, 2012). Neurorehabilitation aims to develop neurobiologically informed therapies that tackle the key behavioral and neural signals to drive neural plasticity. Patients with neurological disorders can simultaneously present different impairments of the nervous system including both motor and cognitive disorders (Albert & Kesselring, 2012). The clinical evaluation and recovery of patients with neurological disorders is complex and requires the development of new techniques to support these processes. The growing interest in the development of new technologies has therefore led to the introduction of different technological devices, aimed at enhancing clinical assessment and improving the clinical outcomes of conventional clinical intervention strategies (Semprini et al., 2018). As such, the development of virtual reality systems alone or in combination with robotic systems has been increasingly applied for the assessment and rehabilitation of neurological disease. A wide range of researchers in the field of rehabilitation sciences, neuroscience, and medical sciences has focused on the application of such new technologies in neurorehabilitation, revealing promising results. Particularly, the use of non-invasive brain stimulation technologies such as transcranial direct current stimulation (TDCS), transcranial magnetic stimulation (TMS), and functional electrostimulation can be combined with robotic assisted trainings and virtual reality to modulate brain excitability and neuroplasticity processes during the rehabilitation process, potentiating the outcomes in patients with neurological disorders (Miniussi et al., 2008). Recent investigations have found that patients with neurological disorders present severe motor disabilities in controlling their brain signals during training in which they were asked to control these signals, while improving computing capabilities. Such non-invasive electroencephalogram-based brain-computer interface systems being used for neurorehabilitation purposes improve the quality of life of patients presenting critical neurological disorders (Cantillo-Negrete et al., 2018). Currently, there are different technological solutions aiming at improving the different clinical outcomes and the quality of life of patients with neurological disorders, allowing a better interaction with their life events and relationships. Therefore, the application of different non-invasive technologies for rehabilitation alone or in combination with conventional rehabilitation therapies may pave the way to more holistic rehabilitation programs in these patients which present multisensory deficits.

The aim of this book chapter is thus to bring together the latest findings on new technologies and virtual reality (VR) across the multiple research fields of rehabilitation in neurological disorders, mapping key developments and innovations as well as highlighting future directions. Further, this chapter aims at advancing the current knowledge and expertise in the application of new robotic technologies,

brain computer interfaces, and virtual reality systems for the treatment of motor and cognitive disorders in patients with neurodegenerative diseases.

BACKGROUND

From the beginning of the year 2000, the neurological care has experienced a shift from the assumption that the effect of a brain injury on function, participation, and activity is permanent to the aware of the regenerative potential of the brain, and its dynamic reorganization potential even after months (A. M. Barrett et al., 2013). Neurorehabilitation is defined as the neurological care supported by scientists as an emerging intellectual paradigm based on neural regeneration, repair, and dynamic reorganization of functional neural systems (Barrett et al., 2013). Neurorehabilitation science aims to define the best conditions to promote an optimal brain recovery, through a controlled and intensive stimulation of the impaired brain networks (Barrett & Gonzalez Rothi, 2006). Then, neurorehabilitation relies on the principles of neuroplasticity (Albert & Kesselring, 2012; Kesselring, 2001). In this regard, from the paradigm introduced by Ramon y Cajal at 1928 where he postulated that nerve paths in the adult brain are fixed and immutable (Ramón Y Cajal et al., 2012), a paradigm shift has been taken demonstrating that therapeutic exercises can influence the spontaneous recovery of the brain injury (Kesselring, 2001). Indeed, the term 'neural plasticity', introduced by Hebb in 1949 (Attneave et al., 1950), refers to the briefly achieved functional changes in the context of learning and recovery (Møller, 2006). Further, neural plasticity refers also to the plastic changes in the nervous system occurring in four different ways: (1) including functional changes in synaptic efficacy; (2) modifying protein synthesis and proteinase activity in nerve cells; (3) through the creation of new anatomical connections or by altering synapses morphologically; and (4) by specific apoptosis (Møller, 2006).

Neurorehabilitation is a complex treatment process aimed at restoring and minimizing the functional deficits that have arisen in the patient because of an injury to the central nervous system. From a neurological point of view, it has been shown that the function of each brain region cannot be understood as isolated, but as a conjunction with other brain regions with which it interacts at rest as well as in active behavior, in such a way forming neural networks (He et al., 2007). According to this, early neurologists suggested that after a neural damage, neurological deficits do not only affect the local area but also the secondary structures (Andral, 1843). The neurological deficits normally correlate with behavioral deficits which do not only reflect structural damage to a specific part of a network but also after a neural injury there are functional imbalances all through the network as well as in other connected networks (He et al., 2007). Hence, the main goal of neurological rehabilitation is to

restore the neural networks to a normal state or in some cases, enable a new state in which the affected function could be performed through compensatory strategies (He et al., 2007). Currently, neurorehabilitation is considered a multidisciplinary and multimodal service for the recovery of the physiological functioning, physical activity and the participation in daily life situations by creating learning situations (Albert & Kesselring, 2012). In neurorehabilitation the early initiation of the treatment, high intensity therapies with specific and active goals, and coordinated work and the multimodality of a specialized team are crucial aspects (Duncan et al., 2005).

Disorders of cognitive and motor functions are frequent following neurological damage of different etiology, with a significant impact on independence, social relationships, school attendance and employment opportunities, ultimately leading to reduced quality of life. Hence, cognitive and motor impairments are critical determinants of overall neurorehabilitation outcome, which is a growing clinical and research field. Neurorehabilitation encompasses a wide range of interventions to achieve functional changes by reinforcing, strengthening or re-establishing previously learned patterns of behavior or establishing new patterns of activity or mechanisms to compensate for impaired neurological systems (Wilson, 2008).

In particular, cognitive interventions are non-pharmacological therapies that have long been used to target cognition in a range of neurological disorders, including acquired damages and age-related cognitive decline (Pieramico et al., 2014). The Cognitive Rehabilitation Task Force (CRTF) of the American Congress of Rehabilitation Medicine, Brain Injury Special Interest Group has recently published a systematic review of studies addressing cognitive rehabilitation for people with two of the most frequent clinical conditions, namely stroke and traumatic brain injury (TBI) (K D Cicerone et al., 2019). The Authors evaluated 491 articles and made 29 recommendations for evidence-based practice of cognitive rehabilitation, that support (1) attention deficits after TBI or stroke; (2) visual scanning for neglect after right-hemisphere stroke; (3) compensatory strategies for mild memory deficits; (4) language deficits after left-hemisphere stroke; (5) social-communication deficits after TBI; (6) metacognitive strategy training for deficits in executive functioning; and (7) comprehensive-holistic neuropsychological rehabilitation to reduce cognitive and functional disability after TBI or stroke (Cicerone et al., 2019). In general, these recommendations are applicable to a wide range of cognitive deficits including those of neurodegenerative nature. To be effective, cognitive rehabilitation should be intensive and prolonged over time, but personal and external events that should reduce access to care facilities hamper intensive and prolonged cognitive rehabilitation, unless current protocols are modified. Motor rehabilitation strongly relies on physical and occupational therapy sessions, which are primarily based on one-to-one interactions with healthcare practitioners either during an inpatient hospital stay (mostly during the acute to sub-acute phase) or as part of regular visits

to specialized outpatient institutions (mostly during the sub-acute to chronic phase). These cognitive and motor interventions are based on psychological theories and models of behavior and behavioral change, and on neuropsychological models of brain-behavior interactions (Cappa et al., 2005; Cicerone et al., 2000) and can be conducted with paper-and-pencil tools, computer programs or, more recently, VR.

Today, medical advances in neurorehabilitation have increased the number of survivors from neurological disorders, increasing the number of people receiving neurological rehabilitation (Warraich & Kleim, 2010). According to the aforementioned literature, neurological rehabilitation is a complex and intensive process that needs a multidisciplinary rehabilitation team, which entails high costs that further increase as the number of neurological surviving patients rise (Iosa et al., 2019). In this regard, the introduction of new technologies in the field of neurorehabilitation allowed the creation of more effective and patient-tailored rehabilitative approaches to maximize the functional outcome of neurological injuries as well as patients' quality of life (Semprini et al., 2018). Within the last few years, neurorehabilitation has moved from a 'bottom-up' to a 'top down' approach encouraging the development of technological devices for motor and cognitive rehabilitation (Morone et al., 2019). Top-down approaches in neurorehabilitation involve both motor and cognitive systems in which patients have an active role in their own rehabilitation process (Morone et al., 2019). According to this, an increasing number of new technologies have been developed with the aim of fostering the effectiveness of rehabilitation strategies. In detail, the introduction of non-invasive technologies such as the use of computer-based interventions, TMS, tDCS, VR systems, robotic devices, and BCI systems are crucial for inducing greater neuroplasticity changes, fostering both motor and cognitive improvements in patients with neurological disorders.

The following section aims to describe some of the latest findings, using the above commented non-invasive technologies directed to improve motor and cognitive deficits in patients with neurological disorders.

NON-INVASIVE TECHNOLOGIES FOR NEUROREHABILITATION

Computer-Based Interventions Motor and Cognitive

Currently, we are experiencing the emergence of an information society increasingly based on the production and exchange of information. In particular, new information and computer technologies (ICT's) are having an impact in the field of rehabilitation of cognitive and motor functions. Over the past twenty years, this progress in technology has provided clinicians with new opportunities for evaluation and treatment of motor and cognitive disorders, which were not available with traditional methods.

As regard cognitive impairment, ICT have kindled interest in alternative rehabilitative approaches. Computers are the most widely used technology to assist delivery of cognitive interventions in most cases with commercially available software or programs, and rarely with training programs developed for the specific study purpose. In particular, computer based cognitive training (CCT) allows to overcome the limits of traditional paper-and-pencil techniques, providing patient tailored interventions that can be easily delivered not only in person, but also remotely at patients' homes (Irazoki et al., 2020). With respect to traditional paper-and-pencil techniques, CCT provides real-time feedback, allows modulation of task complexity and response time during and across sessions, requires less exercise preparation (therefore saving therapists time), and allows the recording of all session parameters. All these advantages promote the application and popularization of CCT.

Overall, CCT has demonstrated promising beneficial effects on various domains of cognition with moderate to large effect sizes. Interestingly, these benefits were not limited to the trained task, but also in other non-trained tasks and other cognitive domains, suggesting a transferable beneficial effect (Ge et al., 2018). The effect of the same technology-based cognitive intervention seems to vary according to the level of cognitive decline and the same intervention should be tailored according to the degree of cognitive impairment. For instance, the use of CCT for improving attention and executive functions in acquired brain injury is supported by recent evidences (Bogdanova et al., 2016), which recommend to tailor the treatment according to severity of injury and chronicity. In the field of neurodegenerative diseases, participants without cognitive impairment seem to obtain a larger cognitive improvement from technology-based cognitive interventions than those with Mild Cognitive Impairment (MCI); whereas MCI seem to gain a larger cognitive benefit than those with Alzheimer's disease (AD) (Ge et al., 2018).

In the field of neurodegenerative diseases, some researchers have recently used a software tool for cognitive rehabilitation called "CoRe" (acronym for cognitive rehabilitation) (Alloni et al., 2017, 2018; Bernini et al., 2019, 2020; Quaglini et al., 2019; Rodella et al., 2021). CoRe is an adaptive CCT program for individual face-to-face sessions between patient and therapist. In a previous study (Alloni et al., 2017, 2018), it has been preliminarily tested for its usability and safety as a clinical tool in dementia-related disorders with a view to optimizing it and making it easier for patients to use. In another study (Bernini et al., 2019), the authors demonstrated its effectiveness in single-domain training targeting logical-executive functions in MCI inpatients. Furthermore, considering the importance of multi-domain interventions, designed to produce broader effects across different cognitive domains, the authors adopted an extended version of CoRe (Bernini et al., 2021, Rodella et al., 2021). The new version is a patient-tailored, multi-domain cognitive training tool targeting logical-executive functions, attention/processing speed, working memory, and

episodic memory. Results showed positive effects of CCT compared with the same stimulation activities delivered using a traditional paper-and-pencil approach, and with an active control group.

As motor disabilities, ICT mostly focused on digital technologies and biofeedback. Digital training is an evidence-based intervention using high-quality software, with the sole purpose of treatment. The need for digital training and solutions is gradually increasing in the clinical field, given the high demands of quality outcomes in the healthcare system (Choi et al., 2019). Here the rehabilitation process focuses on muscle strengthening, walking and balance training, arm movement training, and fine movement training. For instance, the use of gait-training software enables the early verticalization of patients and is more effective when compared with physiotherapist trainings alone in terms of improving the motor function and increasing patient adherence to and enjoyment of exercise, although it does not replace the physiotherapist (Knecht et al., 2011). The biofeedback is instead a well-established technique in physical rehabilitation, which aims to improve treatment outcomes by educating and engaging patients (Fernando & Basmajian, 1978). It involves providing an individual with additional information (feedback) on a physiological parameter, allowing the individual to influence the physiological parameter based on this feedback (Frank et al., 2010; Huang et al., 2006). In this field, a digital biofeedback system (DBS) consists of an input sensor, a data-processing system, and an output device, which displays the feedback. DBSs have been shown to effectively improve motor learning, engagement with and adherence to rehabilitation in patients with musculoskeletal, neurological and orthopedic diseases (Giggins et al., 2013; Huang et al., 2006; Storberget et al., 2017).

Since daily habits are amongst the modifiable factors contributing to the outcome of the neurorehabilitation process, recent attention has been strongly drawn on lifestyle habits. The adoption of appropriate practices alongside cognitive/motor rehabilitation and enhancement activities can indeed activate brain compensation mechanisms to tackle the physiological and pathological neuro-degeneration processes. Hence, attention has recently focused on the combination of cognitive and motor training, which may provide additional benefits that go beyond cognitive or motor training alone. Combined training appears to complement the advantages of different types of training that may produce additive effects and lead to better outcomes compared with a single type of training (Reinkensmeyer & Boninger, 2012). In the current literature there are many evidences about the combination of cognitive and motor training by using traditional approaches (Lauenroth et al., 2016; Pichierri et al., 2011). Recently, there is a growing interest in these combined interventions administered via ICT, such as digital solutions and mobile app (McCaskey et al., 2018; Tacchino et al., 2020).

TMS and tDCS in Neurorehabilitation

Progresses in cognitive neuroscience are linked not only with the development of sophisticated neuroimaging techniques, but also with the emergence of novel brain stimulation techniques. These techniques allow functionally intervening on the central nervous system plasticity, in different ways, depending on how the brain is stimulated. Among these techniques, there are either noninvasive brain techniques (NIBS), such as Transcranial Magnetic Stimulation (TMS) and Transcranial Direct-Current Stimulation (tDCS). These methods have been increasingly accompanying other therapies such as neurorehabilitation, pharmacology, or psychotherapy. Most NIBS are based on the delivery of electric current on the brain tissue at the peripheral or central level. The efficacy or adverse reactions depend on the adaptive response of the brain to the electric stimulation (Higgins & George, 2020). This section aims to describe two of the most NIBS used in clinical and experimental neurorehabilitaion contexts: TMS and TDCS.

From one side, TMS can modulate the neural activity, enhancing or decreasing the cortical excitability. It consists of a coil that delivers an electric field in the brain (Rossi et al., 2009) and its effects depend on intensity, frequency, number of pulses delivered, type of coil employed, and location of the stimulation (Diana et al., 2017). Based on the number of pulses, TMS can be distinguished between single-pulse TMS, in which one stimulus at a time is applied or paired-pulse TMS in which pairs of stimuli separated are applied. At last, repetitive TMS (rTMS) delivers pulses in trains (Pascual-Leone et al., 2000). Single-pulse TMS has a higher temporal resolution which allows one to measure the specific time frame in which an area takes part in a cognitive process or to study the temporal sequence in which different areas take part in a cognitive, motor or perceptual event. Particularly, when the pulses are delivered with more than 1 Hz (high-frequency), the stimulation increases the cortical excitability, in contrast, when are delivered with less than 1 Hz (low-frequency) TMS inhibits the targeted region (Fitzgerald et al., 2006; Rossi et al., 2009). The stimulation can reach 2-3cm in depth: the more the distance from the coil increases, the more the effect of the stimulation decreases. Therefore, TMS can reach only the superficial areas and not the deep structures like the thalamus or basal ganglia. TMS can be used for assessing and measuring functional and temporal cortical parameters such as brain connectivity, cortical excitability and transcallosal transmission of information; studying cerebral maps underpinning sensorimotor systems and cognitive functions; modulating neural plasticity to boost psychiatric and neurological pathologies' treatments. Again, by stimulating the visual cortex, flash of light can appear (phosphenes) or interferences in linguistic tasks when stimulating the frontal area. rTMS has been revealing a non-invasive potential technique for the treatment of psychiatric and neurological diseases (Sanches et al., 2021). rTMS could

prevent motor cortex reorganization following a limb disuse (Ricci et al., 2008) but also have potential for cognitive and motor disorders after a stroke.

From another side, tDCS is another non-invasive brain technique consisting in delivering a continuous electric current with low intensity (1-2 mA), for a period of 2-30 minutes. This stimulation, although not perceptible and with low intensity, is able to modulate the discharging frequency of neurons, even after the period of stimulation. This makes tDCS particularly important and suitable for those pathologies characterized by focal alterations of the cortical excitability. It is composed of a cathode and anode that are placed in different positions of the scalp depending on the stimulation area. The anode (negative) is the place in which the electrodes reach the brain whether the cathode (positive) is the place through which the electricity leaves the brain (Nitsche & Paulus, 2000). The stimulation depends on the size of the electrodes and the distance between anode and cathode. Anodal stimulation raises the resting membrane potential towards the firing threshold in neurons, making neural cells more likely to depolarize when they receive an action potential via presynaptic inputs. Cathodal stimulation, on the other hand, tends to hyperpolarize neurons' resting membrane potentials, lowering their chances of triggering an action potential (Nitsche et al., 2005; Radman et al., 2009; Rahman et al., 2013). The use of rTMS and tDCS to improve brain function is currently revolving around two primary strategies: (1) to promote cortical excitability in areas of interest hosting specific cognitive tasks and/or (2) to inhibit networks in damage-free brain areas that interfere with performance under normal settings (Liebetanz et al., 2002; Luber & Lisanby, 2014).

The application of NIBS has reached widespread attention in neurodegenerative diseases' field. In this regard, five meta-analyses have evaluated the effectiveness of high frequency rTMS in cognitive impairment (Chou et al., 2020; Dong et al., 2018; Lin et al., 2019; X. Wang et al., 2020) and tDCS (Cai et al., 2019), showing a statistically significant cognitive improvement. However, there is no convincing evidence that these therapies can address the physiopathological root of Alzheimer's disease and eventually stop progression. For a complete review of TMS/tDCS application in neurodegenerative diseases see Sanches et al., 2021. Moreover, the use of repetitive TMS has been shown to be both safe and effective to alleviate motor problems, aphasia, dysarthria, oropharyngeal dysphagia, depression, and perceptual-cognitive deficiencies in patients with stroke (Fisicaro et al., 2019; León Ruiz et al., 2018). According to this, a recent metanalysis form Bai and colleagues (2019) revealed that tDCS led to significant effects in upper limb function in post-stroke patients but also short-term improvement of gait and balance in some neurological disorders such as stroke and Parkinson's Disease (Ghosh, 2019). The effectiveness of NIBS techniques in motor rehabilitation outcomes could be related to either a directly enhancement of motor cortical excitability of the stroke-affected hemisphere

using ipsilesional cortical stimulation and reduction of inter-hemispheric inhibition from the intact to the affected hemisphere by stimulating the hemisphere contralateral to stroke lesion (L. Wang et al., 2010).

VR Technologies in Neurorehabilitation

Over recent decades, many researchers and clinicians have started using VR to implement innovative rehabilitation treatments in cognitive and motor domains. VR can be described as "an advanced form of human–computer interface that allows the user to interact with and become immersed in a computer-generated environment in a naturalistic fashion" (Schultheis & Rizzo, 2001) (*p*. 82). According to this, crucial components related to the use and implementation of VR in rehabilitation are immersion and presence (Riva et al., 2003; Slater, 2018). Immersion defines the degree to which the user is isolated from the real world when interacting with digital environments. Non-immersive environments are usually displayed on a computer screen, and users interact with virtual objects with a keyboard and mouse. Fully immersive systems completely immerse users within the simulated world thanks to head-mounted displays (HMDs) – which, through advanced head and motion tracking, enable complete correspondence between a user's movements and real-time changes in virtual environments – or the use of CAVE, a four-walled room that projects the virtual environment and covers the user's entire field of vision (Riva et al., 2020). From a psychological perspective, the added value of VR over other synthetic experiences is the feeling of presence, i.e., the sensation of actually "being there" inside the digitally-created environment (Slater, 2018). This feeling of presence can be an incredible instrument for assessing and treating neurological disorders because individuals act in a digital world as if it were real, thus living meaningful experiences. One of the main features of immersive VR is that individuals can be embodied in a virtual body and experience the movements of a virtual avatar synchronized with their real body, form a first-person perspective (Maselli & Slater, 2013; Riva et al., 2020). This generates a feeling of ownership and enhances the feeling of presence in the virtual body, which produces measurable motor, physiological and cognitive reactions in the real body (Burin et al., 2020; Matamala-Gomez et al., 2020). For example, experiencing an avatar doing aerobic exercise, even without actual movement, has beneficial consequences on cognitive components and their neural substrates, and being immersed in the body of a genius, such as Albert Einstein, can improve cognitive task performance (Banakou et al., 2018).

Currently, VR offers several benefits in the neurorehabilitation process. VR is better able to simulate functional tasks compared to traditional therapies (Kwakkel et al., 2004; Merians et al., 2002; Olivia Realdon et al., 2019), and within a controlled, safe and ecologically valid setting (Perez-Marcos, 2018). Moreover, VR systems

provide total control of many aspects of the rehabilitation process, such as presenting hierarchical and repetitive stimuli or multisensory and continuous feedback, and can thus personalize therapeutic exercises according to patients' needs (Larson et al., 2014; O'Neil et al., 2018). This controlled system allows therapists to assess in real time patients' performance and improvements during sessions (Bohil et al., 2011). VR offers a fun and interesting experience that usually includes different gaming elements, such as exploration or challenges, which engages and motivates patients (Giuseppe Riva et al., 2020). By providing repetitive, multimodal and hierarchical stimuli as well as more naturalistic behaviors and environments typical of daily activities, VR is an approach that encompasses both restorative and compensatory strategies (Tieri et al., 2018).

Several benefits have been widely reported in relation to motor function. VR-based intervention has been associated with an improvement in balance and gait (Held et al., 2018; Verma et al., 2017), neuromotor monitoring of recovery (Steinisch et al., 2013), strength fitness (Lotan et al., 2009), skills (Monteiro et al., 2017), shoulder movement and spasticity (Simkins et al., 2016), and participation in both domestic and community environments. Moreover, it has been shown that it is possible to exploit the induction of virtual body ownership illusions for motor rehabilitation (Matamala-Gomez et al., 2020; Pyasik & Pia, 2021), and for improving mental health (Matamala-Gomez, Maselli, et al., 2021). Regarding psychological and cognitive benefits, several studies found that VR-based neurorehabilitation improved attention and memory and decreased depression symptomatology in elderly participants (Massetti et al., 2018), even several years after stroke. Specifically, a recent systematic review (Giuseppe Riva et al., 2020) showed the efficacy of VR for the rehabilitation of executive functions and visuospatial abilities, particularly for both acute and neurodegenerative conditions. VR-based intervention enhanced cognitive flexibility, inhibition and working memory in patients with traumatic brain injury (TBI), mild cognitive impairment (MCI) and Parkinson's (PD). Visuospatial abilities improved after VR interventions in post-stroke patients and in patients with PD and TBI. VR-based interventions are capable of enhancing memory abilities, particularly verbal memory, in post-stroke and PD patients. VR is also a promising tool for rehabilitating the attention domain, specifically for post-stroke and PD patients, and the language domain in PD patients (Maggio et al., 2018).

There are several explanations for these positive outcomes. The repeated performance required by VR neurorehabilitation – usually consisting of patients physically interacting with the virtual environment and performing repetitive tasks with hierarchical differences in complexity – could improve patients' knowledge about the results and quality of their movements, impact cognitive outcome (Maggio et al., 2019), release the neurotransmitters choline and neurotrophic factor (Cho & Lee, 2019; Giuseppe Riva et al., 2020) and enhance blood flow, with positive effects

on cerebral metabolism (Liao et al., 2020). These changes could promote cerebral modifications, reorganizations and neuroplasticity (Maggio et al., 2018; Russo et al., 2017). Furthermore, VR-based rehabilitation can activate the mirror neuron network when patients observe their shadows performing the same movements. Activation of mirror neurons can enhance cognitive and motor recovery, which could increase patients' awareness of the movement, self-identification and recognition, with positive effects on cognitive and functional outcomes (Ainley et al., 2012; Ouhnana & Kingdom, 2016). Therefore, VR could be an effective tool to motivate patients during rehabilitation sessions (Trombetta et al., 2017), to improve spatial orientation and attention in daily life activities (Fordell et al., 2016), and to improve pain relief scores and emotional aspects related to functionality. VR provides safe and engaging multidimensional rehabilitation not offered by traditional paper-and-pencil cognitive programs, either alone or combined with physical training. Furthermore, VR-based rehabilitation provides multitasking possibilities, personalized training, and increased patient adherence and motivation, often at a lower cost than traditional methodologies (Massetti et al., 2018).

Robotics in Neurorehabilitation

In the field of neurorehabilitation robot devices have been mainly developed to support the physical rehabilitation routines for upper or lower limbs, for fostering a neuro-motor recovery (Semprini et al., 2018), but also to enhance the disability reduction, to improve the physical and cognitive activity, and to maximize the social acceptance and the participation of the patients (Parre & Sujatha, 2021). From a clinical point of view, a robotic device is a perfect rehabilitation tool for providing intensive, repetitive, and goal-oriented treatments (Duret et al., 2019; Masiero et al., 2014). In this regard, it has been shown that rehabilitation trainings focusing on these three elements are effective improving motor function and recovery (Langhorne et al., 2009). However, the simple application of these devices for providing repetitive training therapies does not exploit their full therapeutic potential, as they have been described as 'assisted therapy' where the robot is the active and the user is the passive (Turner et al., 2013). Further, robot-assisted rehabilitation is often accompanied of different environments (real or VR-based), variability on the task difficulty (variable or fixed), and the possibility of adapting kinematic and force parameters to the treatment (Gandolfi et al., 2021).

In a recent scoping review recently conducted by Gandolfi and colleagues (2021), the authors found 164 studies using robotic devices for walking and balance rehabilitation, and 99 studies for upper-limb rehabilitation. In both cases, most of the studies were randomized control trials (63% and 53% respectively). Interestingly, most of the analyzed studies were conducted in patients with stroke (169 studies), with

spinal cord injuries (56 studies), and multiple sclerosis (21 studies) (see Gandolfi et al., 2021 for detailed information about the studies). Another systematic comparison of different approaches for both upper and lower limb rehabilitation suggested that robot-device training is one of the most effective techniques in motor rehabilitation (Langhorne et al., 2009). Indeed, through robotic-assisted therapy it is possible the precise sensorimotor performance feedback during exercise in terms of movements kinematics and exchanged forces (Semprini et al., 2018). Current rehabilitation devices automatically adapt task difficulty and assistance modalities to the performance ability of each subject (Marchal-Crespo & Reinkensmeyer, 2009). Nevertheless, one of the main limitations when using robot-assisted therapy is that the improvement is only limited to the specific body regions involved in training and this can represent a limitation when dealing with patients with multiple affected body areas because of their neurological condition. Moreover, the substitution of the physical contact with the patients when using robotic devices, which requires minimal human intervention, may minimize the role and the importance of the therapist within the rehabilitation routine as well as the patient-physician relationship (Semprini et al., 2018). The robotics-assistive trainings are showing promising results in the process of neurorehabilitation for the patients, helping them regain their confidence through calibrated training, practice, and increasing their emotional and mental confidence. However, there are still several technical challenges to overcome in the near future such as the improvement of precision and accuracy, flexibility, the mechanical movement of the prosthetics, the development of more personalized solutions, and a regulation of the cost-effective regulation (Parre & Sujatha, 2021).

Brain Computer Interfaces in Neurorehabilitation

Brain computer interfaces (BCI) are neural interfaces which allow to mediate the communication between the brain and an external device (Fetz, 2007). BCI systems use evoked brain potentials signals (e.g., P300) (Birbaumer et al., 2006) or neural signals generated after a motor imagery task (Nierula et al., 2019; Pfurtscheller et al., 1998), enabling the user to communicate with a speller device (Wang et al., 2005), or to control limb movements either through a virtual (Nierula et al., 2019) or a robotic system (Galán et al., 2008), and even through both systems at the same time (Donati et al., 2016). There are some evidences demonstrating the efficacy of such BCI systems for improving motor and cognitive deficits in patients in a chronic stage, with a prognostic of very limited recovery with standard rehabilitation care. For instance, it has been shown that it is possible to modulate μ-rhythm amplitude over the affected hemisphere improving the grasping movement in patients with stroke through the use of a robotic orthosis (Buch et al., 2008), or for improving strength in hand muscles (Ramos-Murguialday et al., 2013). Such motor improvements are

due to the cortical changes occurring during the interaction of the patients with such systems, through controlled objects such as virtual arm, or a robotic orthosis, or others (Downey et al., 2017; Grosse-Wentrup et al., 2011). Moreover, BCIs have been revealed useful for cognitive rehabilitation in patients with neurological disorders. A crucial factor when using BCI for rehabilitation is to provide a motivating feedback allowing the user to clearly see the progression of their performance throughout the training sessions (Jeunet et al., 2016; Pillette et al., 2020). In this regard, the neurofeedback provided to the users when using BCI devices, in which the patients can have a direct and real-time feedback about their performance and neural data are visually displayed to the user (Martin et al., 2018; Sitaram et al., 2017). This approach, has shown to be effective mainly in the treatment of attention deficits and other cognitive dysfunctions (Holtzheimer et al., 2017; Lubar, 1997; Polli et al., 2017; Sueyoshi & Sumiyoshi, 2018).

The continuous technological developments in the creation of more sophisticated systems and the demonstrated clinical efficacy prevents a widespread use of BCI systems for neurorehabilitation purposes. One open challenge when using BCI systems is the measurement of addition (non-motor) networks and the performance of non-motor tasks to demonstrate its efficacy to improve both motor and cognitive domains (Simon et al., 2021). It has been shown that BCI intervention can have an important impact on the quality of life of the patients with serious neurological disorders (Semprini et al., 2018; Simon et al., 2021). Hence, the future developments of these devices can represent a key factor for improving the patients' quality of life, even though the implementation as a usual clinical training is still far to be implemented due to the technological barriers and in some cases by the invasiveness of the procedure (e.g., brain implant) (Kipke et al., 2008).

FUTURE RESEARCH DIRECTIONS

The introduction of the above-commented non-invasive technologies in the field of neurorehabilitation are paving the way for the development of new rehabilitation strategies, including the combination of these for fostering the motor and cognitive rehabilitation outcomes. Indeed, recently, some studies proposed the combination of VR trainings with NIBS techniques (Mancuso et al., 2020; Stramba-badiale et al., 2020), robotics (Maggio et al., 2019), and BCI (Leeb & Pérez-Marcos, 2020). Moreover, other studies combined the use of robotics with BCI (Cantillo-Negrete et al., 2018; Donati et al., 2016), and NIBS techniques (Reis et al., 2021). The combination of these non-invasive technologies allows the potentiation of the induction of neuroplasticity processes that will facilitate to achieve the target rehabilitation outcomes.

Another opportunity that brings the introduction of new rehabilitation trainings with the combination of different non-invasive technologies is the development of telerehabilitation (TR) systems. It is known that telerehabilitation interventions are directed to facilitate the rehabilitation period limiting or avoiding the presence of the patients in the rehabilitation centers (Zampolini et al., 2008). TR systems bring the opportunity of beginning the rehabilitation process as soon as possible after hospital discharge and increasing the care access to individuals who are home-forced or in a far location from their healthcare service (Bernini et al., 2021; Carey et al., 2007; Giordano et al., 2016). Hence, TR systems represent an optimal solution to treat patients with an alternative way compared to the traditional face-to-face approach (Carey et al., 2007), providing benefits for the healthcare system and patients in terms of cost-effectiveness and feasibility for large-scale implementations. Hence, in the field of neurorehabilitation TR may be useful for the treatment of both motor and cognitive deficits (Alloni et al., 2017) (Alloni et al., 2017; Caltagirone & Zannino, 2008; Isernia et al., 2020; Mantovani et al., 2020; Peretti et al., 2017; Quaglini et al., 2019; O. Realdon et al., 2016).

In addition, in line with the necessary adaptation of healthcare services due to the COVID-19 pandemic, TR solutions are increasingly considered as potentially effective options for continuing the rehabilitation process at a distance (Bernini et al., 2021; Mantovani et al., 2020; Matamala-Gomez, Bottiroli, et al., 2021; Stasolla et al., 2021). Due to the pandemic situation during the last year many efforts were focused on the treatment of subjects recovering from COVID-19 (Andrenelli et al., 2020; CURCI et al., 2020; Negrini et al., 2020). However, it has been noticed that it could be extremely important to implement TR protocols also in non-COVID subjects such as patients with neurological disorders in order to provide a continuity of care (Motolese et al., 2020; Ramalho et al., 2020; Stipa et al., 2020). Future investigations should explore how to combine different non-invasive technologies to enhance both motor and cognitive rehabilitation outcomes, and to create new telerehabilitation strategies that will facilitate the care of patients at a distance providing patient-centered rehabilitation approaches.

CONCLUSION

Non-invasive technologies provide new top-down rehabilitation strategies inducing brain stimulation and neuroplasticity processes for implementing new therapies in cognitive and motor rehabilitation. Nevertheless, there is still a need for more research in the area of top-down rehabilitation using non-invasive technologies to elicit more assistive approaches in motor and cognitive therapy in order to enhance the efficacy of the rehabilitation trainings with cost effective programs in a shorter

period of time. Moreover, combining the main non-invasive technologies brings the possibility to adapt to the different patient's characteristics and the development of new telerehabilitation systems.

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KEY TERMS AND DEFINITIONS

Brain-Computer Interface: Is a direct communication pathway between an enhanced or wired brain and an external device.

Computer-Based Interventions: Are a field of research and practice, where medical interventions are supported by computer-based tools and methodologies.

Neurorehabilitation: Is a complex medical process which aims to aid recovery from a nervous system injury, and to minimize and/or compensate for any functional alterations resulting from it.

Non-Invasive Brain Stimulation: Refers to a set of technologies and techniques with which to modulate the excitability of the brain via transcranial stimulation.

Transcranial Direct Current Stimulation: Is a form of neuromodulation that uses constant, low direct current delivered via electrodes on the head.

Transcranial Magnetic Stimulation: Is a noninvasive form of brain stimulation in which a changing magnetic field is used to cause electric current at a specific area of the brain through electromagnetic induction.

Virtual Reality: Is a simulated experience that can be similar to or completely different from the real world. Applications of virtual reality include entertainment (e.g., video games), education (e.g., medical or military training) and business (e.g., virtual meetings).

Chapter 6
The Role of Museums in the Development of Sustainable Tourism in Calabria Between Infrastructural Deficiencies and New Communication Technologies:
Focus on the Amarelli Company Museum and on the MuSaBa Museum Park

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ABSTRACT

The spread of the internet has had important consequences in all economic sectors, including tourism. The chapter analyzes the role of the museum in the recovery, management, and enhancement of the local cultural heritage as a tool capable of promoting the development of sustainable tourism in a region with evident infrastructural problems located in the south of Italy. In particular, the following work focuses on the management dynamics of two museums—the Amarelli Company Museum and the MUSABA Museum Park—and their relationship with new technologies. The aim is to demonstrate how an adequate museum management activity through an innovative and integrated organization of tangible and intangible resources, an efficient use of resources and effective communication, can significantly contribute to its growth by attracting the attention of sustainable tourism.

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INTRODUCTION

According to the World Tourism Organization (UNWTO) "*sustainable tourism development meets the current needs of tourists and host regions, while protecting and improving prospects for the future. It must integrate the management of all resources in such a way that economic, social and aesthetic needs can be met, while maintaining cultural integrity, essential ecological processes, biological diversity and living systems. Tourist products are those that act in harmony with the environment, the community and local cultures*". In other words, the optimal use of environmental resources through the protection of natural heritage and biodiversity, and respect for the socio-cultural identity of the host communities through the preservation of traditions and the enhancement of cultural heritage, represent the indispensable elements to be laid at the basis of any process that wants to aim at the development of sustainable tourism. A process that, in order to take shape, must adopt a strategy that foresees the involvement of all local actors (institutions, economic operators, associations, etc.) to be shared by them and, therefore, feasible. The role of the museum is placed within a complex strategy, in the absence of which it is difficult to imagine that a given territory could play an important role in the competition of global tourism, and, at the same time, in responding to an increasingly widespread and emphasized demand also by the current health emergency of Covid-19, of a tourism more attentive to the dynamics of development of the place itself. The museum, a place of culture which, with its material and immaterial testimonies, is called upon to safeguard, manage and enhance the cultural heritage of a specific territorial context. A task entrusted to museums that can be carried out efficiently must rely on the best possible use of the tools at its disposal. The analyzes on the development of sustainable tourism and on the ability to make museums real tourist attractions cannot therefore ignore changes in society and in the behavior of individuals themselves. Changes that have taken place as a result of the electronic revolution, the so-called third industrial revolution, which has practically changed the way people use goods and services, making it necessary to adapt their technology on the supply side. Changes made further necessary in the face of the Covid-19 emergency which has practically shocked the whole world, upsetting the life and work habits of billions of people. Lockdown periods that have shown how technologies are really the only tools with which to face crisis situations such as the one we are experiencing. Tools capable of allowing entire economic sectors to remain functional with innovative working methods, even managing to have positive impacts on the climate of cities and on costs for companies. The digital world insinuates itself strongly and becomes the only tool truly capable of facing the challenges of the future. A revolution that will have to materialize through the spread of 5G and the development of digital skills now necessary to efficiently manage any sector of the economy, including

the tourism sector that has suffered most of all from the negative economic effects due to the health crisis of this long period. Digital and innovative technological tools to relaunch reasonable tourism through a modernization of cultural heritage management infrastructures. In this general context, the role of the museum also becomes an object of transformation, from a traditional and now outdated conception that sees the museum as a place of conservation and exhibition of works of art and objects of historical and / or scientific importance to a more modern conception that frames the museum as a place of culture capable of evolving and improving thanks to a continuous interaction with its public. A museum capable of innovating its image to reach a wider audience through the use of new technologies. The chapter analyzes the information and communication processes adopted by two museums, unique of their kind, present in the Calabria region and capable of attracting a good percentage of international tourism. These are museums that have made the singularity of their respective projects the weapon of their success and the use of digital communication as a great ally through which to spread their mission around the world. The author's goal is to focus on how an adequate use of all those technologies that scientific progress has made available is the only way to fully enhance the cultural heritage of the territories, for the success of museums who deal with it and for the development of sustainable tourism. ICT and the use of specific profiles and professional skills have become essential tools for any museum actually does not intend to remain isolated but, on the contrary, who cares about not only his own reputation in an increasingly competitive industry but has desire to grasp and contribute to the great challenge towards the sustainability of the future. After the pandemic, we will be faced with a new scenario and it is necessary that even museums do not get caught unprepared and that they are able to adopt in time the most appropriate tools and strategies to carry out that task that has increasingly required them: not only a testimony of past traditions and culture but an integral part of the communities, capable of becoming places of participation and social inclusion. The web and social platforms used as digital intermediation tools at the service of the dissemination of culture. The ability to reach a potentially infinite audience and to intrigue targets that are also different from those that one would expect, to the point of physically dragging travelers to places of culture. On this basis, the following work tries to highlight the potential of digital in the tourism/cultural field. Through the analysis of the management and promotion activities of the Amarelli company museum and the MuSaBa park-laboratory, it tries to provide a reflection on the advantages that can derive from it in terms of a real enhancement of the cultural heritage and a better distribution over time and in space of tourist flows even for a 'geographical area characterized by obvious infrastructural deficiencies. Museums, whose role has profoundly evolved over time by adapting to the new needs of society, can play a strategic role in the development of responsible tourism, especially in some contexts with a significant

cultural heritage which is not fully exploited. The author, through an in-depth study of the two museums, intends to contribute to strengthening the hypothesis, already widely supported in literature, according to which new technologies represent a fundamental driving force in the direction of the growth of sustainable tourism. The work closes with ideas for what, according to the author, should be the research perspective in the years to come.

BACKGROUND: ICT AS A TOOL FOR PROMOTION AND INCLUSION

Within the tourism sector, the idea that an indispensable tool for the promotion of a tourist destination, whether it be a city of art, a seaside destination or, as in the following context of analysis, a more specific place of conservation and enhancement of the cultural heritage of a territory such as the museum, is explicitly represented by ICT. Already in the past, several scholars have expressed themselves about their importance and on how *"the new information technologies represent new opportunities and, at the same time, an unprecedented challenge"* (Choi et al., 2007, p.60). In fact, these are powerful means if used adequately. In a world where the dissemination of information is within the reach of a click, it is necessary to avoid the proliferation of unclear or partially correct information or the generation of unnecessary redundancies. The message you want to forward to potential customers / visitors must be precise and included in a specific communication strategy. The way in which a specific tourist activity has to be promoted, must be included in a studied and well defined plan by those who want to adopt it in order to arouse interest and curiosity towards their product. Tourism organizations and destinations that resort to appropriate use of these technologies *"gain an abundant competitive advantage over their competitors"* (Buhalis & Amaranggana, 2013, p.555). In Italy, the process of digitization in the management and communication strategies of museums is certainly slower than in the rest of Europe and also appears to be patchy with some realities that are better suited to accommodate changes and others that, instead, they struggle to keep up with the times. However, the need for a change of pace is undisputed and the Three-Year Plan for the Digitization of Museums published in 2019 by the General Management confirms the importance of new communication technologies. The plan responds to the need to provide members of the new National Museum System with an organic, reliable and shared reference framework to adopt digital tools and processes that contribute to the objectives of protecting and enhancing cultural heritage in the short and medium term. It addresses the need to be effectively present on digital channels with adequate content and able to engage the public, but also with *ticketing* and marketing services. The plan is therefore proposed as a useful

tool to support the digitization process of museums, offering solutions at different levels[1]. In what is now called the era of the digital transition, the new communication tools represent an enormous potential for the dissemination of information and the construction and / or consolidation of the image of a cultural institution. In this regard, social networks are real "places" in which each user of the network expresses their evaluations on a purchased product, on a service they have used, on a place they have visited, letting their opinion is read and shared by any other user of the network. Other people's judgments as an index of satisfaction or not, whatever the object in question. Not only the likes, but also and increasingly, the reviews left online, on online sites, on social media and on dedicated platforms, contribute to the formation of the web reputation of an activity, a place, a museum. As with any other activity dealt with in the infinite world of the internet, also for the museum the good reputation that it manages to build on the network represents the main tool that, in the 4.0 era, can strongly contribute to the realization or consolidation of success of the same, prompting users satisfied by others' online feedback to visit it, inevitably increasing the number of entries. Conversely, a bad web reputation or even a non-existent reputation on the web, due for example to the scarce use of communication tools connected to it, certainly cannot positively influence the orientation of visits by the people of the network to that particular cultural container. *"Real users, potential users and remote internet users are new categories of public which museums must address by exploiting new technologies so as to communicate and promote at best its heritage"* (Carrozzino & Bergamasco, 2010, p.453). *"[…] social media networks provide a significant and possibly more efficient way of "making public" the ways in which audiences respond to cultural content"* (Russo et al., 2006, p.4). For this reason, the use of social networks cannot be improvised. *"'Being there' is not enough, and it could be even counterproductive if the museums do not understand the new communication and interaction mechanisms these platforms provide"* (Badell, 2015, p.261). Museums need to learn how to use these tools properly to reap all the possible benefits. In fact, these are digital innovations with enormous potential which if well managed and integrated with the functions of museums, can improve the attractiveness of tourists and encourage greater inclusion of the local community. For example, *"New communications strategy, learning and technologies can be useful to develop relationship between museum and school"* (Ferrara & Sapia, 2013, p.1356). Digital media can therefore prove useful for strengthening relations with the educational world and, in general, with all potential visitors. Tools capable to encouraging interaction between museums and web visitors (Arends M. et al., 2011) also through the creation of online communities (Caruth & Bernstein, 2007). In the last decade, studies on ICT and its usefulness have greatly intensified and highlight the need for museums to adapt to the new digital age, even if their availability to embrace the participatory potential

of social media and the consequent organizational change varies according to the characteristics of the museums (Booth et al., 2019). Despite the different approaches, *"[...] the cascade of innovations in digital media has already deeply changed museum formats and characteristics"* (Badalotti et al., 2011, p.115). The Internet has therefore changed the order of priorities in the choices of tools to be used for promotional activities, causing the consequence that "for the cultural sector, escaping the digital agora today means condemning oneself to irrelevance" (Coccoluto, 2019). *"The information of various kinds, multimedia, known as Big Data, collected through the IoT - among which first of all the digital traces left by tourists simply with their activities during their visits - can allow us to know their behaviors and tastes. The management of this data and also of Open Data (i.e., information freely available to everyone provided that the source is cited) allows tour operators (individuals and especially associated) and the community of the tourist destination to extract useful information to interact with tourists, improve the offer and marketing actions"* (Adamo, 2018, p.15). It should be noted that, when one thinks of the museum and its ability to attract tourists, it is not possible to delude oneself that its success depends exclusively on the use or not of innovative technological tools *"it is necessary to start from the goal you want to achieve, not from the inclusion at all costs of technology in a visit path. In fact, it is not technology that decrees the museum's innovation, but rather the overall cultural policy, accompanied by a correct communication strategy"* (Mandarano, 2019, p.113). What can prove decisive is rather the way in which the web and digital infrastructures are used to disseminate historical testimonies, territorial characteristics and cultural projects among online users, then trying to actively involve them in order to favor accessibility and increase social inclusion. The strategic use of the internet to ensure "sharing, accumulation and sedimentation of knowledge" (Gangemi, 2015). Furthermore, "*a real and effective ability to strengthen the contents of sense and meaning of spaces and to convey them on a global scale through the Web, can finally allow the emergence of places, regardless of distance, previous notoriety or ability of investment, offering a sort of redemption for those areas traditionally penalized by margins*" (La Foresta, 2016, p.153).

MAIN FOCUS

The Importance of Digital in the Most Complex Territorial Contexts: The Amarelli Company Museum and the MuSaBa Laboratory-Park

The Pandemic and the Opening to Digital

Virtual Reality and Augmented Reality, video games, 3D constitute great opportunities for the protection and the promotion of cultural heritage of each country. In Italy, however, innovation applied to cultural heritage appears to be a rather slow process. There are good practices but these are not yet widespread throughout the national territory. Furthermore, with reference to the period immediately preceding the pandemic, from the data relating to the Istat report "Italy of the Museums" it appears that in 2019 only 10% of the museums have digitized their catalog and less than 45% have adopted digital technologies and interactive tools. The restrictive measures adopted to allow the containment of the virus have somehow placed museums in front of a new challenge by accelerating the digital transformation process that has involved the entire Italian museum system, and beyond. The virtual tours, the online reservation systems, applications, social networks and more generally, digital technologies, made it possible to maintain constant contact between cultural heritage and communities. Analyzing the relationship between the museum and the digital during the pandemic, it is unthinkable to imagine that this emergency could find an end without leaving permanent marks in cultural institutions. The near future can only concern digital culture and this does not mean that the role of the museum is destined to be lived only through digital intermediation but that the approach that it will have to adopt towards its interlocutors cannot ignore ICT. Moreover, the museum, in its most modern vision, as indicated in the statute of the International Council of Museum, ICOM[2], and implemented by the Italian legislation in 2014, to be considered as a "*The permanent INSTITUTION, non-profit, serving the society and its development. It is open to the public and carries out research concerning the material and immaterial testimonies of humanity and its environment; acquires them, preserves them, communicates them and exhibits them for the purposes of study, education and pleasure, promoting their knowledge among the public and the scientific community* ". This definition, which is the result of a profound reflection carried out over the years with the aim of adapting the museum and its functions to changes in society, highlights how places of culture must become increasingly inclusive and accessible. The pandemic has done nothing but highlight the fragility of the Italian cultural system and the need to carry out a long-awaited transformation that has never really taken off. The long intermittent lockdown period has given

everyone the opportunity to understand the enormous potential of digital. In the museum field, the use of technology does not only concern the possibility of offering virtual tours but also that of leaving room for a new type of interaction with one's audience, both in the phase preceding the visit and during the tour in the physical structures of the museums. During this long situation of extraordinary nature, it is as if a mechanism of openness on the part of museum managers towards society and its more contemporary means of communication had been triggered. In a certain sense, it is as if the desire to react to that forced interruption of the "physical contact" that has always characterized the relationship between the work and its users, had somehow broken down barriers. Those limits of view that have characterized for years the hostility on the part of a certain category of cultural elites towards the possibility of opening up to new horizons. And here, too, the approach of the relationship seems to have changed: if the tourist cannot physically go to the desired place, then the work will try to reach its visitor. In reality, it should be noted, as even before the spread of the virus, there were many museums that had adopted innovative tools to make the visit more attractive and to provide answers to the increasingly demanding requests from visitors interested in more immersive cultural itineraries and engaging. The pandemic has drawn a definitive line between the old way of interpreting cultural fruition and a new concept that will see the increasingly intense use of digital tools as the protagonist. Without ignoring the obstacles still present and which will have to be faced in the immediate future to make the museum sector truly inclusive and accessible, the author intends to demonstrate, through the Amarelli Museum and the MuSaBa, two internationally recognized museums, such as the use of new technologies, albeit in small steps, can really favor the long-awaited transformation process. These are museums that immediately understood that the solution to some problems deriving from infrastructural conditions and which are now atavistic in the Calabria region could have been achieved through digital. Before addressing in detail the activities carried out by the two museums, it is considered necessary to deepen the context in which the two museums are located also to explain why it is believed that favoring the diffusion of 5g, strengthening digital infrastructures and promoting digital culture is more necessary in some areas of the world that are less developed than others.

The Territorial Context of the Museum in Calabria

A territory endowed with particular environmental qualities has within itself the potential and the characteristics to develop tourist activities. In most cases, the tourist vocation can arise from the multiple resources within the territory, but it can also be the result of planning aimed at attracting tourists. Tourism is, in fact, an economic activity which, in order to develop, needs two fundamental components:

Table 1. Distribution of museums for the province (Source: Census Region Calabria 2011)

Province	Total Museums	%
Catanzaro	51	17.96
Cosenza	118	41.54
Crotone	25	8.81
Reggio Calabria	55	19.36
Vibo Valentia	35	12.33
	284	**100**

the place of destination and the activities connected to it (Bizzarri, 2006, p.41). As regards the resources available in the area, the so-called "Endowed Resources" (endowed or inherited) considered, together with a whole series of other factors, of fundamental importance for the competitiveness of a tourist destination and defined in the model developed by Dewyer and Kim (2003), the Calabria region has them in abundance. The regional territory enjoys an enormous naturalistic heritage. The mainly mountainous and hilly landscapes mix with each other and descend almost to the sea, leaving some flat stretches in the areas where the rivers flow. In fact, two furrows separate the Calabrian peninsula into three mountain groups rich in green woods, pastures and spring waters. The conformation of the land isolates the urban centers where the population is concentrated. The region is characterized by the presence of three national parks, almost 800 km of coastline and numerous inland areas. The Calabrian territory can boast a rich offer also on the cultural front. According to the latest regional census [3], Calabria is characterized by the presence of 284 museums and whose distribution by province and category is shown in the following tables:

It is an enormous cultural heritage concentrated with a significant share in the province of Cosenza and with lower but still significant percentages in the other provinces of the region. For a more up-to-date cognitive picture, it is necessary to refer to the ISTAT data relating to the year 2018 and according to which, the number of museums and similar institutions (archaeological park, monument or monumental complex) stands at 166. If from the point of view of internal resources, the Calabria region with its cultural and landscape heritage, has the necessary requisites to express also different tourist vocations (seaside tourism, ski tourism, cultural tourism, agri-food tourism, etc.) different is the discourse relating to the territorial capacity to intercept different target of tourists to be distributed in a more homogeneous way over time and territorial geography. The region, in fact, is characterized by the presence of a predominantly holiday and seaside type of

Table 2. Distribution of museums by category (Source: Census Region Calabria 2011)

Type of Museum	Number of Museums	%
Ethnography and Anthropology	86	30.28
Archaeology	71	25.00
Art	45	15.85
Holy art	29	10.21
Territorial, specialized and general	20	7.04
Science and natural history	18	6.34
Science and documentation	8	2.82
Military	3	1.06
History	3	1.06
Environmental	1	0.35
	284	**100**

tourism which therefore tends to concentrate only in the summer months and with greater tourist flows in the most well-known locations. Instead, it struggles to enhance the innermost areas and to stimulate the curiosity of travelers towards less popular destinations and in seasons other than summer. Also, in terms of planning and territorial marketing, the Calabria region presents a structural gap due to the implementation of spot and non-systemic interventions. There is therefore a lack of an overall strategy with a long-term perspective. Moreover, the attractiveness of the places, which depends mainly, although not exclusively, on the quantity and quality of available resources, is certainly an indispensable requirement for them to develop tourism. " *On the other hand, it is increasingly evident that the allocation of resources is not sufficient: an increasing number of destinations are implementing increasingly sophisticated strategies to attract visitors, overcoming the traditional models of tourism promotion "* (Antonioli & Baggio, 2013, p.54). The absence of an adequate territorial promotion strategy is also confirmed by the results published in August 2020 by the national report on the tourist reputation of the destinations and summarized by the Regional Tourism Reputation Index, drawn up by the Demoskopika Institute. This is a study conducted through the analysis of some indicators including: visibility and interest of regional institutional tourism portals, social appeal with stakeholders, popularity, trust and trends of each regional tourist destination as a whole and the reputation of the accommodation system. The region to obtain the first position was Trentino-Alto Adige, on whose victory also the first place as the "most social destination in Italy" weighed significantly. Only sixteenth for the Calabria region which still makes a leap forward of three positions compared

to 2019.[4] In a territorial context characterized by infrastructural deficiencies and a fragmented communication strategy, it is necessary to highlight and tell examples of good practices. The cultural heritage, through the numerous museums shown in the previous table, is in fact of great value. There is no shortage of examples of museums with a high historical-cultural importance and for this reason known all over the world and there are numerous examples of specialized museums capable of attracting numerous visitors. The reason why the author has decided to place the "Giorgio Amarelli" Museum and the MuSaBa Laboratory Park as the object of analysis is linked to the importance and international importance of the same and to the uniqueness of each of its kind. Both museums represent in the Calabria region, two noteworthy museums that, despite not a few difficulties, have been able to make a commitment to the enhancement of the artistic, historical and cultural heritage, a winning tool capable of attracting tourists from all over the world.

Comparing Museums: "Giorgio Amarelli" Museum vs. MuSaBa Museum

The "Giorgio Amarelli" Museum is a business museum located in the municipality of Corigliano-Rossano, in the province of Cosenza. Opened in 2001, it is the only licorice museum in the world. Born to tell the three centuries of production, it exhibits the tools used in the processing and marketing of the root of Glycyrrhiza glabra from which licorice is obtained, as well as a wide range of objects and documents related to the over one hundred year old Amarelli family. The seat of the museum is the Palazzo Amarelli, a residence that dates back to the XV-XVII century and has always belonged to the family, it is part of the Italian Historic Houses Association. The museum, which has now become a reference model in the context of Italian business museums, tells the story and identity of a family business present with its factory in the Calabrian territory since 1860 and considered an undisputed entrepreneurial excellence for the whole Southern Italy. The Amarelli museum is a clear example of how *"The company museum becomes a physical testimony and an active promoter of the identity fusion between the two dimensions of company and territory"* (Appaiani, 2001). The almost twenty years of activity have allowed the museum to develop the necessary know-how to attract about 60,000 visitors a year (Touring Club statistics), second only (in the context of business museums in Italy) to Ferrari, and to establish itself as a small cultural enterprise capable of generating significant revenues and employing 14 people in the period of maximum influx. A type of tourism that is attracted by the museum which is essentially divided into a holiday tourism that records its highest levels in the summer season but with good attendance also in the other months of the year, an industrial tourism, food and wine and tourism also of the scholastic type. Furthermore, with its activities, the museum

is able to attract a good percentage of European and international tourists. Also in the year 2018, about 17% of the total visitors registered were of foreign origin, with British tourists ranking first, followed by the Japanese and the French. As for the visit to the museum, it begins with a visit to the Galleria del Passato which, through ancient documents and old tools, illustrates the history of licorice and its processing, continues in the Galleria della Modernità (a second wing inaugurated in 2017) with a historical excursus on the evolution that the production of licorice has had over time and ends with an original licorice-experience in the Factory Store (annexed to the museum). The latter, inaugurated in 2017, represents an innovative shop with totems and multimedia screens inviting customers to make their purchases directly in the factory and offering them a real shopping experience. The store has launched a constantly developing merchandising sector. The Museum is open every day and the tour is offered not only in Italian but also in English, French, German and Spanish. Admission is free, guided and by reservation only, through the more traditional telephone channel or by sending an email or using the site with a special tool for online booking. The cultural tourist route is carried out in the following phases:

- Visit of the ancient "Concio" and of the production plant;
- Visit of the Museum;
- Tasting in the shop attached to the museum.

As for the staff, the museum is equipped with highly qualified personnel selected on the basis of their skills, subjected to initial training in the company and continuous training updating since these skills are constantly evolving. The team is made up of three museum assistants with specific degree qualifications and permanent contracts who also deal with the management of the online site and communication through social networks. There are also four permanent collaborators who follow the shop attached to the museum and the online shop. Additional specialized collaborators are added in the peak periods (May-August). The museum also enjoys a large turnover of curricular and extracurricular interns and trainees, mainly students who apply for an internship or school-work alternation. The museum activities include, in addition to the traditional reception and the back or front-office ones, also all those activities concerning two contiguous areas connected to it and constituted by the Archive and the Auditorium. The archive, in which a series of documents and some manuscripts are kept, is present in the National Portal of the Company Archives and has been declared an archive of "particularly important national historical interest" by ministerial decree.[5] The auditorium, on the other hand, which was in the past an area dedicated to production, is now a comfortable and efficient conference room equipped with the most sophisticated technologies (computer, video projector, acoustic amplification, etc.) and entirely dedicated to events, screenings

and conventions with a frequency of about forty / fifty events per year. In almost twenty years of existence, the museum has managed to create a database of 20,000 contacts, various mailing lists and contacts of people. The latter also had a strong impulse with the introduction of the Amarelli Card - also Cashback - of which (out of a total of over six thousand), only two thousand were delivered in the 2018 summer season. This demonstrates the attention of the Amarelli cultural institute towards a scrupulous collection and efficient use of information, indispensable tools for orienting one's activities towards the new and constantly evolving needs of visitors. Another aspect of particular importance concerns the way in which the promotion of the museum is conducted. The communication plan, in fact, does not take place through advertising. As explained in the interviews and in the documents provided by the managers, the very birth of the Museum is the representation of a company philosophy, according to which it is estimated more productive to invest in culture, rather than in the usual promotional activities, taking into account that, in the generation of Millennials, communication takes place mainly through the web, that is, through the various social channels. In fact, the results achieved by the Museum in the world of the web confirm the effectiveness of a good use of the most innovative means of communication for museum governance. In the search for the best museums in the Calabria region, the Amarelli museum is part of the TripAdvisor top ten, the largest travel site on the web that collects and publishes in real time all the evaluations expressed by users interested in the structures present on it (hotels, restaurants, museums, etc.), winning fourth place and therefore the "Travelers' Choice" award [6]. According to the official page, this is a recognition assigned by the site to accommodations, tourist attractions and restaurants that constantly get very positive reviews from travelers and are ranked in the 10% of the best properties on TripAdvisor. The museum receives the certificate of excellence every year and obtains an average score of 4.5 out of 5 on a total of 742 reviews with the following percentages: Excellent 63% - Very good 26% - Poor 1.4%. With his official page he gets about 7,000 likes on Facebook with about 4300 people who registered (that is, they were physically present) at the museum. In reality, being Amarelli a centuries-old licorice factory, it is necessary to take into account how it is present on the social network also with other specific pages. For example, the "Amarelli Fabbrica di Liquirizia" page which reaches over 18 thousand likes and finally the Fb "Amarelli Shop" page linked to the e-commerce of all liquorice products, which manages to win almost 4,700 likes. On Instagram, the "Amarelli Liquorice Museum" page is followed by almost 2500 followers, to which are added the museum's promotional activities also through the "Amarelli" instagram page with its almost 3,000 followers and finally, to complete the picture informative, there is also a page dedicated to the shop, this is the "Amarelli Shop" page with its almost 1200 followers. For completeness, even on google it manages to win an average

rating of 4.5 points out of 5 with a total of 350 reviews. What emerges from the analysis of the responses to the questionnaires submitted to the museum managers is the awareness of the power of Information and Communications Technologies and the role they must assume within an adequate marketing strategy that must be based on an organization and on an effective information system, on the planning of actions and on the monitoring of results. A strategy in which a central role is played on the web and through the use of social networks with which to regularly share valuable content capable of involving the user even before the visit. Tools whose use was enhanced during the lockdown made necessary by the Covid-19 pandemic, in particular with a daily presence on Instagram, with the aim of keeping the relationship with one's audience "alive" and constant. Upon reopening, the museum immediately resumed its usual channels with travel agencies and with all tourist and accommodation facilities in the area and resumed its annual proposal to schools in Calabria and beyond. To better deal with the so-called restart phase, a synergy was also created with other local realities, such as the Codex Museum and the Corigliano Castle. The museum, through specific agreements with foreign tour operators and with cruises that arrive at the port of Corigliano, is committed every day to trying to seasonally adjust the flow of visitors. The museum also seems to have an enlightened vision on the future and on how to deal with it through the creation of paid workshops (Internships, Amarelli Educational training center), active participation in sector fairs, extension of opening hours, creation of interactive installations (iBeacon, games, App), a feasibility plan of the Licorice Theme Park (botanical garden, giftshop, bookshop) and the implementation of partnerships with media, businesses, museums and associations.

The MuSaBa (Museo Santa Barbara) is instead a museum park located in Mammola in the province of Reggio Calabria. Created in 1969, the art park was born from the idea of the artist-architect Nik Spatari who, after traveling around Europe, meeting Picasso, exhibiting his works at the Venice Biennale, and directing an art gallery in Brera, decides to return to Calabria. And it is exactly in his homeland that, together with his Dutch partner Hiske Maas, he is advancing the project of enhancing the environment and the Greek territory of the region through sculpture-structure. An experimental laboratory is located inside it for the creation of works by artists from all over the world. The museum, with its activity, manages to attract visitors from all over the world. Tourists curious to know the artist's undisputed artistic skills but also to actively participate in the life of the park through training courses and internships. From the information provided by the museum managers, the number of visitors per year is around 25,000 admissions, with peaks in the summer and a good turnout also in the spring and autumn months and among these a good percentage of tourists are of German origin. A type of tourism that attracted by the MuSaBa which can be divided into holiday tourism, artistic and school tourism. The visit

to the museum begins with the vision of some works by the artist Spatari, mainly paintings and mosaics accompanied by the narration of the story reported on totems in Italian and English. There is also a space reserved for the exhibition of the main articles that have appeared in the national and international press and finally it is a small corner where visitors can buy explanatory manuals of the artist's creations, gadgets of various kinds and from the beginning of the pandemic, even masks. The visit continues in what is called the Calabrian "Sistine Chapel", it is the church of 1100 where the monumental work the "Jacob's dream" resides and ends with a tour along the entire park in which it is possible to admire the numerous sculptures created by Spatari and many other Italian and international artists, as well as the mosaic located in the Foresteria. The MuSaBa is open every day and the tour is offered for a fee to visitors with a discounted rate for groups and school groups. The booking of the visit can be made by phone, email or directly by request on social networks. As for the staff, the museum avails itself of the collaboration of a team of 5 people who, on a completely voluntary and free basis and in rotation, allow the use of all museum services to the interested public. Even the MuSaBa, as for the Amarelli museum, has its own website on which it is possible to have easy access to all the information relating to entrance costs and opening hours. It is a well-structured site that allows users of the network to immerse themselves in a real preview of what the actual visit to the museum will then be. Inside, not only the history of the museum is told but also the photos of the works kept in the museum, a rich press review and all the activities carried out within it with detailed programs reserved for school students are collected and presented to curious web surfers and universities. For MuSaBa, the use of digital tools is also of considerable importance for the promotion of museum activities. The communication of events and all cultural initiatives takes place through the strategic use of social networks. Also in this case, as for the Amarelli museum, the use of these innovative tools is effective. Analyzing the data always coming from those sources that can be defined as "non-conventional" and among which fall Wikipedia, TripAdvisor and social networks (Facebook, Instagram, Twitter), etc…, what emerges is the great interest shown by network users in the museum in question. In the online search for the best museums in the region, the MuSaBa ranks among the top 10 occupying the seventh place in the ranking drawn up by the US company TripAdvisor for the year 2020, winning the "Travelers' Choice" award and registering an average score of 4,5 out of 5 from a total of 234 reviews. It is interesting to note that the museum in question has a significant number of appreciations expressed in likes and followers even among the main social platforms. On Facebook, the official page of MuSaBa gets about 27,000 likes, surpassing, for example, if only slightly, the number of likes of the nearby National Archaeological Museum of Reggio Calabria and known throughout the world for preserving the famous Riace bronzes. On Instagram, on which the

museum has been actively present with its own page since 2016, it has more than 5,800 followers. Finally, even in the context of reviews Google records excellent ratings with an average score of 4.5 out of 5 out of a total of 547 opinions expressed.

All the information provided so far in the paragraph and through which the researcher conducted the analysis and developed the reflections are summarized in a summary sheet with the aim of easily highlighting the main characteristics of the management of the two museums (personnel, activities, ICT, social, etc…).

Some Considerations: ICT and the Success of Museums

In the world of culture there are many museums and cultural institutions that are trying to innovate their structures and processes. Among these there are the museums under analysis. The study revealed a clear propensity on the part of both museums to use ICT, albeit with the necessary differences. Moreover, thanks to the company resources it enjoys, Amarelli is able to make the visit to the museum completely free and to do it even with the most modern digital tools. The MuSaBa, on the other hand, represents a museum laboratory which, in order to sustain itself economically, must rely on the revenues deriving from the sale of the works and tickets to which can be added (even if to a completely residual extent) the sale of gadgets or, as in this period of health emergency from covid-19, of customized face masks with the most representative works. The considerations set out so far help to confirm the important role that the museum can play in the process of developing sustainable tourism. Indeed, in some territories characterized by a rather fragile socio-economic fabric, such as the one observed, it can even prove to be a determining element for the development of tourism better distributed over time and space. The regional context is in fact characterized by strong infrastructural deficiencies, an inadequate communications network and a railway network not yet electrified (on the Ionian coast). To this can be added the lack of a territorial marketing strategy, a poor organizational capacity and the lack of an overall planning. Just think of the data of the last census which show the presence of 284 museums in the face of tourist flows well below the potential of the territory. Despite the difficulties described, it is noted that the two cultural institutes are configured as two winning realities. The first element is that they have something to tell and are two plastic demonstrations of how sustainable tourism can be done concretely. Amarelli basically tells its own company history, a story strongly linked to its territory and to indigenous productions. It makes the museum a corporate investment with which to consolidate the image of the company on the one hand and on the other offer an added value to the territory. In this sense *"Business museums are exceptional witnesses of these transformations and become an instrument of dialogue and sharing between the company and the territory, telling much of what makes up the collective imagination of a company"* (Rossato,

Table 3. Summary sheet of key features/activities of the two museums (of our processing Source)

Museum	Giorgio Amarelli	MuSaBa
Typology (according to regional census)	Territorial, specialized and general museum	Art park
Category	Business Museum	Park-laboratory
Municipality	Corigliano-Rossano (CS)	Mammola (RC)
Legal form	An integral part of Amarelli Srl	Foundation
Year of establishment	2001	1969
Average annual number of visitors	50,000	25,000
Content	Documents, manuscripts, machinery, and everything related to the evolution of the licorice production process	All the works (paintings, mosaics, installations) of the artist Nik Spatari and numerous works by international artists
Tourist reference target	Industrial tourism, food and wine tourism	Art tourism
Entrance	free	For a fee
Staff	- 3 museum assistants with a specific degree and hired for an indefinite period - 4 permanent collaborators (implementation of staff in the period of maximum turnout)	-5 collaborators on a voluntary basis with specific skills
Online site	Yes, well structured: - history description -opening time - online booking	Yes, well structured: - history description -opening time - booking by email -photo and description of the main works - press review
E-commerce	Yes. The online shop can be reached from the museum website	No
ICT use	Yup. -Technological support, especially in the Auditorium -Particular attention to the use of social networks. -Mailing list.	Yup. - Technological support in the guided tour - Particular attention to the use of social networks. -Mailing list.
Wi-Fi access for visitors	No	Yes, free
Position on TripAdvisor in the ranking of the 10 best Calabrian museums (year 2020)	Fourth - 4.5 out of 5 (with a total of 742 reviews including: Excellent 63%, Very Good 26%, Poor 1.4%) - "Travelers' Choice" for 2020	Seventh - 4.5 out of 5 (with a total of 234 reviews) - "Travelers' Choice" for 2020
Presence on social networks	- Facebook with about 4,700 likes - Instagram with about 2,500 followers	- Facebook with about 27,000 likes - Instagram since 2016 with around 5,800 followers
Importance attributed to ICT 1 to 10	10	10
During the lockdown	- by strengthening of social networks, particularly the Instagram	- enhancement of the use of social networks - creation of face masks with the works of MuSaBa
Projects for the future	- paid workshops (Alternation, Internships, Amarelli Educational training center), - active participation in trade fairs - extension of opening hours - creation of interactive installations (iBeacon, games, App) - feasibility plan of the Licorice Theme Park (botanical garden, giftshop, bookshop) - implementation of partnerships with media, businesses, museums and associations	- Establishment of a network of contacts with the international association of the deaf

2013, p.56). The MuSaBa, unlike traditional museums, is a living art laboratory. The recently deceased architect and artist Nik Spatari, despite being well integrated into the circuits of Milanese galleries, made a courageous choice and in contrast to what is the art market. He created from scratch, in the Aspromonte hills, a place that has become a point of reference and production for numerous international artists in the spirit of the most authentic environmental sustainability. An original example of fusion between art and territory created with the recovery of the existing. With his work, he managed to raise a small Aspromontano municipality to the honors of the international news and to make MuSaBa a strong tourist attraction in an economically depressed geographical area. Both museums immediately grasped the extraordinary importance of Information and Communications Technology. The need for a new approach to information management and communication activities in order to encourage greater interaction between cultural institutions and the public with the aim of establishing a dynamic relationship capable of involving people even before the visit. The new communication technologies are affirmed as indispensable tools capable of facing the current challenges and carrying out the projects of the future.

ICT, Agenda 2030, Museum Networks and Digital Transition

The use of new technologies can only be implemented in the future. This will affect all sectors of society. Tourism, even in the face of the objectives established by the 2030 Agenda that must be achieved by all 196 signatory countries of the action program, in the perspective of economic, environmental and social sustainability, can only develop by consolidating its own link with the cultural heritage of the destinations. Among the 17 objectives set out in the action plan, objective 11 and objective 12 refer respectively to the need to make cities increasingly inclusive and sustainable through the enhancement of cultural heritage and to the need to develop sustainable production and consumption models. This will mean taking a series of actions to ensure that cities become safe, inclusive and sustainable places through urban regeneration of the poorest areas, road and transport safety, expansion and protection of green spaces, and finally, through a collective effort aimed at safeguarding the cultural and natural heritage. The future production of goods and services must therefore aim at improving people's quality of life. For many years the importance of implementing actions that go both in the direction of production, favoring a substantial reduction in the use of natural resources, and in the direction of consumption, has emerged in the world debate, with the aim of sensitizing people towards responsible consumption behaviors. After all, the tourism sector over time has been characterized as an element capable of disfiguring the beauty of the places through the exploitation of natural resources and the creation of real urban havoc just to satisfy the demands of the market, made for the greater part of a tourism

empty and reckless. To reverse this trend, it will be necessary to encourage responsible tourism models aimed at enhancing the cultural heritage that tourist destinations can offer to visitors. This will mean that the role of museums will also become central to the promotion of the culture of sustainability by strengthening their activities of participation and education of local communities. The technological tools, in their opinion, could be useful to favor the creation of networks between cultural institutes, stimulating collaborations and forms of aggregation especially in those territories characterized by strong infrastructural deficiencies and greater socio-economic fragility as in the case of the Calabria region. The author intends to focus on the need to deepen the study relating to museum networks and the way in which ICTs can prove to be strategic to favor the creation of synergies capable of translating into a wider cultural offer capable of reaching specific tourist targets. As we have seen in the first paragraphs of this chapter, the Calabria region boasts the presence of a large number of museums. Not all, however, enjoy the same resonance as the Amarelli museum and the MuSaBa. So, it could be interesting to start studying forms of aggregations between different cultural institutes, providing for mixed collaborations between private museums and state-owned museums, mixing different cultural proposals and aiming to "use" the fame of the most famous museums to consolidate the reputation of the network and to improve the performance of smaller museums that decide to be part of it. Working online by sharing professional and technological resources. Using digital platforms to promote network activities and programs through the web. According to the author, the need to deepen this aspect also derives from the renewal process started in the Italian cultural sector starting from 2014 which over time, through a series of decrees, has redefined the role of the museum, introduced new types of museums and, in particular, it has planned the creation of the National Museum System. A system articulated in turn into regional museum systems, which aims to network the almost five thousand Italian museums and, therefore, to be understood as a network of museums and cultural sites connected to each other in order to improve their use, accessibility and guarantee a more sustainable management of cultural heritage. In this perspective, the role of museum networks and systems will become increasingly strategic for the enhancement of cultural heritage as well as for the development of new models of territorial tourism that are increasingly culturally driven. The importance of networking has also been well understood by the International Council of Museums - ICOM - Italy which, precisely to encourage the creation of these forms of aggregation between cultural bodies, has decided to start working groups in the various regions of Italy with the aim to develop, through the study of the "best practices", guidelines that will also be useful for identifying patterns of governance through which ensure the proper functioning of the networks over time. The provision of digital infrastructures through which to foster communication between museums and the

communication of museums online towards users, potential visitors, will be increasingly essential. However, as already specified in the first paragraphs of the chapter, it is not the technological progress that guarantees the attractiveness of a museum but its ability to enhance its cultural offer through management dynamics and marketing strategies that are adequate and supported by digital tools. The success of a project always depends on the inclination of museum managers to clearly define their mission and to know how to spread it, to interact with the communities, to create more interactive visits, to involve tour operators to be included as tourist-cultural destinations in travel proposals, in the propensity to network. These are the bases from which to start and which will have to be perfected through digital tools, especially in the organizational-managerial and promotion dynamics. In the post-pandemic, the real challenge will be to work on innovation processes to promote the networking of cultural heritage. To make this path feasible, a decisive change of pace will be required in identifying adequate resources to be used in digital innovation investments and staff training. Investing in information and communications technology, as has already been amply said in the previous paragraphs, represents an obligatory step for all those subjects who want to act as attractors of tourist flows in a specific destination. The NRPR - National Recovery and Resilience Plan - is the tool with which to plan Italy's economic and social recovery and provides that a considerable portion of resources will be allocated to the "Digitization, Innovation and Culture and Tourism" mission. In particular, the investments provided them by the plan will be oriented to the improvement of tourist facilities redeveloping and improving the standards in order to promote a tourism based on sustainability, innovation and digitalization services. The action will include the regeneration of the tourist and cultural heritage which will have to be implemented through an overall restructuring program of the tourist and cultural assets. All this starting from the assumption that Italy has a heritage of great value but at the same time presents many sites that require investments aimed at improving their attractiveness. Innovative models of work organization will be promoted, also through the development of networks and other forms of aggregation to develop the skills, digital and non-digital, of operators in the sector through access to qualified training. The author believes that the prospect of research in the immediate future must continue in the direction of the creation of museum networks that will be able to enjoy the support provided by the enormous potential of technological infrastructures towards which large investments will be directed even in the face of the strong push towards digital transition proved necessary precisely to address the consequences of the pandemic. A digitization process which, as indicated by the European Union, will have to involve the strategic sectors of all countries and will have to take shape through the guidelines drawn up by the respective governments.

CONCLUSION

Through this chapter, the author wanted to deepen the debate on the importance of digital technologies with reference to the cultural sector, which was one of the most affected sectors during the covid-19 pandemic due to all the various forced closures that they involved places of culture during the health emergency. The aspect that we wanted to highlight was the ability of many cultural institutes to react through a notable increase in the diffusion of their activities with the use of digital tools. In particular, compared with the period immediately prior to the pandemic, there was a strong growth in the use of all social platforms provided by the web with the objective to maintain a strong relationship with the target audience. Through the analysis of two specific museums, it was possible to see how a wise use of social media can prove to be a strategic tool for conveying one's cultural offer to a potentially infinite audience with no space-time limits, not only in emergency situations such as that recently lived but also in the most ordinary everyday life. The museum, through the digital, discovers that it is a place capable of opening up to the world through the use of a more contemporary language. The museum that, through the use of social networks, tells and disseminates its project and becomes more inclusive, managing to attract particular tourism segments that, intrigued by the uniqueness of the proposed projects, make themselves available to reach the territories in which they are located, even surpassing the logistical difficulties imposed by the region's infrastructural deficiencies. The study, however, did not limit itself to "narrating" the potential of digital communication but tried to provide food for thought on how technological innovation in the coming years should be the main ally for the entire Italian cultural sector, in particular in the regions of southern Italy, such as Calabria. The resources made available by the PNRR for the digital transition will also be used for a full renewal in the field of preservation and promotion of cultural heritage of the various areas of the country, especially for those which in recent years have suffered the most from the weight of a lack of social, economic, and infrastructural development compared to the rest of Italy. The investments of the so-called digital transition will allow, together with adequate national and regional policies, to innovate museums, adapting them to European standards. Resources that must also be used to encourage the creation of networks, in the logic of promoting sustainability through concrete actions that must increasingly include local communities in the development processes of the territories and that must take an active role in the requalification and regeneration of destinations tourism and in attracting responsible tourists. A process of transformation that can only materialize if there is a real willingness from the museums to sell shares of sovereignty in favor of a more noble objective, that of strengthening the territorial cultural offer to make it more easily identifiable by potential users. Networking

through the network. Take advantage of the digitization process that will involve the whole of Europe to start imaging new governance models that are able to guarantee the constant functioning of cultural networks over time and not for limited periods when the resources invested in specific projects are exhausted.

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KEY TERMS AND DEFINITIONS

Cultural Heritage: The set of goods and tangible and intangible testimonies that define the identity of a territory, a community.

Cultural Institutes: Places dedicated to the conservation and enhancement of cultural heritage, e.g., museums.

Digital Marketing: Promotion of one's activities through the use of the web and any other digital tool.

ICT: The set of all those innovative technologies that make it possible to process data and disseminate information.

Identity: Belonging to a homogeneous socio-cultural context.

Responsible Tourism: Sustainable tourism, which makes it possible to meet the needs of travelers without disfiguring the places visited.

Social Network: Digital platforms that have become commonly used for the dissemination of information and the sharing of multimedia content.

Territory: A defined geographical area which has specific characteristics.

ENDNOTES

1 On the 23rd of August 2019, the Directorate General for Museums published the Three-Year Plan for the Digitization of Museums and the Innovation of Museums (created with the collaboration, among others, of MiBAC, AgID, CNR, Politecnico di Milano, ICOM, etc.).

2 The Statute of ICOM, approved in the context of the 22nd General Assembly of ICOM in Vienna, on the 24th of August 2007, contains the most recent definition of a museum. This definition was implemented by the Italian legislation with the MIBAC Ministerial Decree of 23 December 2014 "Organization and functioning of state museums" in art. 1 which incorporates it in its entirety with a final clarification " *promoting knowledge of it among the public and the scientific community"*

3 Census of the Calabrian Museums. Survey carried out by the cultural sector of the Department of Culture of the Calabria region in the period of time from the 7th of September 2010 to the 31st of January 2011. This is a second regional census. A first census of regional museums instead refers to the year 2005.

4 From the Demoskopika report, now in its fourth consecutive year, to positively weigh on the new position of the Calabria region, there are three indicators: the good volume of online offers (fifth place), the online popularity of the categorized "Calabria" query for travel (fourth place) and Appeal tourism destination (fifth place). To negatively affect the rank of the regional destination, there is mainly an inadequate use of institutional promotion activity in social networks (eighteenth place).

5 Decree of the Ministry for Cultural Heritage and Activities of the 20th of December 2012

6 Tripadvisor uses a proprietary algorithm to determine Travelers' Choice winners. The algorithm takes into account the quality, quantity and topicality of the reviews and opinions posted by travelers on Tripadvisor in the last 12 months, as well as the presence of the business and its ranking in the site's popularity index.

Chapter 7
Earthquake Risk Prediction With Artificial Intelligence Methods

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ABSTRACT

Earthquakes are one of the most difficult natural phenomena in human history to predict. Today, despite very advanced technologies, earthquake predictions still have not been conclusive. It is especially known that the trilogy of location, time, and magnitude is quite difficult to predict at the same time. In order to discover this powerful natural phenomenon, scientists are trying to collect and make sense of the parameters affecting the earthquake and the earthquake results. In general, their goal is to determine the characteristics that have an impact on earthquakes, to perform classifications thanks to various artificial intelligence algorithms, and to predict future earthquakes. The aim of this study is to compile, examine, and analyze earthquake risk prediction researches or applications carried out using artificial intelligence methods. The studies obtained as a result of the literature review were grouped according to the metrics used, data sets, features, and models used and evaluated according to the success rates obtained.

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INTRODUCTION

Earthquakes are caused by sudden vibrations caused by fractures in the earth's crust, spreading in waves and shaking the earth. This natural phenomenon, which is difficult to predict today, has caused many losses of life and property over the centuries. Therefore, human beings have been trying to detect and predict earthquakes with the help of various signs since primitive times to predict the disasters that will happen to them and take precautions when necessary. Thanks to developing science and technology, human beings who base their predictions on mathematical and statistical methods have tried to make probability-related earthquake predictions, especially by using the ground, time, and magnitude parameters of previous earthquakes. This statistical prediction is usually carried out by artificial intelligence methods and is called seismic risk prediction. The first models used in seismic risk estimation are Poisson (Bath, 1979) and discrete value statistics (Epstein & Lomnitz, 1966). In these models, calculations were made based on the assumption that earthquakes are independent in terms of time and place. Today, these models have been replaced by machine learning (ML), deep learning (DL), transfer learning (TL) methods. With these methods, more robust calculations and predictions can be made.

In this chapter, the studies carried out in order to calculate the possible risk estimates of earthquakes and the data sets used are discussed. In particular, the evaluation of current studies between 2010 and 2021 was carried out.

BACKGROUND

In order to better understand the literature review section, this section will focus on earthquake magnitude types and some data sets used in earthquake prediction approaches. Although the data types are different, all of this data is used in the study to estimate the loss of earthquakes, lives, or property.

Magnitude Types

The magnitude is derived from the energy released by the earthquake. It allows us to express the magnitude of the earthquake numerically. In this way, we can determine the corresponding effects of magnitude levels by categorizing earthquakes.

The general purpose of the AI-based studies examined in this chapter is to predict the magnitude of earthquakes and to take precautions without overestimating the possible effects. Previous earthquake data of the designated region are used to develop earthquake prediction models with artificial intelligence methods. The measurement of calculated earthquake data is carried out indirectly. In other words, by studying

the effects of earthquakes, magnitude is calculated, and various magnitude values that define earthquakes are obtained using multiple methods (Kandilli Observatory, 2021; British Columbia Institute of Technology Department of Civil Engineering, 2021). These are the ones that are going to;

- Time-dependent magnitude (Md): Measurement is made using the duration of vibration in the seismometer. Magnitude range ~4.0 or smaller.
- Local magnitude (Ml): Measurement is made using the amplitude of the sound wave. Magnitude range ~ 2.0 to ~6.5.
- Surface wave magnitude (Ms): Measurement is made using wave amplitude emitted from the epicenter to the environment. Magnitude range ~ 5.5 to ~8.5.
- Body wave magnitude (Mb): Measurement is made using sound waves and cutting waves. Magnitude range ~ 5.5 to ~7.0.
- Momentum magnitude (Mw): Calculated by performing a mathematical model of earthquake formation. Magnitude range ~ 5.0 and above.

Table 1 lists the earthquake magnitude scale and its effects.

Table 1. Earthquake magnitude scale and effects

Magnitude	Class	Effect
2.5 or less	-	It is usually not felt but can be recorded with a seismograph.
3.0 – 3.9	Minor	It is usually felt but can only cause minor damage.
4.0 – 4.9	Light	It is usually felt but can only cause minor damage.
5.0 – 5.9	Moderate	It can damage buildings and other structures.
6.0 – 6.9	Strong	It can cause a lot of damage in multipopulated areas.
7.0 – 7.9	Major	It can cause very serious damage in multipopulated areas.
8.0 or greater	Great	It could completely destroy communities close to the epicenter. It's a total earthquake.

Examples Used in Earthquake Forecast Approaches

Various data on earthquakes that occur unexpectedly in certain regions of the world are stored with developing technology and digitalization. This data usually contains a variety of information such as latitude, longitude information, time, depth, ML magnitude of previous earthquakes. However, the data collected includes seismic

Figure 1. Standard seismic earthquake data
(Kandilli Observatory, 2021)

Deprem Kodu	Olus tarihi	Olus zamani	Enlem	Boylam	Der(km)	xM	MD	ML	Mw	Ms	Mb	Tip	Yer
20200829033626	2020.08.29	03:36:26.34	39.6762	27.8122	005.5		3.7	0.0	3.7	3.7	0.0	0.0	Ke	KALAYCILAR- (BALIKESIR) [North East 2.2 km]
20200826180157	2020.08.26	18:01:57.27	35.5632	31.6060	005.0		3.6	0.0	3.6	3.6	0.0	0.0	Ke	AKDENIZ
20200824072741	2020.08.24	07:27:41.94	39.0075	35.8543	005.0		3.5	0.0	3.5	3.4	0.0	0.0	Ke	PALAS-SARIOGLAN (KAYSERI) [South West 2.5 km]
20200823185637	2020.08.23	18:56:37.62	38.1787	38.6887	008.2		4.1	0.0	4.0	4.1	0.0	0.0	Ke	KORME-PUTURGE (MALATYA) [North West 0.6 km]
20200821175714	2020.08.21	17:57:14.64	39.0807	27.6843	007.5		3.6	0.0	3.6	3.5	0.0	0.0	Ke	BAKIR-KIRKAGAC (MANISA) [West 1.7 km]
20200820223855	2020.08.20	22:38:55.70	39.1407	28.9988	008.3		3.5	0.0	3.5	3.4	0.0	0.0	Ke	HACIAHMETOGLU-SIMAV (KUTAHYA) [West 1.0 km]
20200819183620	2020.08.19	18:36:20.78	36.6890	28.2367	071.9		4.0	0.0	4.0	0.0	0.0	0.0	Ke	OSMANIYE-MARMARIS (MUGLA) [South East 6.2 km]
20200818172459	2020.08.18	17:24:59.80	39.3123	40.3288	005.0		3.5	0.0	3.4	3.5	0.0	0.0	Ke	KIGI (BINGOL) [West 1.7 km]
20200813190806	2020.08.13	19:08:06.16	39.1153	37.8243	005.0		3.8	0.0	3.7	3.8	0.0	0.0	Ke	TASLI-KANGAL (SIVAS) [North East 1.6 km]
20200812170333	2020.08.12	17:03:33.46	35.7310	35.5115	004.9		3.6	0.0	3.6	3.6	0.0	0.0	Ke	AKDENIZ
20200811232907	2020.08.11	23:29:07.64	39.8427	44.1557	005.0		4.4	0.0	4.2	4.4	0.0	0.0	Ke	ASAGIERHACI- (IGDIR) [South East 7.7 km]
20200811181644	2020.08.11	18:16:44.96	35.3850	26.6373	002.8		3.6	0.0	3.5	3.6	0.0	0.0	Ke	GIRIT ADASI (AKDENIZ)
20200810042921	2020.08.10	04:29:21.11	37.4255	35.8727	007.6		3.6	0.0	3.5	3.6	0.0	0.0	Ke	ESKIKABASAKAL-KOZAN (ADANA) [South East 2.0 km]
20200808012951	2020.08.08	01:29:51.07	38.2305	38.7802	005.0		3.8	0.0	3.8	3.8	0.0	0.0	Ke	ORMANICI-PUTURGE (MALATYA) [West 0.2 km]
20200807192431	2020.08.07	19:24:31.94	38.0827	42.6287	005.0		3.5	0.0	3.5	0.0	0.0	0.0	Ke	SARPKAYA-HIZAN (BITLIS) [North East 0.9 km]
20200807192012	2020.08.07	19:20:12.40	38.0818	42.5935	004.5		4.8	0.0	4.7	4.8	0.0	0.0	Ke	OGLAKLI-HIZAN (BITLIS) [South East 0.6 km]
20200804184002	2020.08.04	18:40:02.48	38.2168	38.7588	005.0		4.8	0.0	4.7	4.8	0.0	0.0	Ke	PAZARCIK-PUTURGE (MALATYA) [South East 2.1 km]
20200804153056	2020.08.04	15:30:56.42	38.1888	38.7527	005.0		4.5	0.0	4.4	4.5	0.0	0.0	Ke	PAZARCIK-PUTURGE (MALATYA) [South East 4.1 km]
20200804131018	2020.08.04	13:10:18.33	38.2253	38.7723	005.9		4.0	0.0	3.8	4.0	0.0	0.0	Ke	ORMANICI-PUTURGE (MALATYA) [South West 1.0 km]
20200804093735	2020.08.04	09:37:35.08	38.1945	38.7270	005.5		5.7	0.0	5.7	5.7	0.0	0.0	Ke	ALIHAN-PUTURGE (MALATYA) [East 3.3 km]
20200803204817	2020.08.03	20:48:17.30	36.6192	43.7168	005.0		3.5	0.0	3.5	3.4	0.0	0.0	Ke	IRAK
20200802164600	2020.08.02	16:46:00.26	40.3135	41.6203	005.0		3.7	0.0	3.5	3.7	0.0	0.0	Ke	YUKARISIVRI-TORTUM (ERZURUM) [South 2.0 km]
20200731053318	2020.07.31	05:33:18.15	38.6933	38.1057	005.0		4.0	0.0	3.9	4.0	0.0	0.0	Ke	AKYAZI-YAZIHAN (MALATYA) [North West 1.7 km]
20200730234049	2020.07.30	23:40:49.44	35.0137	27.1237	005.0		4.0	0.0	3.9	4.0	0.0	0.0	Ke	GIRIT ADASI ACIKLARI (AKDENIZ)
20200730014758	2020.07.30	01:47:58.39	38.3295	44.4375	005.0		3.5	0.0	3.4	3.5	0.0	0.0	Ke	TURKIYE-IRAN SINIR BOLGESI
20200725170224	2020.07.25	17:02:24.29	35.5870	31.6497	087.0		3.6	0.0	3.5	3.6	0.0	0.0	Ke	AKDENIZ
20200725050238	2020.07.25	05:02:38.34	39.3432	40.3257	005.0		4.0	0.0	3.9	4.0	0.0	0.0	Ke	KIGI (BINGOL) [North West 4.1 km]
20200724021915	2020.07.24	02:19:15.32	39.8870	30.4707	001.8		4.1	0.0	3.9	4.1	0.0	0.0	Ke	SULUKARAAGAC-TEPEBASI (ESKISEHIR) [South West 3.1 km]
20200724011116	2020.07.24	01:11:16.84	39.7715	42.5122	005.0		3.6	0.0	3.5	3.6	0.0	0.0	Ke	CETINSU-ELESKIRT (AGRI) [North West 4.1 km]
20200722102124	2020.07.22	10:21:24.58	38.5718	27.5388	011.7		3.5	0.0	3.3	3.5	0.0	0.0	Ke	SANCAKLICESMEBASI- (MANISA) [North 2.0 km]
20200721072059	2020.07.21	07:20:59.62	38.2657	38.7998	005.1		3.5	0.0	3.5	3.5	0.0	0.0	Ke	KARSIYAKA-PUTURGE (MALATYA) [South West 1.1 km]
20200718195255	2020.07.18	19:52:55.53	38.2433	38.7417	005.0		3.9	0.0	3.8	3.9	0.0	0.0	Ke	BALPINARI-PUTURGE (MALATYA) [South East 0.8 km]

electrical signals, sky events, the position of stars, the pressure of the atmosphere, the behavior of animals before earthquakes.

Possible standard data for developing statistical prediction models using previous earthquake data are shown in Figure 1.

The sample data used for the development of earthquake prediction models using seismic electrical signals is shown in Figure 2.

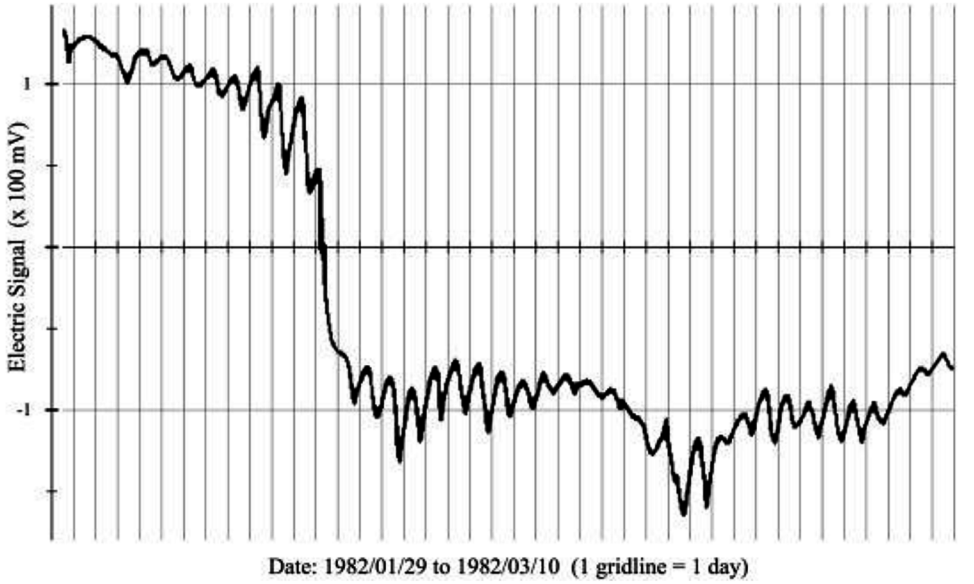
Sample data used for the development of earthquake prediction models using temporal tables and visuals of linear cloud formations by examining sky events are shown in Figure 3 and Figure 4.

The unusual reactions of animal behavior before an earthquake can be used in earthquake prediction. The milk efficiency of cows in a designated area is shown in Figure 5.

Earthquake Forecast Approaches in the League

The methods and success rates used in studies that use different datasets but serve the same purpose differ. There are many studies aimed to predict earthquakes by taking the advantage of natural phenomena: Thomas et al. (Thomas, Masci & Love, 2015) and Fan et al. (Fan, Chen, Yan, Gong &Wang, 2015) examined infra-red cloud images for earthquake prediction, while Korepanov (Korepanov, 2016) designed models based on lithosphere-atmosphere-ionosphere relationships. Similarly, Hayakawa et al. (Hayakawa,Yamauchi, Ohtani, Ohta, Tosa, Asano, Schekotov, Izutsu, Potikaris & Eftaxias, 2016) earthquakes that benefit from natural phenomena can be predicted by looking at the abnormal behavior of animals. Specifically, they

Figure 2. Seismic electrical signals earthquake data
(Helman, 2020)



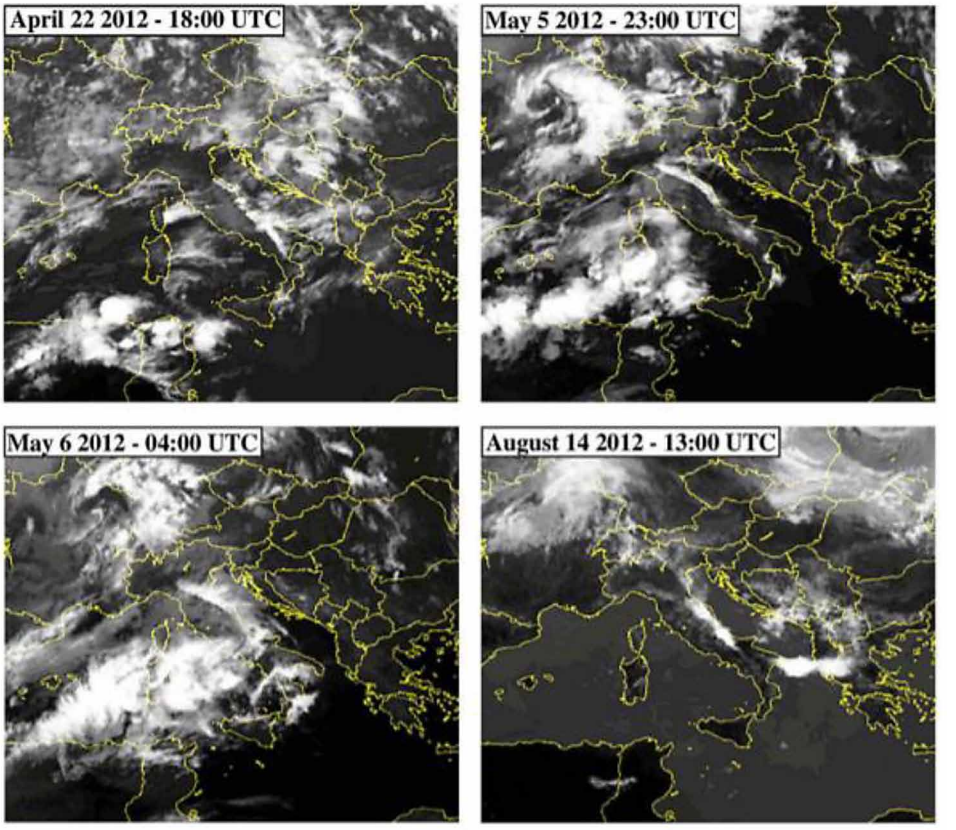
found that cows' milking rates decreased 10 days before earthquakes, suggesting that possible earthquakes could be predicted.

Some researchers used artificial intelligence algorithms to predict future earthquakes with statistics from previous data. Moustra et al. (Moustra, Avraamides & Christodoulou, 2011) tried to predict earthquakes in the Greek region with artificial neural network (ANN) models using seismic electrical signals that occurred before the earthquake. Reyes et al. (Reyes, Morales-Esteban & Martínez-Álvarez,

Figure 3. Temporal table of cloud formations
(Thomas, Masci & Love, 2015)

Date	Year	Approximate appearance time (UTC)	Approximate disappearance time (UTC)
8 Jun	2011	01:00	08:00
5 Dec	2011	07:00	23:00
14 Dec	2011	01:00	19:00
15 Dec	2011	00:00	12:00
21–22–23 Apr	2012	20:00 (day 21)	06:00 (day 23)
5–6 May	2012	21:00 (day 5)	06:00 (day 6)

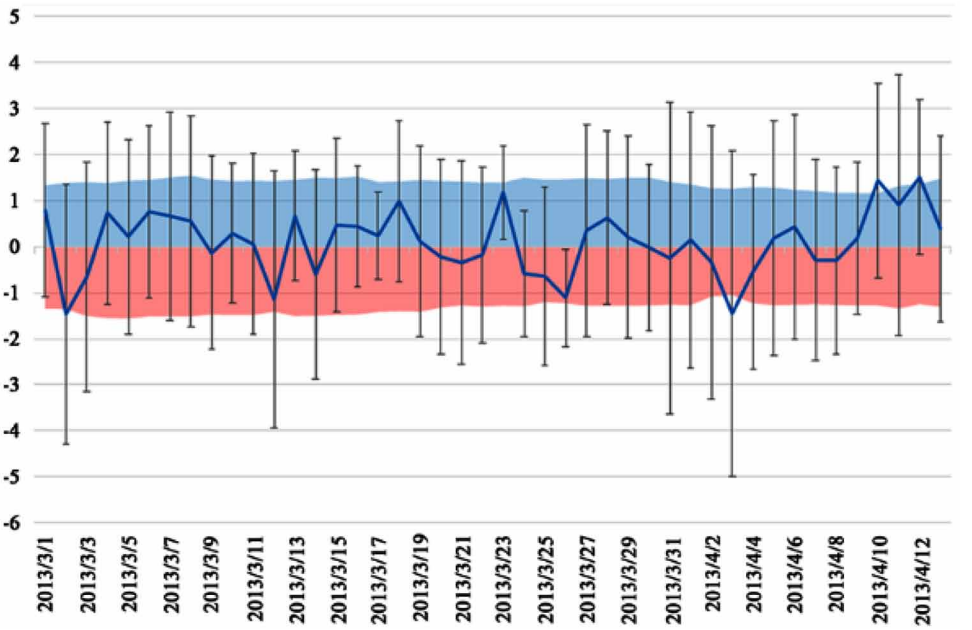
Figure 4. Cloud formations
(Thomas, Masci & Love, 2015)



2013) and Asim et al. (Asim, Idris, Iqbal & Martínez-Álvarez, 2018) developed an earthquake prediction model with data from the Chilean region. When comparing using some of the classic ML algorithms in Reyes et al., Asim et al. (Reyes, Morales-Esteban & Martínez-Álvarez, 2013; Asim, Idris, Iqbal & Martínez-Álvarez, 2018) proposed the Adaboost model, which is powered by genetic programming. Similar to the genetic algorithm (GA) model proposed by Asim et al. (Asim, Idris, Iqbal & Martínez-Álvarez, 2018), Tao (Tao, 2015) proposed the re-spread neural network (BPNN) model, which is strengthened with GA using data from the Himalayan and Nepalese regions.

Using seismic impact data, Celik et al. (Celik, Atalay & Bayer, 2014) and Li et al. (Li, Meier, Hauksson, Zhan & Andrews, 2018) have developed different models with similar data sets. Generative Adversarial Networks (GAN) and random forest (RF) algorithms combined to create a new model. Steel et al. have shown that SVM

Figure 5. Rates of cows giving milk before an earthquake, the abscissa indicates the date, and the ordinate is the milk yield
(Hayakawa,Yamauchi, Ohtani, Ohta, Tosa, Asano, Schekotov, Izutsu, Potikaris & Eftaxias, 2016)

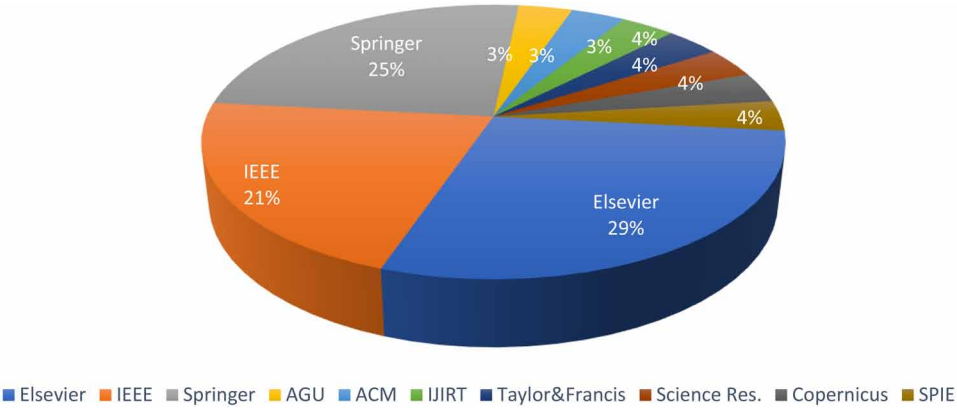


models make more successful predictions by comparing SVM models with ANN models, as Ruano et al. (Ruano, Madureira, Barros, Khosravani, Ruano & Ferreira, 2014) and Hajikhodaverdikth et al. (Hajikhodaverdikth, Nazari, Mohsenizadeh, Shamshirband & Chau, 2018).

Using data from Pakistan's Hindukush region, Asim (Asim, Idris, Iqbal & Martínez-Álvarez, 2018; Asim, Martínez-Álvarez, Basit & Iqbal, 2017a; Asim, Awais, Martínez–Álvarez & Iqbal, 2017b) and Saba et al. (Saba, Ahsan & Mohsin, 2017) proposed early earthquake detection systems developed with different algorithms. Asim et al. (Asim, Martínez-Álvarez, Basit & Iqbal, 2017a; Asim, Awais, Martínez–Álvarez & Iqbal, 2017b) used neural network models and ensemble algorithms, while Saba et al. (Saba, Ahsan & Mohsin, 2017) used an optimization algorithm for the model they proposed. Similar to the model developed by Saba et al., Li & Liu (Saba, Ahsan & Mohsin, 2017; Li & Liu, 2016) and Abraham & Rohini (Abraham & Rohini, 2019) used optimization algorithms to estimate earthquake magnitude. BPNN convergence was achieved faster in both studies thanks to the optimization algorithms. In this way, they were able to obtain better predictive results.

Menon et al. (Menon, Varghese, Joseph, Sajan & Francis, 2020) evaluated the performance of various classic ML algorithms by performing data preprocessing

Figure 6. Publishers of studies scanned in literature

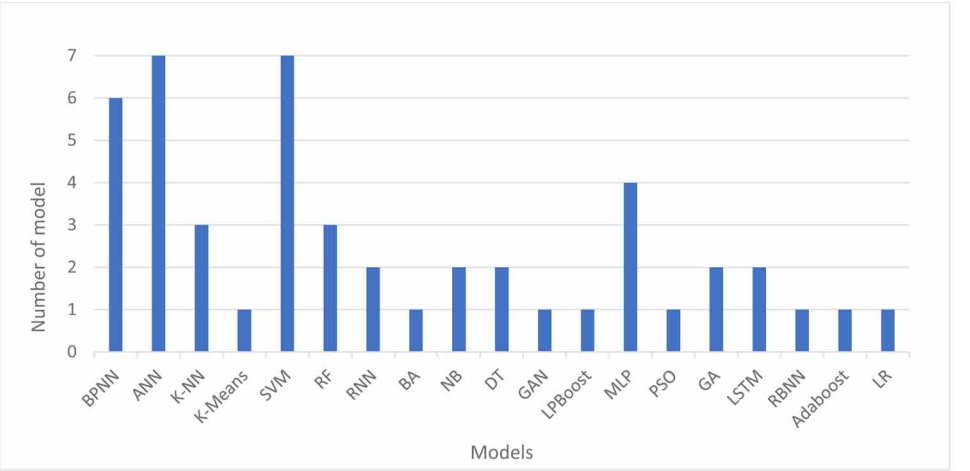


in their study. They found that Naive Bayes (NB) and Decision Tree (DT) models produced more successful results than others. In their study, Asencio-Cortés et al. (Asencio-Cortés, Martínez-Álvarez, Troncoso & Morales-Esteban, 2017) proposed a model called EQP-ANN to predict earthquakes in and around Tokyo. When they compared the models they proposed with various classic ML algorithms, as Menon et al. did, they observed that they worked better than other models. Observing the effect of optimum neurons on ANN models, Lin et al. (Lin, Chao & Chiou, 2018) stated in their study that they were able to predict earthquakes with BPNN models designed with the number of 10 neurons. Two years later, Lin (Lin, 2020) used data sets on the regions he identified with the same model to find recurrence earthquakes in these regions within 500 years. And he mentioned that he ultimately found more realistic results than his previous work.

Wang et al. (Wang, Guo, Yu & Li 2017) and Berhich et al. (Berhich, Belouadha & Kabbaj, 2020) used long short-term memory (LSTM) networks in earthquake prediction models. Both studies observed that the proposed parsing feature increases model success. In their research, Maya & Yu (Maya & Yu, 2019) compared their performance by combining multilayer perceptron (MLP) models with ML and TL algorithms. The benchmark calculated that the MLP+ML+TL model produced faster and more accurate results. Apart from earthquake prediction models, Xia Wang et al. (Xia Wang, Xin Niu & Feng Wu 2011) and Gul & Guneri (Gul & Guneri, 2016) tried to estimate the loss of life and property in earthquakes with artificial intelligence models.

The majority of the studies reviewed in the literature have been published by Elsevier, Springer, and IEEE, as shown in Figure 6. In addition, 82% of the

Figure 7. Models used in studies scanned in the literature



publications obtained as a result of the review were published in journals, and 18% were published in conferences.

DISCUSSION

As a result of the literature review, the models and other features used in the studies examined were turned into graphs and tables and examined in detail. The models and numbers used in the studies are shown in Figure 7. As seen in the graph, it has been observed that the usage rates of ANN, SVM and BPNN models are higher than other models. When we looked at the performance results obtained by using these models, it was seen that they produced better results than other models. It is thought that researchers prefer these models because they obtain more successful results in earthquake predictions. In addition, when the common characteristics used in ANN and BPNN models were examined, it was observed that 1 or 2 hidden layers were usually used, and they performed training procedures with an average of 10 neurons.

The reviewed resources are shown in Table 2 by making them tabled according to the results produced by the data sets used, the models used, metrics, and the best models. When the table was examined in detail, it is seen that the authors used data from regions at high risk of earthquakes (Li, Meier, Hauksson, Zhan & Andrews, 2018), (Abraham & Rohini, 2019), (Asencio-Cortés, Martínez-Álvarez, Troncoso & Morales-Esteban, 2017), (Wang, Guo, Yu & Li 2017) and (Maya & Yu, 2019). They used Accuracy or MSE metrics in order to evaluate the models they designed. There are three main parameters that can be predicted for earthquakes

in studies. These are the earth, the time, and the greatness. Looking at the studies scanned (Berhich, Belouadha & Kabbaj, 2020), the location, time, and magnitude of earthquakes were tried to be estimated at the same time. When looking at the binary estimates of earthquakes, the ground-magnitude binary (Reyes, Morales-Esteban & Martínez-Álvarez, 2013), (Asim, Idris, Iqbal & Martínez-Álvarez, 2018), (Hajikhodaverdikhan et al., 2018), (Asim, Martínez-Álvarez, Basit & Iqbal, 2017a) and (Asim, Awais, Martínez–Álvarez & Iqbal, 2017b) studies tried to predict the time-magnitude binary (Saba, Ahsan & Mohsin, 2017). In addition, in (Tao, 2015) and (Ruano, Madureira, Barros, Khosravani, Ruano & Ferreira, 2014), the number-magnitude of earthquakes was tried to be estimated at the same time.

FUTURE RESEARCH DIRECTIONS

This section gives some theoretical advice on developing earthquake risk prediction models. In addition, some useful recommendations are mentioned for the gaps and potential research areas in the literature on this subject.

For a future earthquake to be predictable, a specific pattern must be discovered. It has been seen as a result of reviewed studies that these patterns can be discovered with artificial intelligence models or at least predicted with high success. The design of the targeted earthquake prediction model must produce accurate forecasts for any location, be above a certain forecasting success, and work correctly for any data set. In this case, for the models to work efficiently, attention should also be paid to the data characteristics used during training. Researchers used previous earthquake data to predict earthquakes in the literature and took this data specifically from specific pilot areas known as earthquake zones. It is thought that more successful results can be obtained by adding groundwater levels, soil temperature, weather conditions at and before earthquakes to the data features used.

It is seen that the issue of predicting earthquakes with artificial intelligence methods has become more popular in recent years (Figure 8).

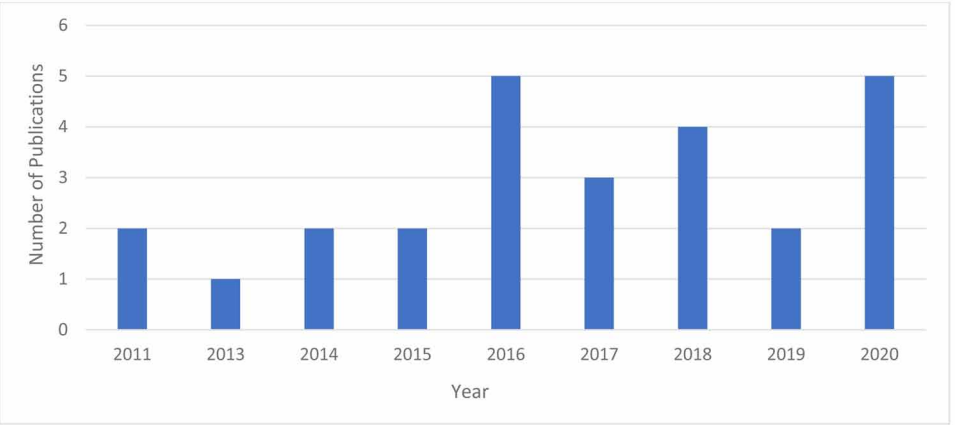
Work in this field is expected to increase over time. In particular, it has been observed as a result of reviewed studies that hybridized models using ANN, BPNN, or Genetic algorithms can produce more successful results. In addition, earthquake risk prediction studies carried out with DL algorithms during the literature research were less common than those carried out with classic ML algorithms. It is thought that if comparative performance analyses are carried out by applying this subject on DL algorithms, its contribution to the literature will be significant.

Recent studies have observed that the binary characteristics of earthquakes such as place-time, magnitude-time, or magnitude-place are more predicted. In such studies, it is considered that it is crucial to estimate the location, time, and magnitude values

Table 2. Models used in studies and performance evaluation of these models

Authors	Data Set	Models	Metrics	Model Performance
Moustra et al. 2011	It uses 21 years of seismic electricity signal data from the Greek region of Ml ⩾ 5.2.	BPNN	Accuracy	Earthquake ML forecast %83,56
Reyes et al. 2013	Uses data from Ml ⩾ 3 for the cities of Talca, Santiago, Pichilemu and Valparaíso in Chile.	ANN KNN K-Means SVM	Negative predictive value (NPV)	Average of best results ANN: A %82,5 B %81,3 C1%93,3 C2%78,2
Asim et al. 2018	Uses data from 1980-2016 in Hindukush, Chile and S. California regions in Pakistan.	GP-Adaboost	Ek Accuracy le	Hindukush %87 Chile %84,5 Pannakat %86
Tao 2015	It uses Mw ⩾ 6.5 data from the Himalayan and Nepal regions.	BPNN BPNN-GA	MSE	Earthquake ML estimated BPNN: Nepal: %0,72 Himalayan: %0,28
Celik et al. 2014	It uses seismic impact data from a coal mine in Poland.	ANN SVM	Ek Accuracy le	Best results SVM: %91
Li et al. 2018	Uses P wave and noise signal data from 1990-2016, which is Ml ⩾ 3 from S. California and Japan.	GAN-RF	Accuracy	%99,2
Ruano et al. 2014	It uses data from seismographic network stations in Portugal.	MLP SVM	Sensitivity	Best results SVM: %88,4
Hajikhodaver-dikth et al. 2018	It uses the climate and seismic data of Tabriz in Iran between 2006-2014.	MLP SVM	Accuracy	Earthquake ML forecast SVM: %96
Asim et al. 2017a	It uses data from 1976-2013, which is Ml ⩾4 belonging to the Hindukush region in Pakistan.	PRNN RNN RF LPBoost	Accuracy	LPBoost: %65
Asim et al. 2017b	It uses data from 1976-2013, which was Ml ⩾ 4 in Hindukush and 3 other regions in Pakistan.	ANN RNN RF MLP RBNN SVM	Accuracy	Best results ANN: %75
Saba et al. 2017	It uses data from 2002-2012, which was 3.5⩾ Ml ⩾7.5 for Azad, Kashmir, Hindibird and Belucisan regions in Pakistan.	BA-ANN BPNN	MSE	Best results BA-ANN: Azad %0,91 Baluchistan %1,5 Hindukush %2,7
Li & Liu 2016	It uses seismic data of coastal regions.	BPNN PSO-BPNN IPSO-BPNN	MAE	Best results IPSO-BPNN: %3,1
Abraham & Rohini, 2019	It uses the seismic data of Japan between the years 2010-2016.	PSO-BPNN	MSE	The PSO-BPNN model produced more accurate results than a simple BPNN model.
Menon et al. 2020	-	SVM KNN DT LR NB	Accuracy	Best results NB: %96,27 DT: %96,02
Asencio-Cortés et al. 2017	It uses data from Ml ⩾ 5 and 2015, which occurs within 200 km of downtown Tokyo.	EQP-ANN SVM KNN NB DT	Accuracy, mean	Hindukush EQP-ANN: Average ~%75
Lin et al. 2018	It uses the data of earthquakes of Ml ≥ 5 and depth ≤ 300 km of Taiwan region between 1990-2014.	EEMPBNN IEMPBPNN	MSE, mean	Hindukush EEMPBNN: Average %3
Lin 2020	It uses time, epicenter, Ml value, slip rate and depth data of earthquakes in Chi-Chi, Meishan, Hualien regions.	EEMPBPNN PBPNN	Accuracy, MSE	ML> 7 earthquakes in 3 regions have a recurrence period of 210 years in Chi-Chi, 170 years in Meishan and 70 years in Hualien with a probability of over 60%.
Wang et al. 2017	Uses data between 1966-2016, which is Ml ≥ 4.5 that occurred in China.	non-discrete LSTM, discrete LSTM	Accuracy	Best results Discrete LSTM: %87,59
Berhich et al. 2020	Uses seismic activity data of Morocco regions between 1900 and 2019.	discrete LSTM, ANN	MSE	Best results Discrete LSTM: %0,59
Maya & Yu, 2019	It uses the earthquake data of Ml > 4 from Italy.	MLP MLP+ML MLP+ML+TL	MSE	They achieved the best result with MLP+ML+TL. With this model, they have increased the convergence rate, giving more flexibility to learning parameters.
Xia Wang et al., 2011	It uses data from 37 major earthquakes in China between 1990 and 1995.	BPNN	-	They stated that close results were produced with the expected values.
Gul & Guneri, 2016	Mw ⩾ 5 which used data from 1975 to the present day in Turkey	Levenberg Marquardt (LM) - ANN	R-Square	They have shown that survivors are likely to be able to produce accurate predictions and provide information to improve the policies implemented in earthquake emergency management.

Figure 8. Distribution of publications by year



of earthquakes at the same time and that they can contribute to the literature. In addition to such studies, it is thought that it is similarly important for the authorities to take precautions and complete the necessary preparations in order to estimate the possible loss of life and property after the earthquake.

In short, it has been seen that trying to predict possible earthquake predictions, especially with artificial intelligence methods, has been more popular in recent years. Each study will contribute significantly to the literature. In particular, it is very important that earthquakes can be discovered a certain period of time before they occur, or that the date range is determined, and that the approximate magnitude and location are estimated. In addition, it is thought that estimating the loss of life and property in the aftermath of the earthquake will contribute to more measures and care of the official institutions and the public.

CONCLUSION

In this study, earthquake risk prediction studies prepared between 2010 and 2021 were compiled and examined using artificial intelligence methods. These studies, which were carried out in order to calculate possible risk estimates, were evaluated by making tables according to the metrics, data sets, and models used. In the studies obtained as a result of the literature review, it was seen that the magnitude of earthquakes was estimated, and ANN, BPNN, or SVM models were usually used for these procedures. The training of models used previous earthquake data in certain regions and data not found in the training data set with similar characteristics in the same region for testing. It was observed that all but one of the studies (Berhich,

Belouadha & Kabbaj, 2020) others could not predict the parameters of location, time, and size at the same time but could be easily predicted when binary combinations were preferred. In these studies, it has been observed that AI algorithms have achieved high success in earthquake risk predictions. It is thought that earthquakes will be one of the predictable natural phenomena with the proliferation and development of more effective models in the following years.

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Chapter 8
Scaling of Streaming Data Using Machine Learning Algorithms

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ABSTRACT

Today, data is generated continuously by millions of data sources, which send in the records simultaneously, in small to large sizes. The rapid growth of data in velocity, volume, value, variety, and veracity has presented big challenges for businesses of all types. This type of data is called streaming data. Streaming data includes a variety of data such as mobile application notifications, e-commerce purchases, sensors in transportation vehicles, information from social applications, IoT sensors. This data is required to be processed sequentially and incrementally on record by record and used for a wide variety of analytics including correlations, filtering, and sampling. Information derived from such analysis gives visibility into many aspects such as customer activity, website clicks, geo-location of devices. There has been a great interest in developing systems for processing continuous data streams. This chapter aims to design a scalable system that can instantly analyze the data using machine learning algorithms.

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INTRODUCTION

The volume of data currently produced by various activities has never been so big and generated at an increasing speed. With the development of technology day by day, its place and importance in our lives are increasing. Developing technology has improved the interaction of many devices with each other and with people. As a result of this interaction, a large amount of data emerges. Real-time generated data is valuable as soon as it arrives and supports decision-making. These data, which are sequential due to their characteristics, obtained in different sizes and irregular periods, are defined as streaming data. Streaming data may lose value or be lost entirely if not processed immediately. Therefore, it is crucial to develop scalable systems that continuously receive and analyze unstructured data. Streaming data is datasets with different properties than static data. In streaming data, the processing time of the algorithm is more critical than the processing time of the static data processing algorithm. Streaming data is valuable as soon as it arrives in the system and needs to be processed and evaluated quickly. E.g., The data coming to the application about the security of financial applications should be evaluated at that moment in terms of transaction security. The data model designed in static data is permanent, and it can update itself according to the data used in streaming data. Since the future data size cannot be predicted, the data model must be adapted to the time-varying data flow. The time required for processing and evaluating streaming data is more limited than static data. The shortening of the evaluation period is critical for the value of the data in the application where streaming data is used.

The setup and continuity of a system that can receive and process streaming data is essential for resource usage. Data analysis hardware is insufficient for good design and easy use. Along with the status of these aircraft, resources are acquired if needed. This system of systems will also be financial (Nittel, 2015). With the data being stored, the references taken from the streaming data model are put in the foreground instead of the applications related to the data records. A small size velocity detail is vital for data in such programs. Volume refers to the unknown of the total size of the data and the size of the entire data. Scanning significant volumes of streaming data in entire storage or time intervals has a negative impact on system performance. The speed will be the probability of being given for a period of time it can process data that can be a job once. Since the streaming data may change over time, the algorithm used if it runs more than once, the model needs to be updated. Accuracy refers to the reliability of the data and whether it needs review. Streaming data is often heterogeneous, and many different types of data are processed together. The concept of diversity provides information about this feature of streaming data.

Fields such as social media applications, e-commerce, mobile applications, the internet of things, operation tracking systems, advertising can be examples as

streaming data sources (Kolajo et al., 2019). With the development of e-commerce and web applications, web analysis has gained an increasingly important role. Big data processing tools are used to analyze data such as the number of visitors to the relevant website, the relationship between the products examined, and the user profile. Thus, it was possible to collect and process data in real-time. Physically monitored operations tracking systems are one of the main data sources of streaming data. Basically, metrics that affect the overall performance of discrete computer systems are monitored. A lot of data is processed and recorded, such as the status of disk drives, processor load and performance, network usage, storage unit performance, and access times. Monitoring these systems is important for overall system performance and identifying potential problems. Advertising applications is one of the most critical areas where data is produced and evaluated in real-time. Metrics such as purchases and ad clicks in different environments, together with real-time bidding systems, offer the opportunity to reach the right customer group at the right time. The data produced for this is collected and processed with the metrics determined from the system. Valuable data produced as output is used in new proposals.

Streaming data differs from static data with some features. In streaming data, access is provided in a sequential manner, while in static data, access can be sequential or irregular. Due to the large volume of data, memory usage is more limited in streaming data. In algorithms used to process data, the processing time is more important than static data. Since the arrival rate of the data is high, possible extensions in the algorithm time directly affect the system performance. Since the data is valuable as soon as it arrives in the system, the data processing speed must be high.

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This study aims to design a scalable system that can instantly analyze the streaming data using machine learning algorithms. The following parts of the study are organized as follows: In the Background section, the studies in the literature are examined and the analyzes made, and the methods used are discussed. In the third section, the platforms to be used to process the streaming data, the system design developed, and the algorithms used are detailed. The fourth section analyzes how the proposed system processes the streaming data and analyzes the scaling results. Finally, the fifth section gives information about the conclusion and the future work planned to be done.

BACKGROUND

Although the analysis of streaming data is a new concept, there are studies in the literature on this subject. In the first studies, determining the characteristics of the streaming data, evaluating the streaming data in different application areas, and the success of the solution methods applied against the problems encountered was evaluated. Krishnaswamy et al., in their related study, gave information about the characteristic definitions of streaming data and the studies to be developed for the needs of streaming data (Krishnaswamy et al., 2005). One of the biggest problems encountered in streaming data analysis methods is that most of the data that makes up the streaming data are unlabeled. Jing et al. tagged the unlabeled data based on the learning set in their related study. Using the K-means clustering algorithm, the learning set was divided into as many clusters as the number of labels in the labeled data, and the unlabeled data were labeled in the obtained clusters. As a result of the study, 89% accuracy was achieved in the learning set with 11% labeled and 89% unlabeled data (Jing et al., 2011).

One of the important studies on streaming data analysis is Bifet et al.'s related work (Bifet et al., 2011). In this study, classification, regression, and clustering algorithms are used for streaming data analysis problems. It is possible to monitor the streaming data instantly and work with more than one algorithm on the same data. With the user interface provided in the application, it is possible to analyze the streaming data with different algorithms.

Lindburg et al., the method developed in their related studies consists of four steps: data collection, evaluation, analysis, and processing (Lindburg et al., 2017). Different calculations are performed to evaluate the data flow. These calculations are used in the planning and evaluation steps. Data such as size, processing time, bandwidth are measured for each data message. By comparing the memory usage and processor consumption values of the data set, the performance of the new system designed according to the existing systems is evaluated.

Meng et al., related work, the data is used in relation with machine learning by extracting all its properties (Meng et al., 2017). With too many queries, workloads and datasets, multiple models were implemented. For the trained model, the amount of resources that will be consumed in new upcoming workloads is estimated. In the tests, less resource consuming and pump compressor was made.

Liu et al., in their related study, the distribution of the streaming data coming into the system is discussed. With a distribution planner module created, functions are created for the operations to be performed by listening to the speed of the streaming data coming into the system. With these functions, data load and resource estimation were made, and scaling was made. The efficiency of the system was evaluated by measuring the output from the system according to unit time (Liu & Buyya, 2019).

Li et al., in their related study, a scheduling algorithm has been developed based on the traffic of the streaming data between stations and the load balances at the stations. Efficiency was evaluated by testing memory usage, estimated and actual CPU loads, latency, and traffic density between stations (Li et al., 2016).

Regarding streaming data analysis, Hulten et al., in their related study, aimed to make changes in the learning phase of the decision tree method and work according to the streaming data (Hulten & Domingos, 2000). The index value used in the calculation during the learning process was calculated for each new data sample concerning its effect on creating leaf nodes. In this method, since the index value is not recalculated for each data sample, it has been observed that the analysis of the streaming data accelerated by 20% compared to the classical decision tree algorithms.

One of the important points in streaming data processing studies is to increase resource efficiency. Li et al., in their related study, a predictive model that processes fast and distributed data is designed. A topology-sensitive algorithm is used that estimates the model's average beam processing time for a given solution time using runtime statistics (Li et al., 2015). The model was enabled to pass the learning phase with metrics such as memory, workload, processor usage load by using a supervised learning algorithm. It was evaluated that the topology created in the tests with word count workload was successful at 83.7%.

MAIN FOCUS OF THE CHAPTER

Analysis Method

Streaming data processing systems are generally developed on Apache Kafka, Apache Spark, Apache Storm, Massive Online Analysis (MOA). This section discusses the Java programming language, the processing of data flow using MOA, and its working with Apache Flink for scaling. The structural features and operation of these tools are explained below.

Recommended System Model

In this study, the CluStream-Kmeans++ algorithm obtained by customizing the CluStream algorithm, one of the clustering methods, was used. Streaming data clustering algorithms are a combination of classical clustering methods against streaming datasets that appears as an adaptation. CluStream clustering algorithm can be characterized in two steps as online and offline components. Data abstraction can be expressed as an online component and data clustering as an offline component.

The online component only takes care of extracting relevant information from certain data structures for use later in the offline component step.

The CluStream algorithm is an algorithm that can be used to cluster the streaming data set effectively. The clustering problem aims to divide the dataset into one or more similar object groups using a distance measure. Since streaming data clustering cannot preserve all the information used due to memory limitation and cannot reprocess historical information, the algorithm must keep a small summary of the received data. CluStream efficiently circumvents this problem by using online and offline components. The online component analyzes the data in one pass and stores summary statistics, while the user can use the offline component to query the cluster evolution over time. To maintain these summary statistics, CluStream uses a micro-clustering technique. These micro sets are further used by the offline component to create higher-level macro sets (Sheikholeslami et al., 2000).

Definite data structures are used to work in each algorithm. The CluStream algorithm uses certain data structures called Cluster Feature Vectors to summarize large amounts of data in the online component. Set feature vectors consist of the number of data objects (N), linear sum of data objects (LS), and sum of squares (SS) of data objects. The variable n expresses the data sample. LS and SS are n-dimensional arrays. The set feature vector retains the increment and additive properties to add points to or combine vectors. In the CluStream algorithm, cluster feature vectors are called microclusters with an additional time component. The time components are the sum of timestamps(LST) and timestamps squared(SST). A new incoming data point can be added to the cluster feature vector by updating the following information of the vector.

The offline stage of the algorithm takes as input a value of h as a time scope and a set of k high-level clusters. The k value determines the verbosity of the final clusters, the h value determines how much history should be covered by the algorithm. Lower h values take in more recent information, and higher k values create more detailed clusters. At this stage, macro sets are determined using the K-means++ algorithm, which produces faster and more efficient results than the K-means algorithm used in the classical CluStream algorithm. The K-means algorithm uses a method that randomly selects the initial cluster center when starting clustering in the offline step. This method has a negative effect on the worst-case running time of the k-means algorithm and is directly related to the streaming data size to the system. For this reason, there is a risk that the results to be produced will not be close to the optimum solution.

The K-means++ algorithm is used as a new macro clustering method that can solve the above problems in the offline stage of the CluStream algorithm (Vassilvitskii & Arthur, 2007). The K-means++ algorithm determines cluster centers using a technique known as D2 weighting. In this method, the center to be determined

according to the first selected point is determined by choosing a point proportional to the square of its distance from the nearest determined center.

The CluStream-Kmeans++ algorithm was integrated with the Massive Online Analysis (MOA) application and used in the study. MOA; It is a program developed based on Java, preferred in academic studies, suitable for open source development, and can process data with machine learning algorithms online and offline. MOA; It supports steps such as processing the streaming data, statistical evaluation of machine learning methods on the data, and visually monitoring the streaming data and the model extracted from this data by learning.

When the MOA architecture is examined, the data connections received from the external environment are processed in the data feed step, and a data flow connection is created. In the second step, learning algorithms are integrated into the received dataset. In this step, besides the ready learning algorithms offered by MOA, new learning algorithms developed can also be integrated. The application code of the CluStream-Kmeans++ algorithm developed in this study was integrated into the MOA in this step. In the evaluation step, the performance of the method used in the application is evaluated on the streaming data. In the conclusion step, the outputs of the study are obtained, and the result analysis is performed. With the Clustream-Kmeans++ algorithm, the state of the system is monitored periodically according to the metrics determined during the processing of the streaming data. Input instant status results in the MOA app. In the system state monitoring method, which takes the system as the basis, an evaluation is made by monitoring the changes in the system parameters. When necessary, an analysis is made to send a request to the Apache Flink application for scaling.

Apache Flink is a distributed computing architecture that can process limited and unlimited data and be used in stateful computations. It is of great benefit in projects where high efficiency and low latency are expected, such as streaming data, and where processor and memory problems arise. Apache Flink enables applications to process data from one or more sources in parallel via the DataStream API. In the Flink architecture, three operators take part during the operation of a stream. The source operator determines the data source that will enter the stream. The operation operator is the operator that performs the operations during the flow. The output operator is responsible for delivering the output streams produced to the relevant receiver. This receiver can be a block of code or a file listening for this stream.

Along with the CluStream-Kmeans++ algorithm developed within the scope of the study, ClusTree, DenStream, StreamKM++ algorithms in the literature were used for the accuracy evaluations. The ClusTree algorithm (Assent et al., 2011) is one of the streaming data clustering algorithms that uses micro-clusters as a data aggregation method consisting of two stages, online and offline. The micro-clusters in the online section are combined with the hierarchical clustering principle. Cluster

union and cluster separation operations are performed continuously. A data sample processed by the algorithm is directed to the tree-shaped data structure and reaches the most appropriate leaf. If there is no suitable leaf for the data sample, a new cluster is created for the data sample and added to the tree structure. The ClusTree algorithm can adjust the operating speed according to the arrival rate of the streaming data it processes and can cluster at any time. The soft clustering feature also gives the opportunity to produce clustering results at any time and to observe and correct these results.

DenStream algorithm (Ester et al., 2006), similar to ClusTree algorithm, consists of two parts as online and offline. Before starting the online clustering, which is the first clustering stage, the initial clustering processes must be completed. Apart from ClusTree, the density-based clustering method DBSCAN is used in the initial clustering process. DenStream algorithm performs the online clustering step after completing the initial clustering process. The nearest microcluster is searched for the incoming streaming data sample and the data sample is assigned to that cluster. If the data sample is not close to any microcluster, a new micro set is created for that data sample. With the microclusters determined in the online clustering part, the real clustering process is carried out in the offline clustering phase. The DenStream algorithm gives more importance to the most recent streaming data in its calculations. This distinction is made by the calculation given in equation 2. In this equation, the value of a is the factor value; r represents the arrival time of the data sample.

$$f(r) = 2^{-a.r} \tag{1}$$

StreamKM++ algorithm (Singh, 2017), unlike the algorithms mentioned above, uses kernel tree structure instead of microclusters in the streaming data summarization process. In this structure, data is hierarchically clustered in a binary tree structure. The StreamKM++ algorithm is a streaming data clustering algorithm based on Euclidean distance and k-means.

SOLUTIONS AND RECOMMENDATIONS

In this section, the analysis of the proposed system and the developed CluStream-Kmeans++ algorithm with other algorithms in the literature are detailed. Six different evaluation indices were used to evaluate the algorithm performances.

Evaluation index is the measurement values that show how successfully the data is processed, regardless of having prior knowledge about a data set. Evaluation indices are divided into internal and external evaluation according to variable criteria. Internal evaluation methods evaluate the data with its appearance when data is

processed, without any prior knowledge about the data. Silhouette index, Davies-Bouldin index, the sum of squares of error are the most well-known and widely used internal evaluation indices. External evaluation methods perform evaluations by having preliminary information about the processed data and using the label information. F1- Precision, F1- Recall, purity, Rand index are the most known and widely used external evaluation indices. In the scope of this chapter, six evaluation indexes were used to test the developed algorithm. These are the Silhouette index and the sum of squares of error as the interior evaluation indices and F1-Precision, F1-Recall, Rand index, and purity as the external evaluation indices.

F1-Measurement; It is a criterion used in binary classification statistically, which is found using real labels (Singh, 2017). It determines how successful the prediction is. It is calculated with the values of F1-Precision and F1-Precision and a value in the range of [0,1] is obtained. A high calculated value indicates a successful clustering. F1-Precision expresses the ratio of the correct information obtained to the correct information that needs to be obtained. F1-Recall expresses the ratio of obtained correct information to all incoming information. It gives information about the accuracy of the clustering.

Purity refers to the ratio of the largest number of data in each cluster to the total number of data in the clustering approach made in the model used (Singh, 2017). The purity value takes a value in the range of [0,1]; a high purity value indicates successful clustering. The purity value is calculated by equation 2.

$$P = \frac{\sum_{i=1}^{k} c_i}{N} \tag{2}$$

In equation 2, N is the total number of data samples, c_i is the sample data with the largest number in the cluster.

Sum of squares of error expresses the sum of the squares of the distance of each element in the cluster from the center of the cluster (Singh, 2017). The small values obtained show that the clustering study was successful. This method, dependent on the number of clusters, is calculated by equation 3. In this equation, x_i is the number of cluster elements in the cluster, N is the total number of elements in the cluster, y is the corresponding cluster center.

$$SSE = \sum_{i=1}^{N} \left(x_i - y\right)^2 \tag{3}$$

The rand index is an external evaluation metric that calculates the similarity of the data in the cluster by evaluating the data in pairs with other data in the cluster it is included during the calculation (Singh, 2017). The rand index value takes values in the range [0,1]. The larger the calculated value, the greater the similarity of the two clusters.

Silhouette index is an index value calculated to measure how similar the elements of a cluster are to its own cluster when compared to other clusters (Singh, 2017). Silhouette value takes values in the range of [-1, 1]. High values to be obtained as a result of the calculation show that the clustering process is successful. Silhouette index is calculated with the following equation 4.

$$S\left(i\right) = \frac{k\left(i\right) - m\left(i\right)}{\max\left(k\left(i\right), m\left(i\right)\right)} \tag{4}$$

When calculating the Silhouette index of the i. element in the X_i set; k(i) is the Euclidean average of distances to other cluster elements other than the cluster to which the relevant point belongs; m(i) represents the Euclidean distance mean to the elements in the cluster to which the point i belongs.

In the accuracy assessment study, real and synthetic data sets were used. The Forest Cover Type dataset, which contains data on seven plant species, the dominant species in Roosevelt National Park in North Colorado, obtained from the US Forest Service Resource Information System data, was used as the actual dataset. There are 12 feature spaces in this data set, of which 2 are binary data sets, and 10 are continuous.

In the study, Forest Cover Type was used as the real data set to create a streaming data flow. The Forest Cover Type data set consists of 581.012 data and includes the observation information of the trees in the forest. Numerical 10 feature data were used in the experimental studies on the data set. Measurement information such as the height, direction, and distance of the trees to the nearest water source is included in the data set.

As seen in Table 1, in the test studies performed with other algorithms in the literature on real streaming data, it was seen that the CluStream-Kmeans++ algorithm produced better results than other algorithms. The biggest reason for this situation is that other algorithms used in the tests do not have a structure to detect the data size and regulate the parameters they use. The fact that the real data used was more irregular than the synthetic data, and the two data points in the same group were not similar to each other compared to the synthetic data, which also contributed to these results.

Table 1. Study results with real data

Algorithms	F1-P	F1-R	SSE	Silhouette Index	Rand Index	Purity
CluStream-Kmeans++	0,74	0,69	11,1	0,79	0,6	0,8
CluStream	0,44	0,41	20,2	0,6	0,55	0,7
StreamKM++	0,09	0,08	42,4	0,65	0,52	0,6
ClusTree	0,4	0,28	25,8	0,7	0,51	0,6
DenStream	0,38	0,21	29	0,66	0,48	0,6

While the algorithms can produce consistent and accurate results, the time they spend processing the streaming data is also important. The instant change of the streaming data and the value of the produced results also increase the importance of the time spent processing this data. The algorithms are evaluated according to the data type and the number of data they process.

Table 2. Process time with real data

Algorithms	Process Time(s)
CluStream-Kmeans++	47
CluStream	58
ClusTree	84
StreamKM++	142
DenStream	109

In Table 2, the time spent by the algorithms in the study on real data is given. The factors such as noise and size information in the real data processed cause the working time to prolong. As a result of the study, the CluStream-Kmeans++ algorithm showed better results than other algorithms with 47 seconds of running time. The operations performed by DenStream, StreamKM++ algorithms in the offline clustering step, depending on the number of micro-clusters in the online clustering step, extend their working time. In the ClusTree algorithm, the working time is completed in a shorter time than the DenStream and StreamKM++ algorithms due to the hierarchical clustering with the tree structure.

In the MOA application, synthetic data flow can be created with certain configurations. Algorithms run on a randomly generated data set of 1,200,000 samples. Their performance was evaluated according to the six evaluation criteria

Table 3. Study results with synthetic data

Algorithms	F1-P	F1-R	SSE	Silhouette Index	Rand Index	Purity
CluStream-Kmeans++	0,79	0,71	8,73	0,79	0,81	0,88
CluStream	0,68	0,61	13,5	0,72	0,8	0,82
StreamKM++	0,75	0,68	9,67	0,78	0,89	0,87
ClusTree	0,48	0,54	17	0,71	0,73	0,86
DenStream	0,31	0,17	42,6	0,69	0,44	0,75

given in the section. In order to send this synthetic data set to the system as streaming data, 1500/period data was sent to the algorithms on the application side.

Table 3 shows the average results obtained with accuracy assessment measurements on synthetic data. It was observed that the CluStream-Kmeans++ algorithm achieved better results compared to other algorithms in the literature in terms of F1-P, F1-R, SSQ, Silhouette index, and purity criteria. In the evaluation made with the Rand index criterion, it was seen that the ClusTree algorithm and then the CluStream-Kmeans++ algorithm produced better results.

Table 4. Process time with synthetic data

Algorithms	Process Time(s)
CluStream-Kmeans++	24,2
CluStream	37,2
ClusTree	57,5
StreamKM++	104,8
DenStream	80,5

In the study with synthetic data in Table 4, it has been observed that the developed CluStream-Kmeans++ algorithm works in the shortest time with an average of 24.2 seconds. Compared to real data, all algorithms produced more successful results in the study with synthetic data. The most important reason for this difference is that synthetic data is more stable than real data. The offline clustering of the DenStream and StreamKM++ algorithms described above and the hierarchical operation of the ClusTree algorithm with the tree structure affected the working times.

FUTURE RESEARCH DIRECTIONS

Within the scope of this study, the analysis of the streaming data with machine learning algorithms using the developed CluStream-Kmeans++ algorithm, instant monitoring of the system during the flow, and scalability analysis when necessary. It has been observed that successful results have been produced in this context in real and synthetic data tests. More robust resources are needed to carry this work forward. Systems with more stations can be installed on distributed systems with specialized computers. In this context, it is thought that it can be done by getting support from big data processing systems such as Apache Spark and Apache Hadoop.

CONCLUSION

With the development of technology day by day, its place and importance in our lives are increasing. Developing technology has improved the interaction of many devices with each other and with people. As a result of this interaction, a large amount of data emerges. This real-time generated data is valuable as soon as it is produced. These data, which are sequential due to their characteristics, obtained in different sizes and irregular periods, are defined as streaming data. Streaming data can lose value or be lost forever if not processed immediately. Therefore, it is crucial to develop scalable systems that continuously receive and analyze unstructured data.

Within the scope of this chağter, the main features and sources of the streaming data were examined and detailed. Afterward, the algorithms used in the literature and the studies were analyzed. Detailed information about the features of machine learning algorithms used in the study is also given. The developed CluStream-Kmeans++ algorithm was detailed and technical information about application integration was discussed. The working principle and features of CluStream, ClusTree, DenStream, and StreamKM++, which are other algorithms in the literature used in the testing phase, are explained.

The developed CluStream-Kmeans++ algorithm works integrated with the MOA application. The usage details of the MOA application are explained, and the critical points to be considered in application integration are detailed.

By explaining the streaming data evaluation metrics used in the evaluation step of the application, information was given about the real data, and artificial data sets used. In the test study with the Forest Cover Type data set, it was seen that the algorithms were more complicated than the artificial data. It has been observed that situations such as inconsistency in real data and noise cause this situation. It has been observed that the CluStream-Kmeans++ algorithm produces better results

against CluStream, DenStream, ClusTree, and StreamKM++ algorithms with the K-means++ method used in the offline clustering step.

The results produced by the algorithms were observed in the test study conducted with 1,200,000 artificial data created with the flow data creation feature in the MOA application. In the average results, it was seen that the CluStream-Kmeans++ algorithm produced more performance results.

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Chapter 9
Active Institutional Investors: Impact Investing and Some New Trends – The Rise of the Generation Z

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ABSTRACT

This chapter, moving from some brief general considerations on different types (or models) of "active" (or "activist") institutional investors, analyses the birth of the "impact investing" phenomenon and the role of the COVID-19 pandemic crisis in accelerating the rise of sustainable finance. Within this framework are identified those institutional investors that effectively invest their assets according to the "ESG" criteria, highlighting that the post millennials, or Generation Z, are—at least apparently—the chosen beneficiaries of this new financial investment model.

INTRODUCTION

This paper in the first place attempts to answer to the main question who are the "active Institutional Investors", to describe the rise of the *impact investing* phenomenon and to explain the role of the *Covid-19* pandemic crisis in accelerating the rise of the sustainable finance. Moreover, the second part of this work look at the Italian specific context and describe what kind of institutional investors are more widespread in Italy among the new generations of investors, the so-called Post-Millennials, (named "post-Millennials" because they follow the "Millennial Generation", so defined by Strauss and Howe in their 1991 book intitled "Generations"). The post-Millennials

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are also known as "Z-Generation", or "Gen-Z" (and as "Centennial", "Digitarian", "iGen", "Plural", "Zoomer")The ultimate goal is to verify the real propensity of this cohorts of investors towards this new financial investment model, that is impact investing, which actually invest assets according to the ESG criteria.

WHO ARE THE ACTIVE INSTITUTIONAL INVESTORS?

Although the assertion that financial intermediaries and institutional investors take an active role in the companies whose shares are present in their securities portfolio is common and widespread, in reality the behaviour of these investors is much more varied and diversified.

Activism is not a generalized and widespread behaviour among all categories of financial intermediaries and institutional investors, and estimates show that the most relevant phenomenology of activism comes, at an international level, from foreign hedge funds, especially North American hedge funds, and the "AIF" and "reserved AIF" under European financial markets law.

With specific reference to the European framework, it is known that with the AIFMD directive the legislator has chosen to introduce a minimal framework of common rules, using a *subjective* rather than an *objective* approach (i.e. a framework of rules, especially in the supervisory field, which is harmonized not for *types of funds* but for *types of fund managers*) precisely because of the difficulty of harmonizing such a great variety of types of alternative mutual funds as is the one present in Europe.

It can be observed, for example, that *absolute return funds*, or *total return funds*, are characterized by the purpose of obtaining a return that is totally independent and unrelated to market performance, and therefore even if belonging to the UCITS macro-category (and therefore ranking among the harmonized funds) they are closer to hedge funds. In turn, *flexible V.a.R. finds* are similar to *total return funds* which have the constraint of respecting a "Value at Risk", i.e. an estimate of the maximum potential loss that the subscriber of a share of the fund could suffer in a given time horizon. Some *flexible funds* are market neutral, i.e. managed with the ambition of making its performance depend exclusively on the performance of the chosen instruments. Overall, in terms of volumes, most of the AIF's assets under management are attributable to "closed-end" funds.

Therefore, it is strange that the activism of *closed-end mutual funds* has always been poorly investigated, although they have a *strong propensity for collaborative behaviour* in the companies in which they have invested, due to poor liquidity and the constraints on diversification.

Even the activism of *real estate funds*, institutionally "closed", is a growing phenomenon which remains, on the whole, very little investigated, and so is that

of *listed real estate companies*, which are, however, numerically rather small and therefore less significant. Compared to American real estate investment trusts, the latter boast greater freedom: no limit to the number of shareholders, no absolute limit on the *ratio* between risk capital and debt capital - which allows them to choose the debt threshold - no risk concentration limit (except for the prudential parameter for which no more than 20% of revenues can come from the same lessee), direct administration by the shareholders without the management intermediation of the investment management company ("società di gestione del risparmio, or SGR" in italian).

Phenomena of activism also come from some *closed private equity funds* and *venture capital (closed) funds* and from *business angels*. These types of investors usually buy unlisted shares on regulated markets and adopt an active behaviour and a behavioural policy very similar to that of hedge funds in the relative issuers, which is characterized by mutual cooperation and often results in a conflictual relationship with the majority shareholders, that sometimes leads to *negotiating activism*. This explains the stipulation of special negative covenants, having as their scope the undertaking not to adopt resolutions (modifying the statute) that could damage the value of the equity investments.

In conclusion, the specific weight of activism from categories (growing but quantitatively limited) of financial intermediaries stands out, which are largely *non-institutional investors*, i.e. investors that cannot freely collect savings from the public, inasmuch they invest their assets even in complex, illiquid and highly risky financial instruments.

The analysis of this information calls for two further critical observations: firstly, the European data are less up-to-date than the American ones, with the exception of those concerning Germany and Great Britain, and partly France and Scandinavian countries.

Secondly, the literature and data on venture capitalist activism often proceed along parallel and poorly integrated tracks with respect to studies and data dedicated to other financial intermediaries and institutional investors.

Therefore, a survey which, starting from the available data, draws a more detailed state of the art distinguishing between the different types of investors, and clearer conclusions in terms of trends in the behaviour of different types of financial intermediaries and institutional investors is required.

ACTIVE INSTITUTIONAL INVESTORS AND THE RISE OF THE IMPACT INVESTING PHENOMENON

With reference to the topic of institutional investors activism the recent growing development of the so-called *Impact Investing* (Global Impact Investing Network-GIIN, 2018, p. 26) which the Covid-19 Pandemic accelerated dramatically (Global Sustainable Investment Alliance, 2018) deserves a separate discussion and analysis.

As it is known, impact investing supports traditional finance and welcomes a *responsible and ethical investment model* intended - at the same time - to achieve both financial returns and a result with a strong socio-environmental impact in terms of sustainability. The number of impact investing funds it is constantly growing, with hundreds of impact funds targeting every impact theme, geography, and asset class (Global Impact Investing Network-GIIN, 2018, p. 26).

It is evident that impact investing is based not only on excluding investments in certain sectors and unsustainable businesses but "makes the social or environmental impact a primary objective of the investment, the reason for it" (Lenzi, 2021, p. 118), and could represent a great opportunity to restart from a more equitable, sustainable, and inclusive society, precisely in the phase following the health and economic-financial crisis caused by Covid-19.

Apart from the numerous regulatory initiatives taken in the financial sector (like the UNEP Statement of Commitment by Financial Institutions on Sustainable Development, a partnership started in 1992 to promote sustainable finance practices; the Principles for Responsible Investment by UNEP Finance Initiative and the UN Global Compact (2006); the Principles for Sustainable Insurance by UNEP FI, 2012; the Principles for Positive Impact Finance by UNEP FI, 2017; the Final Report Recommendations of the Task Force on Climate-related Financial Disclosures, by Financial Stability Board, 2017; the Global Green Finance Council and the International Association of Insurance Supervisors, Public Consultation: Draft Issues Paper on Climate Change Risks to the Insurance Sector, 2018; the «One Planet Summit» which was held in Paris, in December 2017), it is known the constant growth of *green bonds* issues, starting from 2007 and more recently during the Covid-19 pandemic crisis, as a first step on the initiative of public financial institutions characterized by a social mission (Enviromental Finance, Sustainable Bonds Insight, 2019), and later by banks (Enviromental Finance, Sustainable Bonds Insight, 2020) and private investors both in Italy (for example by the Hera s.p.a. group, years 2014, 2019; "Terna s.p.a.", years 2018-2022) and in all Europe. For example, in Germany the German Federal Government issued its first 30-year Green Federal Bond on May 11, 2021. The placement of the 0% Green Federal Bond 2021 (2050) was issued via syndicate. The order book comprised orders of over € 38.9 bn. The issuance volume was set at € 6 bn. This includes a retention of € 0.5 bn. At

the same time, the conventional twin bond was added to the company's portfolio by € 6 bn. The yield on the Green Federal Bond was set at 0.02 percentage points below the conventional twin. The features of this new green bond are the same as its conventional twin, the 30-year Federal Bond issued on August 21, 2019, with a coupon of 0% and maturity in August 2050.

Alongside green bonds, by similarity, there are the *climate-aligned bonds*, which are financial instruments not strictly "green", but whose issuers operate in sectors that support the transition to an economy with a low environmental impact.

It is also well known the recent but impressive spread of sustainability bonds, which have now largely surpassed green bonds in terms of volume of assets and managed assets, and which investment projections show growth over the decade 2020 - 2030 (Enviromental Finance, Trends in sustainable bonds issuance and a look ahead to 2021, 22 February 2021); thus, the social bonds have also increased by 43% during the *Covid-19* Pandemic, reaching the value of 66 billion (NN Investment, Responsible Investing Report 2020). This is a market segment not yet mature but which has had a higher relative growth compared to green bonds, even with issues reserved for professional customers and institutional investors.

However, the effects of the economic-financial crisis following the Covid-19 Pandemic have left an important mark also on the segment of social bonds, in terms of the kind of funded projects: before the Pandemic crisis, the financial vocation of social bonds was substantially linked to social housing and job creation, whereas now they are used above all to finance projects related to health, employment maintenance and support of small and medium-sized enterprises so as indicated in the "NN Investment" report as *Covid-19 bonds*. (NN Investment, Responsible Investing Report 2020).

Starting from 2016 also the ESG-themed Exchange-Traded Funds (*ETFs*) has been steadily growing (Morgan, 9 January 2019; Morgan, 20 January, 2021; C.S. Ferrua Rotaru, 2019, p. 2), and data show very good performances from ETF with high ESG requirements. This is the case for example of index like *Invesco MSCI World ESG Universal Screened UCITS ETF*, Invesco MSCI Europe ESG Universal Screened UCITS ETF, Invesco MSCI USA ESG Universal Screened UCITS ETF*)*, as the more recent ETF *green bonds*; or the case of the *ETF green bonds* issued by Luxor according to article 9 of EU Regulation 2019/2088, the so-called Sustainable Finance Disclosure Regulation (SFDR), effective from 10 March 2021. These types of green bonds comply with the requisites of SFDR regulation and of the contemporary EU Regulation 2019/2089, of the European Parliament and the Council, dated 27 November 2019 (amending Regulation EU 2016/1011, the so-called Benchmark Regulation) which regulates the EU reference indices (or benchmarks) of climate transition, the EU benchmarks aligned with the Paris agreement and communications relating to sustainability for the benchmarks.

Altogether the "GSS market" (*green bonds*, *sustainable bonds* and *social bonds*) counts for +52% referring to 2019 (Lenzi, 2021, p. 120, footnote 19) and a transactions volume referring to 2020 for 491 billion dollars (Environmental Finance, 22 February 2021).

According to figures from Environmental Finance Data, total GSSS bond issuance reached $1.03 trillion in 2021 – an increase of about 69% on the $606 billion total in 2020, and more than triple the $326 billion issued in 2019 (Enviromental Finance, 16 February 2022). In 2021, the green, social and sustainable bond market grew to over € 1.8 trillion.

Moreover, this is understandable, given that the already mentioned EU Regulation 2019/2089, in recital no. 5 it says that "sustainability and the transition to a low-carbon, climate-resilient, more resource-efficient economy and the circular economy are crucial to ensuring the long-term competitiveness of the economy of the Union economy (...)".

IMPACT INVESTING AND THE COVID-19 PANDEMIC CRISIS

Institutional investors are playing an increasingly large role in financial markets, holding on average 40% of the equity market (von Schickfus, 2021, p. 2), and, exactly for this reason, a considerable literature is devoted to better understanding their role during a market crash (Ling - Wang - Zhou, 2021, p. 1 *et seq*.).

Some recent institutional investors surveys reveal that undoubtedly ESG considerations are increasingly influencing investment decisions: according to Edelman trust Barometer (2018) 93% institutions believe that long-term value depends on both financial and ESG performance, and 89% of U.S. institutional investors said that their firm has changed his voting and/or engagement policy to be more attentive to ESG risk; according to Callan Institute Survey (2019) institutional investors increasingly incorporate ESG considerations into their investment decisions making process; according to State Street Survey (2017) 80% of institutions have an ESG component as part of their investment strategies and, more importantly, still a large number of institutional investors have voiced concern about climate risk (Ivantsova - Stepanova, 2021, p. 2 et seq.).

Moreover, after an excellent 2020 and the extraordinary results of the beginning of the year 2021, the "green" stocks have experienced a strong consolidation, especially in the clean energy sector. According to the reports of the Sustainable Investment Challenge by "Banca Generali" and "Reply", from this point of view "Tesla", "Microsoft", "Nvidia Corporation" and pharmaceuticals stocks are the most promising stocks.

Someone has specifically measured the geographical footprint of the firm and therefore the exposure of the assets to the Covid-19 Pandemic by focusing on listed equity real estate investment trusts (REITs) (Ling - Wang - Zhou, 2021, p. 1 et seq.).

One of the main results achieved is that during the early stages of the pandemic institutional investors reduced their holdings more in REITs in areas heavily affected by the pandemic, where the majority of their properties were located: more precisely "reductions in the ownership of REITs with an economic presence in the investors' home markets were more pronounced in markets in which REITs were more heavily invested", and those ownership reductions were also larger among short-term and nonpassive investors (Ling - Wang - Zhou, 2021, p. 25 et seq.).

With reference to the Italian context, regarding the ways in which sustainable investment policies are implemented, the most adopted strategy is that of exclusions (67% in 2021), slightly higher than 2020 and decidedly increased compared to 2019, but the biggest novelty is represented by impact investing, chosen by 48% of institutions in 2021, compared to 31% in 2020, and 23% in 2019; thematic and best in class investments follow with 44%. The declining strategies, on the other hand, are international conventions, which fell from 54% to 37%, and engagement, adopted by 33%, i.e. less than both 2020 and 2019 (Ling - Wang - Zhou, 2021, p. 25 et seq.).

Notwithstanding many data on institutional investors study them as a general group, it is necessary to study them also according to different types and classifications. By the way, a unified speech on the sensitivity of the various categories of institutional investors to ESG factors does not make sense, whereas it is necessary to distinguish among different institutional investors, because "different types of institutional investors have their unique qualities" (Ling - Wang - Zhou, 2021, p. 9). Moreover, institutional investors can be categorized in many different ways, and particularly according to their portfolio turnover or for the legal type classification (Ivantsova - A. Stepanova, 2021, p. 9).

With regards to the sustainability policy, there are "different weights for ESG factors in different industries depending on the materiality of any particular issue for that industry" (Ivantsova - A. Stepanova, 2021, p. 7). From this point of view, it is very significant the example of the banking sector, where the environmental issues are not considered to be the most material because the so-called environmental footprint of banks is smaller if compared to other industries (Ivantsova - Stepanova, 2021, p. 6). Consequently, since environmental factors have the lowest materiality for this industry (Ivantsova - Stepanova, 2021, p. 8), "the evidence on preferences of investors regarding other ESG metrics and their influence on returns is inconclusive and institutional investors seems to dislike banks with better ESG ratings and the existence of CSR committee" (Ivantsova - Stepanova, 2021, p. 1).

Furthermore, while rewards for unsustainable, short-term profits will recede, analysts and decision-makers will prioritize long-term performance (both impact

and financial) and long-term value creation, giving more weight to non-financial factors in investment decisions: undoubtedly ESG factors are material to long-term financial performance (Global Impact Investing Network-GIIN, 2018, p. 15). In the same way, hand in hand, accountability for impact is also becoming more widespread (Global Impact Investing Network-GIIN, 2018, p. 10).

Moreover, the impact investing industry is increasingly diversified for asset classes and approach, and the relative market is growing steadily in depth and sophistication (Global Impact Investing Network-GIIN, 2020, p. 7); it promises to give a significative contribute to the environmental change. More generally, the widely diffused opinion is that "financial markets ultimately drive social and environmental change" (Global Impact Investing Network-GIIN, 2018, p. 14 *et seq*.; Global Impact Investing Network-GIIN, 2020, p. 11).

The Italian Case

With specific reference to the Italian case, it is generally observed that the adoption of sustainable investment policies by institutional investors has been increasing in the last years. Even regardless policies formally adopted, sustainable investment practices are growing (Centro studi e ricerche itinerari previdenziali 2021, p. 17).

Regarding the subject matters adopted, the environment is dominant with reference to the thematic investments, which are for the 80% addressed to the energy efficiency, and for the 70% to the climate change (more than tripled compared to 2019), herein including instead data regarding the considerable decrease of the sustainable real estate (-23%) and sustainable mobility (-17%) (Centro studi e ricerche itinerari previdenziali 2021, p. 22). Instead, the demographic aging trends show the rising of subjects such as social responsible investments (henceforth "SRI") in Healthcare, Nursing Home and Silver Economy. Data on the relative growth of the silver economy referred to consumers is particularly meaningful (Confindustria, 2020).

At the same time, it becomes more and more important to examine separately the different categories of institutional investors that make impact investing according to their type organization (i.e. mutual funds, investments companies and so on), to understand if there is a link between their organizational features and their choice for impact investing. From this point of view a recent survey - using data submitted in 2020 - shows that the categories of institutional investors that make impact investing are "asset managers" for-profit (49%); "asset managers" not-for-profit (14%); "banking foundations" (13%); followed by "diversified financial institutions" (5%); "family offices" (4%); development finance institutions ("DFIs"), which are development banks or subsidiaries set up to support private sector (3%); pension funds (1%); other (11%), where the voice "other" (organizations) include "community development finance institutions (CDFIs), cooperative organizations, nonprofits, permanent

investment vehicles, social impact investment wholesalers, and nonprofit carbon o set developers" (Global Impact Investing Network-GIIN, 2020, p. 7).

The asset class typologies more involved in sustainable investments, which therefore ESG criteria apply to, are – as predictable – share and bond, however there are also those who instead apply them to the whole assets, without distinguishing among the different asset classes. More precisely the share and bond asset classes are chosen respectively by the 63% and 52% of respondents; 33% of those applies them to the whole assets; 22% applies them to the private equity; 22% to the real estate; 19% to the private debt (Centro studi e ricerche itinerari previdenziali 2021, p. 24); private equity, real estate assets and private debt, even if less represented, also result increasing in the sustainable investments sector (Centro studi e ricerche itinerari previdenziali 2021, p. 24).

Moreover, it is clear that the economic-financial shock due to the Covid-19 crisis has established an increase in ESG investments, although the institutional investors' opinion on the impact that those kinds of investments may have on the portfolio risk is not unanimous. On the whole, 51% of authorities believes that the ESG component has mitigated the overall portfolio risk during the pandemic, while 46% believes that it had an irrelevant impact, and only the 3% affirms that such mitigation did actually not occur. For instance, specifically among banking foundations 64% of respondents defines irrelevant the ability of ESG component to mitigate the risk with reference to a particularly troubled year just as 2020 was; instead, with regard to pension funds, the 85% believes that the Covid-19 pandemic accelerated the ESG investments, 54% believes that ESG component mitigated the risk in a year of great instability of financial markets such as 2020, 92% will increase sustainable investments in the near future and 85% will do that through a direct management (Centro studi e ricerche itinerari previdenziali 2021, p. 28 et seq., 42 et seq.).

With regards to the specific aim to manage better the financial risk, the percentage of institutional investors interviewed who declared to choose to increase sustainable investments in order to "manage financial risks more efficiently" was equal to 81% in 2020, in comparison to 50% in 2019 (Centro studi e ricerche itinerari previdenziali 2020, p. 16).

With regards to the specific aim to increase the financial return or pursue a positive reputational effect, among the institutional investors interviewed, 5% of them believes they can "obtain better financial returns", that is +17 percentage points in comparison to the previous year; 42% of them believes that they can "improve the authority's reputation" due to the ESG component of the investment, and this percentage results dobled in comparison to the previous year (Centro studi e ricerche itinerari previdenziali, 2020, p. 17).

However, it is certain that a paradigm change in terms of investing strategy is ongoing, and institutional investors start to recognise the impossibility to maintain

a method based exclusively on returns: choices behind an investment must, indeed, consider the impact in terms of *sustainability* – and *not only a green and environmental impact* of the said investment (Centro studi e ricerche itinerari previdenziali, 2020, p. 47).

Moreover, the authorities and funds which are rethinking their asset allocation in the near future favouring the Alternative Investment Funds- AIF (like hedge funds, private equity funds, real estate funds, not regulated at EU level by the UCITS directive), rather than the traditional mutual funds (UCITS), are numerous (Centro studi e ricerche itinerari previdenziali, 2020, p. 23).

In the analysis, it is also important to take into account the asset manager's level of autonomy in determining the proportion among the different assets of the portfolio, including ESG option. On the basis of data from the last reports, it results that the majority of institutional investors let the manager decide with regard to the investment selection: more precisely, 12% of them let the manager be totally free, 65% gives "a lot of freedom, even if in compliance with guidelines set forth by the board of directors; 15% declares to grant a limited freedom, and only 8% gives a very restricted freedom. Finally, not every institutional investor assigns specific benchmarks. From this point of view it has been noted that 54% of authorities affirms that they did not assign specific management mandate with sustainability goals. Instead, those which have or does not have adopted specific benchmarks of sustainability to assess the investment performance are equally allocated (Centro studi e ricerche itinerari previdenziali, 2020, p. 16).

Analysing single investors in details, important differences can be observed with reference to this matter: for instance, regarding the insurance companies, the range of freedom granted the manager is rather high, reaching approximately 62%, however they are a particular case in comparison to other institutional investors, because all of them have an actuarial consultant, and even more than one in the event of investment or biometric risks (Centro studi e ricerche itinerari previdenziali, 2020, p. 31).

In this respect the range of freedom is also very high, around 63%, with regard to banking foundations, which addresses an advisor much less frequently than the insurance companies in order to choose ESG investments. In fact over 70% of banking foundations do not entrust an ESG advisor (Centro studi e ricerche itinerari previdenziali, 2020, p. 40). The same situation also occurs in relation to the pension funds, 92% of them does not entrust an ESG advisor (Centro studi e ricerche itinerari previdenziali, 2020, p. 43), and the majority of their Boards of Directors carries out an audit with regard to SRI strategy impacts on the assets (Centro studi e ricerche itinerari previdenziali, 2020, p. 45); with reference to closed pension funds, 60% of them declares that their Board of Directors assesses the SRI strategy impacts on the assets once a year, while the remaining 40% does that several times a year (Centro studi e ricerche itinerari previdenziali, 2020, p. 35).

Either way, some categories of institutional investors largely adopt the impact investing and SRI strategy among their strategies of investment, which reach around 71% in the insurance companies (Centro studi e ricerche itinerari previdenziali, 2020, p. 31) and 86% in the banking foundations (Centro studi e ricerche itinerari previdenziali, 2020, p. 41). From this perspective closed pension funds are upstream, impact investing continues not to be preferred by them: only 30% of funds opts indeed for "other", and particularly for SRI benchmarks (Centro studi e ricerche itinerari previdenziali, 2020, p. 34).

With reference to the "excluded sectors", weapons and fossil fuels stand out for insurance companies, in the amount, respectively, of 85% for weapons and 69% for fossil fuels (Centro studi e ricerche itinerari previdenziali, 2020, p. 31); weapons, child labour, pornography, gambling, and tobacco market for banking foundations (Centro studi e ricerche itinerari previdenziali, 2020, p. 41).

An important matter, which requires a decisive upgrade, is managers' professional expertise and training on sustainable finance and investments. The majority of authorities interviewed (54%) finds the knowledge of internal departments "good" regarding laws on the sustainable finance, 8% of them finds it "poor". To the question if the authority finds useful examining in depth regulatory details, starting internal training courses, only 4% answered "no", while the remaining 94% split up between a clear "yes" (27%) and a "yes, but no such measure has been adopted yet" (69%) (Centro studi e ricerche itinerari previdenziali, 2020, p. 21).

IMPACT INVESTING AND THE NEW GENERATIONS OF INVESTORS: THE TIME OF THE GEN-Z

It is well-known that *Post-Millennials*, or *Gen-Z* (whose members are known also as *iGen*, *Post-Millennials*, *Centennials Digitarian*, *Zoomers*, *Plurals*) includes the demographic cohorts of young people born between 1997 and 2012. They are the real digital natives born between 1995 and 2010, who are currently aged between 10 and 25 years. Some data show a strong interest and propensity of these cohorts of young people towards impact investing (Bonera - Codini - Miniero, 2020, p. 304).

At the same time, the current historical moment is extremely important in terms of *generational financial turnover*, and a large amount of financial resources is about to pass right into the hands of *Post-Millennials*: the coming decades will see significant transfers of wealth from baby boomers to their children, largely *Gen Xers* and *Millennials*. One estimate put this figure at USD 30 trillion in financial and non-financial assets over the next three to four decades (Global Impact Investing Network-GIIN, 2018, p. 21).

Which means that this generation candidate to make a decisive contribution to the recovery of the post-pandemic economy from Covid-19 Pandemic also in terms of financial investments.

Also for this reason organisations are increasingly using a wide array of instruments, tools and channels - including the new European rules on non-financial reporting - to communicate their ESG reports to stakeholders, and particuarly to potential investors (Camilleri, 2021, p. 237).

Given the leading role they are preparing to play, it also becomes necessary to examine the investment strategies and preferences of some new "categories" of institutional investors that are particularly attractive for *Post-Millennials*, such as *social impact funds*.

According to *Accenture* data, by 2050 thirty trillion American dollars will be engaged in *social responsible investing* instruments (Accenture, November 2014). After all, the success of the ESG issues is such that all investment fund managers, including private equity funds and hedge funds, now hold at least 30% of "SRI capital" (Ferrua Rotaru, 2019, p. 2).

However, this strong predilection of Post-Millennials for financial products that are (*or are perceived as*) sustainable (Smith, 2010, p. 10 *et seq*.) and towards impact investing and responsible investing seems to be deeply rooted, so much so that the financial characteristics of the chosen products are also overshadowed.

In this regard it must be emphasized that the push towards sustainable finance and eco-compatible or green financial products is sometimes only the effect of a personal sensitivity to environmental issues or a current widespread moral suasion. That may also purely be a status symbol, as in the case of the so-called *social green*: the *social green cluster* "seems to be "green" not for feeling a devotion towards the planet, but mostly for showing off this attitude. This might be consistent with the general attitude of Millennials to be "self-oriented"...that, in this case, lead to exhibit green consumption as synonymous of social status" (Bonera - Codini - Miniero, 2020, p. 303). In other words, this attitude is not always combined with real knowledge and skills, nor does it necessarily materialize in sustainable investment choices. Among other things, in some cases it leads to unconscious, emotional portfolio choices and irrational or emotional preferences.

In contrast with the literature and the evidence of some empirical analysis, usually describing Millennials as pro-environment oriented (Smith - Brower, 2012, p. 535 *et seq*.; and with reference to the Italian context Eumetra Monterosa, 30 March 2017), some studies show that not all green Millennials are authentically "green", whereas a high number of them are (*only*) *social green*, *not really green*, so that the percentage of *social green* Millennials is actually higher than the *really green Millennials* (Bonera - Codini - Miniero, 2020, p. 303). This does not necessarily

imply a negative attitude towards green values by them, but of course means that Millennials have *different green attitudes and behaviours.*

Basically three clusters can be identified: "surely not green", "social green" and "really green": "our results do not necessarily imply a negative attitude towards green values by Millennials, but of course different green attitudes in the three clusters. This is also supported by the analysis of green consumption in each cluster" (Bonera - Codini - Miniero, 2020, p. 303).

Italian data are only apparently against the flow: in Italy 77% of Millennials affirms that they asked their own financial advisor for information on this matter, against 67% of Gen X and 59% of baby-boomers (Schroders Global Investor Study, 2020). However, when they switch from a simple request for information to a real financial investment, with regard to the relevant reasons, 47% of Italian investors (global and European data are nearly the same) is attracted by the said investment thanks to a more positive impact on the environment, while 40% (42% with reference to global data, 39% with regard to European data) chooses ESG products because they seem potentially more profitable (Schroders Global Investor Study, 2020).

Furthermore, also the low level of *financial literacy* contributes to hampering the preference of post-Millennials for green and sustainable finance, and looking at the post-Millennial generation, it can be seen that this kind of problem is widespread and generalized (Oecd, 2016, p. 1 et seq.; Oecd, 2017, p. 31 et seq.; Banca d'Italia, 2017, 12; Cossu, 2021, p. 3 ss.).

Lastly, another obstacle to the widespread diffusion of ESG financial products is represented by the fact that the financial tension that have been accompanying the younger generations of investors, first by the 2007-2009 financial crisis and then by the economic-financial crisis resulting from the Covid-19 Pandemic, will hardly be combined with financial products that in all likelihood they will prove to be more expensive both in economic terms and in terms of information costs, and do not promise higher returns (Ottman - Stafford - Hartman, June 2006, p. 25; Chen - Chai, 2010, p. 28 et seq.; Naderi - van Steemburg, 2018, p. 4 et seq.).

From this point of view, some characteristics common to the many forms of impact investing, such as an economic return that tends to be generated in the long term and the repudiation of short termism, could disappoint young retail investors.

Moreover, the sustainable finance asks for developing a new portfolio theory, which optimizes portfolios considering financial and non-financial risks and return factors equally (Global Impact Investing Network-GIIN, 2018, p. 48; Centro studi e ricerche itinerari previdenziali, 2020, p. 59), so that ESG factors are taken and considered in analysis and investment processes, with the aim to maximise the risk-return ratio offered to clients. Can be mentioned the commitment of the asset manager Schroeders, which provides a full integration of new *Schroeders Environmental, Social & Corporate Governance criteria* in its analysis and investment processes.

Namely, Schroeders reached the level "A+" according to the *ONU Principles for responsible investments* and the level "Advanced" according to *Morningstar ESG Commitment Level*.

On the other hand, it should be noted that the development of fintech financial services and cryptocurrencies requires a strong change of pace in educational paths of the retail investors, not only in terms of *digital* but also of *financial culture* (Oecd, 2017, p. 31 *et seq*.). "Young people can be supported through the formal school curriculum: wherever this includes financial education, its content should be enhanced with financial education for DFS, even more so in the light of the use of digital tools and the preference for digital experiences of the younger generations, which may outweigh those of their parents" (Oecd, 2018, p. 20). *Digital education* and *financial education* are two educational forms independent each other but both essential (Paracampo, 2021, p. 37).

In this sense, a low level of financial literacy can hinder the preference of *Gen-Z* for green and sustainable finance: in other words, financial illiteracy and sustainable finance do not get along.

For this reason, another important relevant goal is to compare the Post-Millennials, or Gen-Z, financial preferences and investment risk choices with preferences and choices of both the previous generations, that are the *Generation X*, or *Gen X*, which includes cohorts of those born between 1965 and 1980, and the "Millennials" (Accenture Consulting, 2017, p. 2 et seq.).

On background, the next generation, the *Alpha Generation, or*"Alpha-Gen". It includes cohorts of those born between 2010 and 2020, who – in sociological terms – are digital natives in its literal meaning: *they are digital natives*, *not digital immigrants*.

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Chapter 10
Blockchain and Artificial Intelligence:
Reflections Seen From Private International Law

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ABSTRACT

As the internet becomes part of everyday life, the need arises to study the adaptation of private international law systems to the new requirements. One of them is blockchain, as a decentralized technology, which carries with it some legal uncertainties, such as the legal nature of blockchains and shared digital records, including issues of jurisdiction and applicable law. In view of this, there is a need to reflect on whether the legal criteria currently applicable, from the point of view of private international law, are sufficiently clear.

INTRODUCTION

Rapid technological change and its development have led to an era of technology and applications that are leading us to cross-cutting changes, based on the data that nourishes the Internet. This change is taking place through the Internet of Things (IoT), machine-to-machine communications (m2m), robotics, big data, Blockchain or artificial intelligence (AI). The reason is the current trend of automation, which

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has been called Industry 4.0. It is expected that all of them will change the economic functioning of companies and have a huge impact on society.

On the one hand, the debates have revolved around the need to regulate the sphere of AI itself and set limits, to prevent the development of so-called artificial general intelligence. On the other, Blockchain is becoming popular and its continuous attempts to implement it have curiously given confidence to the digital society of the future, although it really poses serious challenges; that is, Blockchain has the mission of generating trust, transparency and acting as a mediator. So, you are going to have the challenge of making it possible for IA to act and connect with each other. However, we cannot forget the cloud services (computing) marketed. Having said that, it should be born in mind that, as the Internet becomes part of everyday life, there is a need to consider adapting the systems of private international law to the new requirements, although we will focus a little more on the European Union.

THE PROBLEM FOR THE DETERMINATION OF JUDICIAL COMPETITION IN A TECHNOLOGICAL CONTEXT

It should be borne in mind that in the underlying contractual relationship we are going to find cases in which the technology can be given a non-nationality, and we may encounter problems in the connection criteria, cross-border insolvencies, etc. that Blockchain detects us, since otherwise now they will be over time, when artificial intelligence advances and, in addition, companies evolve to the cloud and in the cloud.

The reason is that the blockchain poses different risks because of technology and the way of operations: one of the main problems will affect the blockchain is the inability to control and stop its operation. In addition, the lack of control over the operation can cause the lack of responsibility of the company that manages the platform. Consider that, in its simplest form, Blockchain is a decentralized technology or a distributed ledger in which transactions are recorded anonymously. This means that the transaction ledger is kept simultaneously on a network of unrelated computers or servers. The allocation and attribution of risk and liability in relation to a blockchain service that is not functioning properly must be carefully analyzed, not only at the provider-client level, but also around all participants in the system.

Therefore, it should be considered, regarding the process, that Blockchain could cross jurisdictional boundaries since the nodes in a Blockchain can be located anywhere in the world. This can raise several complex problems that require careful consideration in relation to citizen-state, enterprise-state, enterprise-enterprise, citizen-enterprise, enterprise-enterprise, enterprise-administration, citizen-administrations of the same and different states, in addition to the multiple relationship that may arise between

them. In this regard, it should be noted that, in a decentralized environment, it may be difficult to identify the appropriate set of rules to apply.

Estonia does this by proposing electronic identity as a connection criterion, since it is related to residence, in this case electronic, while the need to link information and its handling, only, with the person who issues it becomes essential for many different interactions: an organizational infrastructure (identity management) and a technical infrastructure (identity management systems)., to develop, define, designate, manage, and specify authorization levels, assigning roles and identity attributes related to specific groups of people, such as company manager, employees, or customers.

The evolution of technology is creating large electronic archives, with its large commercial and state databases. A national identifier, contained in an identity card, makes it possible to capture information about a person, which is in different databases, so that they can be easily linked and analyzed through certain data analysis techniques. At the same time, identity cards are also getting smarter. The generation of data also has the virtuality of being offered in a medium where they can be directly processed. In this way, files are created that can be crossed and structured, as well as ceded. For this reason, special attention must be paid to any identity management system and see who people are.

At its simplest level, each transaction could fall within the jurisdiction of each node's location in the network. This should be noted that in an online environment authenticating the identity of the remote party is more important than ever. It plays a key role in the fight against identity fraud and is also essential for establishing the trust needed to facilitate any kind of electronic transactions. ÿit should be borne in mind that the relationship between law and information technology goes beyond what has been seen so far. That is why one of the main issues that arises, about cross-border services, is the security and confidentiality of information transmitted over the Internet, which must lead us to guarantee the protection of personal data leading to the identification of the holder (Viguera, 2008).

By this we mean that the electronic identity is an identity that is composed of information stored and transmitted to the different users of it. Let us think that identity is a fundamental element, which links the information to its owner, located in some State giving rise to its location, and, therefore, to the effective and secure good management of the specific data that give entry to the cloud.

All electronic identity schemes depend on two processes: first, identity authentication and, subsequently, identity verification. When authenticated, the identity is logged to the system and can then be used to perform transactions. The identity is verified at the time of each transaction, from within the cloud itself. From the information recorded at that time, emerges the information identifying or identifying the person, as if it were the signature, which will be used, later, to link an individual inseparably.

Between the cloud there will be two elements that will come together to facilitate the identity of the person who intends to access the cloud. These two elements are basically: the identity fixed to the individual and another fixed to the transaction itself that is carried out. The first will be the one that identifies the parties and, therefore, will have a direct effect on the formation and enforceability of the contract, thus determining its ability to be contractually bound, by including elements such as the name of the legal person, its legal form, its registration number (if applicable), its registered office or address of the business center, together with the mention of its founding documents. The second would be the largest body of transaction information and one that is continuously updated, depending on the transactions you perform (Cuthbertson, 2014).

If the foregoing is not sufficient, it will be necessary to assess the contract and the specific links with the different countries, considering, as indicated by the CJEU, in its judgment of 23 October 2014, Case C-305/13, the "overall assessment of all the objective elements that characterize the contractual relationship and to assess the element or elements that, in its opinion, are most significant. Where a contract is alleged to have closer ties with a country other than the country whose law is designated by virtue of the presumption laid down in that paragraph, the national court shall compare the links between the contract and the country whose law is designated by virtue of the presumption, on the one hand, and between the contract and the other country concerned, on the other. The national court shall consider all the circumstances in question, including the existence of other contracts relating to the contract in question (Diago, 2014).

In this way, issues related to identity management should be regulated by the different legal systems that discipline the multiple activities of the specialized operators carrying out the identification tasks and the functional operators (UNCITRAL, 2017).

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Thus, a part of the problem can be observed. The other arises in compliance with data protection law, since the use of electronic identification schemes as a means of identity management necessarily involves the processing of individuals' personal data and, consequently, means that all these services must comply with EU data protection rules (the GDPR).

Tol accessing a website, are often trusted, by requirement of the transaction that is intended to be made, data and particularly important personal information, such as the name, address, Number of the National Identity Document, and even, bank details such as the credit card number, which are accumulated by the Internet service provider and the website you are using.

It is then that uncertainty arises about the custody, protection and guarantee of data that allows to identify and, sometimes, "x-ray" the owner of these. To answer these questions, it is necessary to establish common rules, so that it can be guaranteed that personal data enjoy a high level of protection.

Electronic communications and the protection of personal data, based on a logic of building the internal market, where electronic identification must be legally framed, must serve to act as a basis for the protection and management of electronic identity in Europe. The fact that the processing of personal data also serves specific identity purposes (such as correct identification, prevention of misrepresentation or over-identification....) and not "merely" of privacy, makes the legal framework of data protection the most appropriate (Carrascosa, 1992) habitat for it and with it the conflict rules that it raises in articles 79,2 and 3 in relation to judicial competence and applicable law, respectively.

In addition, in the international electrified component that we are raising the data is frequently stored or transferred between servers located in different countries, being the main risks, which we have raised above, when we have talked about the accidental or illegitimate disclosure of confidential or secret information of a node, or cloud or cloud client. In all cases the risks may result from actions or omissions circumstances in your environment or beyond your control. Views or no views; well, in the cloud you can have a vision of the whole (Illescas, 2019).

These problems are becoming more and more frequent and complex, as nodes or providers can host data from any country. When this element appears, this foreign element may have jurisdiction over more than one court to hear the case in question and, furthermore, the legal relationship may be subject to several laws.

In view of this, it can be observed that a significant risk, which consists in seeing how liability is diluted with respect to the operations carried out if the criteria of applicability of the legislation are not sufficiently clear, which is why we think about the need to consider possible solutions to the problem of applicable law raised. In this context, the contractual relationship from which it should be based should be considered, in order to determine the main issues that could arise in cloud computing contracts signed by commercial entities, in which one of the parties (the provider) provides the other (the customer) with one or more services for an end-user.

Considering the set of circumstances of the contract, one of them stands out: the ubiquity of the parties; that is, access to the network from any location. This aspect is important because it is what will determine the applicable law on personal data, accounting data and public sector data, as well as the control of exports that may limit the transmission of certain data or computer programs to certain countries and may even result from contractual obligations, for example, from intellectual property licenses that may require that the licensed content be housed on the user's own secure servers. Also, setting data location requirements may be desirable for purely practical reasons, including to increase latency.

A presumption in favor of location would be the indication given by the service provider himself about his establishment, which is understood as the place where a party maintains a non-temporary place of business, to carry out an economic activity other than the temporary supply of goods or services from a certain place. Where the provider had more than one establishment, it could be determined by which the closest relationship with the relevant contract, considering the circumstances known or foreseen by the parties at any time before the conclusion of the contract or at the conclusion of the contract, thereby referring only to the closest relationship of the contract.

This presumption is more reasonable than determining a connecting factor for the location of the equipment and the technology, since, although it may be a criterion for determining the closest links, it is not necessarily the most important, among other things because it is more than rebuttable and is not absolute because it can be accompanied by forum shopping situations. On the other hand, if we focus our attention on the reference to the information system used during a communication to negotiate the contract and supply the goods and services, the location of the establishment of the company can be determined, thus encompassing all information service providers and web servers. Even if they have no relationship with the parties who negotiated the contract.

The combined reference to the contract and its performance, as currently established, may create uncertainty in situations where a particular place of business of one of the parties would be more closely related to the contract, but another establishment of the same party would have a closer link with the performance

of the contract. These situations are not unusual in contracts concluded by large transnational corporations and may become even more frequent because of the current trend towards greater decentralization of commercial activities.

Another aspect to be considered in relation to the contractual regime is the relatively prolonged interruption or interruption of service during normal working hours, even if it is a service rendered continuously. It can also have other negative effects, such as having to make changes to the customer's applications or computer systems, that prevent access to the service, or issues related to interruptions in the Internet connection. Tending to the fact that the provider will try to keep the services available 24 hours a day, 7 days a week or that the period of availability of the service reaches 100%, but without guaranteeing it, we could be facing agreements that could determine financial losses for the client company and the end user.

The main legal risk posed to the client company is not being able to fully assess the risks associated with the contract, for example, ignorance of the weaknesses inherent in the technology being used; security features that are missing or inadequate; economic risks associated with data loss or breaches agreed upon.

CONCLUSION

As has been observed, there is a need to analyze and deepen an appropriate legal framework, so that both citizens and companies can trust the technology with which they interact, have a predictable legal environment, and have the effective guarantee that their rights and freedoms will be protected.

To this, there must be added a complexity: the international context of the transaction. Electronic communication crosses borders without having any specific link to the territory where the technology is located and users participate in global activities, without the need for physical presence within the state of the forum. To give security to the transaction to be carried out, Blockchain emerges, as a decentralized technology, which entails some legal uncertainties, such as the legal nature of blockchains and shared digital records, which includes problems of jurisdiction and applicable law; therefore, each node of the network may be located in a different place since there is no "central part" responsible for the digital registry, whose nationality could be used for regulation. Rules of international jurisdiction are important determining the situations in which a State will offer the protection of its courts. The competition rules must be combined with an adapted framework, since, in the absence of a valid choice, the application of the lex fori is the only solution in this area.

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Chapter 11
Digital Resources for the Preparation of a Thesis in Roman Law Studies

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ABSTRACT

Because of the recent pandemic, most of the students discovered several difficulties in traditional research concerning sources connected to literature for the elaboration of a thesis in Roman law studies. It should be necessary to help a young student to develop and to complete his work through the use of digital resources. Therefore, this contribution would represent a short digital guide that the young graduating may use in order to consult digital resources, especially online, which spread over the last 20 years. The purpose of the investigation is to highlight the impact of technology on scientific research in particular for what concerns Roman studies, which are settled between tradition and innovation.

INTRODUCTION

The captivating title of the research 'Technology and innovation: new ways to perform known activities?' led the scholar of the legal systems of antiquity to wonder how it could fit in without being inappropriate or off topic.

The idea for this paper finds its roots during some meetings with students that, because of the recent pandemic, couldn't attend libraries and at the same time they complained a certain lack of digital sources for what concerns Giusromanistics thematics and topics. For these reasons, the principal aim of this contribute is on

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the one hand to try to give some answers to the students and on the other hand to emphasize how technologies might improve Roman studies – especially in the perspective of the graduate student for the realization of a thesis in Roman law at the end of a course of legal studies – between tradition and innovation.

Obviously, the principal difficulty in realizing a dissertation about Giusromanistic subjects depends on the accessibility to digital documents by all the students. In these last years, Roman literature has numbered with accuracy several digital sources regarding Roman history and juridic items in order to help both students and skilled researchers (e.g. Manni, 2007; Germino, 2011, Agnati, 2012): therefore, the main purpose of this contribution – without any pretense of completeness, for which reference is made to the aforementioned scientific papers and to those that will follow – maybe addressed particularly to those students that, approching Roman studies, should intensify and increase their studies in consulting online and digital sources.

ANTONIO GUARINO AND DISSERTATION

Antonio Guarino is one of the most important Roman law and Antiquity studious of all the recent times and he is considered an authority and a sort of inspiration by a whole generation of Romanistic studies. The author of this contribution also became passionate about law and the history of law, which later became part of his daily commitment, inspired by the pages of the works of the illustrious Neapolitan academic since he was a first year student of the course of study in Law.

. In the 60s, Antonio Guarino wrote a really efficacious book that is "La tesi di laurea". This work, that will find two new editions in 1989 and in 2007 with a preface written by Umberto Vincenti, propose show to argument a dissertation connecting with Romanistic items: «*comportarsi ordinatamente quando si debba allestire un'argomentazione scritta che sia volta a dimostrare ragionevolmente una certa tesi*» (Guarino, 2007, p. 2). This small book, also full of amusing anecdotes of academic life, is mainly addressed to the graduate student in Romanistic disciplines, but it should be read and consulted by anyone who wants to write a thesis also in other legal disciplines as well as scientific works, because the importance given to the method of approach to legal sources and literature and to the numerous and useful tips for the drafting of the work. Professor Guarino indeed try brilliantly, in these pages, to explain the meaning of dissertation in its several aspects and he gives some precious advice and indications for what concerns the elaboration of the final manuscript. The estimed studious, in the last edition of this work evidences, though he was clearly sceptic, the importance, at those times revolutionary, of using computers during the filing of the thesis bibliography (Guarino, 1970; Guarino, 1990). Infact, at the beginning, Roman studious and students had to filing in an "analogical" way

all the sources utilized in their topics on singule papers concerning a synthesis of all the authors thoughts analysed. By this way, students and researchers would be able to think over the different literature point of view thanks to the file cards references. So the research almost looked like a "cardgame" because the student benefited of these "cards" (Guarino, 2007, p. 19) represented by the paper format file-cards containing all the information about the subject matter and its authors. It was necessary for Roman researchers accessing into specialized libraries in order to consult firstly the famous "*Codex Theodosianus*", "*Corpus iuris civilis*" or the "*Fontes iuris Anteiustiniani*", and also the great productions connected with epigraphic sources, papyri, monographs, encyclopedic and reviews. Furthermore, it was fundamental for Roman studious to examine paper format ancient treatises such as "*Collectio bibliographica operum ad ius Romanorum pertinentium*" up to date until 1975 or also '*Index operum ad ius Romanum pertinentium*' edited and updated by M. Sargenti in the former Ninties. Moreover it is important to mention the great deal of Giusromanistic reviews *index* updated year by year and translated in Italian, whose every Roman students has to compare with and deeply analyse into the University libraries as for example il "*Bullettino dell'Istituto di Diritto romano 'Vittorio Scialoja'*, *Index*, *Iura* – which contains a very particular bibliography appendix –, "*Labeo*" unfortunately interrupted in 2004, "*Κοινωνία*", "*Studia et Documenta Historiae et Iuris*".

RESEARCH AND LITERARY SOURCES: AN INFORMATIC REVOLUTION?

During the last twenty years, as the Internet spreads in every common life aspect, the elaboration of a Roman law dissertation has been overwhelmed by this new technological wave (Purpura, 2001, pp. 9 ss.; Palazzolo & Maggio, 2002; Palazzolo, 2008, pp. 371 ss.).

Since Ninties, several issues have emerged and also initiatives linked to a kind of "electronic treasure", a sort of an online cultural and literary patrimony, which students can consult under the direction of an expert tutor, have spread out. Among the principal informatic literary collection it is fundamental to include:

1. *Aurea Latinitas Biblioteca* (ALB) a collection of works of the Latin Republican and Imperial period authors. This online library allows the user to search all the different juridic lemmas,
2. *Biblioteca iuris antiqui* (BIA), available on CD ROM made up of 3 sections: a) *Fontes*, which contains Giusromanistic sources; b) *Opera,* where it is possible to find bibliographic references from 1940 to 1998; c) *Thesaurus,* which includes

8000 terms about Antiquity law (Mantovani, 1996; Licandro & Spampinato, 1997),

3. *Fiuris,* an electronic archive within sources and bibliographic references (periodics, collections and monographs)*; VIR* (*Vocabularum Iurisprudentiae Romanae*) is the main reference (Catalano, Sitzia, Taddei Elmi, 1992, pp. 291 ss.; Taddei Elmi, 2001, pp. 201 ss.),
4. *CICLT*, on CD Rom from 1994 within the whole Patristic authors works such as St. Augustinus, Girolamus, Gregorius Magnus, *The Corpus Patrum Latinorum* and a part of the *Patrologia Latina* edited by Migne.

Besides, it is possible nowadays to find several Internet websites with juridic sources thus avoiding the consultation of the paper edition into the libraries: the most important Internet websites are surely: "*The Roman law library*" (https://droitromain.univ-grenoble-alpes.fr/), where one can find a selection of *leges, senatusconsulta, negotia, constitutiones principis* and monographs dated between the end of the XIX century and the former 40 years of the XX century particularly in the "*Libreria numerica section*" and in the "*Latin library*" (https://www.thelatinlibrary.com/) where it is possible to discover a wide variety of Latin literary and juridic sources from the Republican period to the Middle Ages. For what concerns Roman Law subjects, there is a particular section called "*Ius Romanum*" which involves *Duodecim Tabularum Leges* electronic texts and also *Gai Institutiones*, *Codex Theodosianus* and *Corpus iuris civilis*.

"*Documenta Catholica omnia*" (https://www.documentacatholicaomnia.eu/) is another website dedicated to those who approach the Late Antiquity period study. This studies are often linked to the influence of Christianism on the Imperial Constitution such as the Bible, the Latin and Greek Patrology edited by Migne, *Corpus scriptorum historiae Byzantinae, Glossarium mediae et infimae latinitatis, Lexicon totius latinitatis* by E. Forcellini that is fundamental in order to restore terms semantic origin. Then, Latin Patrology and the 68 "*Acta sanctorum*" tomes should be consulted by taking out a subscription (Germino, 2011, p. 12). The ones who desire to examine arguments connected with the Roman tradition in the Middle Ages, "*Monumenta Germaniae Historica*" (dMGH, n.d.) represents an excellent internet website together with the *Glossa* edition within the *Corpus Iuris Civilis* available into the lugdunensis edition of 1558-1560 on the University of Bologna website (https://amshistorica.unibo.it/176; Agnati, 2011). Also the students interested in the European Roman Law tradition have different Internet website as "*Storia del diritto.org*" (http://www.storiadeldiritto.org/) and "*Reti medievali*" (http://www.rm.unina.it/). It is possible to find remarkable sources within epigraphic and papirys in particular thanks to the huge attention and engagement of the German and American Universities: "*Papyri.info*" (The Duke Collaboratory for Classics Computing & the

Institute for the Study of the Ancient World, n.d.) for what concerns papirys sources in Latin and in Greek language; "*Eagle*" (Europeana Eagle Project, n.d.) in which it is possible to gain information about ancient Latin and Greek inscriptions belonging to a period before the VII century; "*Epigraphik- date bank* - Clauss Slaby" (EDCS, n.d.) which suggests a 400.000 Latin inscriptions database and 45.000 pictures.

BIBLIOGRAPHIC RESEARCH

Nowadays, bibliographic researchers take advantage of a wider use of different specialized Internet web sites. For example University Paris II exploits "*DRANT*" (that is *Droits de l'Antiquité*) a particular website dedicated to the bibliographic researches on Antiquity and Roman law (https://www2i.misha.fr/flora/jsp/index.jsp). In "*Archive.org*" (https://archive.org/) one can find lots of texts to download in pdf or to read at once. It is possible to consult a conspicuous part of the Teodosian Code or of the *Corpus iuris* edited by Mommsen-Krueger in the *editio minor* and also several tomes belonging to the *editio maior*.

Through "*Academia.edu*" (n.d.) and thanks to the munificent participation of collegues, students may observe each member contribute and eventually, in a pdf format, they should consult articles, collections and at time salso monographs.

Finally, "*Google books*" (n.d.) represents an excellent instrument for reading whole books, as the copyright authorizes their contemplation. Also the portal "*Ius civile – Roman Law Resources* (http://iuscivile.com/) and "*Persée. Portail de revues en sciences humaines et sociales* (https://www.persee.fr/) are rich in information connected with links and databases for the Giusromanistic research. Moreover, students can consult monographs and scientific articles written by Roman law eminents studious especially on the University of Palermo portal ("*Portale di Diritto Romano e Diritti dell'Antichità dell'Università di Palermo*", n.d.) For what concerns Antonio Guarino main production it is available on open sources (Antonio Guarino, 2016). The site edited by the heirs of Prof. Antonio Guarino is simple and intuitive; it is possible to consult and download the most ancient editions of the classic university manuals – *Diritto privato romano* and *Storia del diritto romano* – as well as further works intended for teaching Romanistic disciplines, scientific monographs, articles, reviews and further contributions also on modern law. The web page is enriched by a photo gallery, a biography and a list of the author's works. Finally, the *Dictionnaire des antiquités Grecques et Romaines*, directed by Ch. Daremberg and E. Sagliò, is online (http://dagr.univ-tlse2.fr/sdx/dagr/index.xsp) (Germino, 2011, p. 433).

ONLINE SPECIALIZED REVIEW

Recently, Roman studies specialized reviews have appeared online allowing a public consultation of articles and collations. For example as for Italy subsists the "*Rivista online di diritto romano – led on line*" (2022) from 2001, where it is also possible to consult "*Dike*", a magazine specialized in Greek and Hellenistic rights (http://ledonline.it/dike), and "*Diritto@Storia, Rivista internazionale di Scienze Giuridiche e Tradizione romana*" (2019) from 2004 thanks to the contribution of University of Sassari. From 2008, among the specialized reviews we should highlight "*Teoria e storia del diritto privato***"** (https://www.teoriaestoriadeldirittoprivato.com/); it is also available online "*Roman Legal Tradition***"** (https://www.romanlegaltradition.org/) in collaboration with the University of Glasgow, as well as "*La Revista Internacional de Derecho Romano*" (www.ridrom.uclm.es) edited by the Association Iberoamericana de Derecho Romano and the Universidad de Castilla-LaManca operational since 2008 which contains numerous contributions in Spanish and English, available online and downloadable in pdf format. Furthermore, from the *Iustel* it is possible to access the "*Revista General del Derecho Romano*" (https://www.iustel.com/), but it is currently possible to consult my contribution only after a subscription portal. Another very useful online magazine for research in the field of legal history is certainly "*Forum Historiae Iuris*" (n.d.), in which it is possible to consult and download contributions concerning the history of the legal experience from the ancient age to the modern age with many contributions expressly dedicated to Roman law and its tradition. The Max Planck Institut has made available the "*Digital Bibliothek*" (http://dlib-zs.mpier.mpg.de/) where it is possible to consult some vintages of the very important "*Zeitschrift der Savigny-Stiftung für Rechtsgeschichte*" and the "*Zeitschrift für Rechtsgeschichte*". By now, it is also possible the consultation online of *index* and tome as well as to buy single books both in papery and in kindle or e-book format.

CONCLUSION

From this bird's-eye view of the main online resources to help the graduate, we can certainly draw some conclusions.

The graduate student's work, despite the progress of telematic resources, cannot yet completely disregard a constant attendance of specialized libraries, where the most recent monographic works are still kept and where the most recent writings are available, as well as more up-to-date repertories and scientific magazines.

Undoubtedly, the telematization of libraries on the national territory now allows a more profitable interlibrary exchange at national level (for the Italian system https://opac.sbn.it/opacsbn/opac/iccu/free.jsp), which simply work of the student in

case of gaps in the library closest to him. Nonetheless, often the most well-stocked national libraries equipped with high-resolution scanners allow the transfer of entire volumes that are out of print or no longer subject to copyright. This circumstance for the Roman law graduate is an advantage that should not be underestimated considering that a complete research cannot ignore the consultation of scientific literature starting at least from the second half of the nineteenth century. In short, traditional research is not yet dead and, therefore, the student will not be able to abandon traditional models for many years. However, basic research is undoubtedly strengthened by all the resources we have discussed so far that allow the graduate, compared to the traditional approach, to add an additional activity such as finding sources and bibliographic resources in format on the topic from the comfort of his own home; this activity will allow the student to increase the quantity of scientific material on the work table. Furthermore, it should be noted that the most recent word processing and file archiving programs allow the graduate student to file the sources and the bibliography in an orderly way with hypertext references that allow easy retrieval of the different ones. Yet the same programs give the student an important aid in drafting the text in the most elegant way possible and thanks to a wise use of automatic correctors even without the annoying typos.

But it's not all plain sailing. The telematic search of sources and literature could in fact induce the less diligent student into setting errors or temptations.

A first mistake could undoubtedly be that of proceeding solely with a rapid and inevitably incomplete search for material on the net; a second error, mostly consequential to the first, is to use material found on the web of a purely informative and only to a lesser extent scientific nature in the preparation of the degree thesis. In and of itself the informative text, if of certain and authoritative origin, does not even constitute a problem, unlike a lot of material available on student sites and blogs of uncertain, if not empty, value.

Temptations, or rather, the temptation par excellence for the student is to use the trick of copying and pasting from the net with ease: a dangerous *malpractice* sometimes encountered in last-minute latecomers. Here the various plagiarism software can come to the aid of the tutor and the universities.

Therefore, in advising the use of digital resources and above all of the online material, the graduate student should be recalled with the same worried adage of the Grand Chancellor Ferrer addressed to his coachman during the 'bread revolt' in running in a carriage to the aid of Milan's Vicario di Provvisione: «*Pedro, adelante con juicio*» (Manzoni, 1840, p. 262).

The role of the chair director and the tutor in a careful and responsible correction, will have to take into account today and in the future, therefore, these not insignificant problems, in order to avoid, in the best of cases, the loss of credibility of the scientific

research of base, as the last exercise of the university student on the launching pad in a work context.

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