



M-learning in the COVID-19 era: physical vs digital class

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Received: 17 December 2020 / Accepted: 29 April 2021 / Published online: 8 May 2021

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Abstract

Emerging technologies, such as the development of the Internet of Things and the transition to smart cities, and innovative handheld devices have led to big changes in many aspects of our lives, while more changes were imminent. Education is also a sector that has undergone huge changes due to the spreading of those devices. Even at the era of feature phones, it started to become clear that portable devices with access to the internet can be used for learning. The process of learning with the use of mobile phones was then in an early stage, due to the limitations of feature phones. Whereas, with the introduction of smartphones, education is expected to be drastically altered in the future, in most parts of the world. New, radical, and controversial in some cases, approaches have been developed, over the past years, in an effort to implement a mobile learning process in real life conditions. Intelligent tutoring systems have had rapid growth, especially in the COVID-19 era, while a significant increase in online courses via social networks has also been noted. This paper focuses on presenting the most important research parameters of m-learning during the last decade, while it also incorporates a novel empirical study in the domain. The utilization of educational data has been taken into consideration and is presented, aiming at ways to improve human interaction in the digital classroom.

This approach reviews the literature about new approaches that have been developed, from 2010 until 2020, in an effort to implement a mobile learning procedure and also focuses on mobile assessment and the studies that have been conducted in that field.

The purpose of this paper is to explore some of the major studies that have been conducted during the past 10 years and to emphasize on the factors taken into account while analyzing the possibilities of m-learning. Because of the fact that there are many aspects that should be considered, attention has been paid to the most significant, that is aspects that have concerned the majority of researchers. An empirical study was conducted during the lockdown due to COVID-19. The most frequently mentioned aspects in the literature were analyzed, in order to summarize the most essential parameters that were depicted by other researchers and set of parameters consisted of the backbone for the composition of a questionnaire which was sent to pupils of a high school, students of a University, and participants of life-long learning courses. Conclusions from the answers of the participants are presented in this paper.

This paper contains original work which has not been published previously and that it is not under consideration for publication elsewhere.

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Keywords M-learning · Intelligent tutoring systems · Effective computing · COVID-19 · Adaptive learning

1 Introduction

There has been an enormous growth in the field of computer-based learning that includes e-learning, mobile learning (m-learning), online courses via social media, and the benefits of affective computing. (Politou et al., 2017). M-learning focuses on the mobility of the learner, interacting with portable technologies. Using mobile tools for creating learning aids and materials becomes an important part of adaptive learning. An e-learning environment can be used for tutoring large and heterogeneous groups of students, without the limitations of time and place. (Sotiropoulos et al., 2019). An intelligent tutoring system has to provide personalization to the specific needs, perceptions, interaction, behavior, and attitude of each individual student needs. (Virvou, 2018).

In the 2.1 section, the acceptance, (Sek et al., 2010) of m-learning is investigated and particularly the Technology Acceptance Model (TAM). In Section 2.2 the variety of methods that are used, (Brand et al., 2011), combining traditional and modern techniques, is researched. The important issue of gender differences, (Bao et al., 2013) is referenced in the 2.3.1 section. (Liaw et al., 2010). Moreover, in the 2.3.2 section, several approaches of active learning are referred to, while the 2.4 section deals with m-assessment. (Nikou & Economides, 2014). The third section refers to the empirical study that has been conducted during the lockdown due to COVID-19. In subsection 3.1 the most frequent attributes of m-learning are analyzed, in order to summarize the most important parameters, which consist the backbone for the composition of a questionnaire. Pupils of a high school, students of a University, and participants of lifelong learning courses answered the questionnaire, as it is described in subsection 3.2. The answers of the participants are analyzed in subsection 3.3. The last sections provide valuable conclusions regarding the importance of m-learning and suggestions are made for future studies.

This paper presents interesting results in the question “amphitheater or digital classroom”, while with the creation of a questionnaire for 3 different students’ groups, the focus is shifted to the maximization of the educational effectiveness. This approach promotes individualization and adaptivity in m-learning environments, which is a valuable requirement nowadays, based on the needs and preferences of individual learners. The questionnaire was shared by social media to increase interaction. Social media were chosen because the vast majority of users worldwide are active on social networks and the reflection is instant. Regarding the categorization of the parameters, because of the fact that there are many aspects that should be considered, attention has been paid to the most significant, which is aspects that have concerned the majority of researchers. Our research findings indicate that the attitude of learners seems to be ideal for modeling students’ learning styles and preferences. The purpose is to reveal the students’ learning styles, for students to declare their option between digital class or physically present in amphitheater and design appropriate study plans. Moreover,

students' preferences enable lecturers as well as educational managers to indicate the aspects that influence students which must be taken into consideration. The support of those aspects can reduce eliminations from universities due to students' poor performance.

2 Literature review

M-learning has gained an increasing interest around the globe by academic disciplines, while in the days of COVID-19, the need to enrich this way of education has appeared. The latest technological advances are used to create interactive educational environments where students can learn, collaborate with peers, and communicate with tutors while benefiting from a social and pedagogical structure similar to a real class. (Chrysafiadi & Virvou, 2015). The diversity of the methods that are employed by researchers while using intelligent tutoring systems contribute to enhance adaptive learning. (Virvou & Alepis, 2005). Among all the papers that fall within the specified time period (2010–20), it was discovered that a large proportion of them was dealing with the question of whether there are differences based on gender, which led to the relevant categorization. Features that were encountered among the papers of our sample, such as attitude, (Hwang & Chang, 2011), usefulness, (Garaj, 2010), ease of use (Park et al., 2012), behavioral intention, (Lan et al., 2012), etc. were addressed and evaluated. Statistics indicate that 78% of users are using their smartphones more than they did a year ago, while the corresponding growth for laptops/desktops is limited to 42%, (Kontogianni & Alepis, 2020). The new generation of portable devices, namely smartphones and tablets, has become popular very fast, to such an extent that people in developing countries prefer those kinds of devices, even without having used laptops or computers priorly. (Ally & Tsinakos, 2014). Using such devices, that are easy to carry, helps people to stay connected to the internet almost continuously, allowing them to communicate, entertain themselves, and be informed. Apart from communication, entertainment, and information, smartphones and tablets can and should be used for educational reasons too, consisting of the basis of a new model of learning, m-learning. (Alepis & Troussas, 2017). M-learning can be based on the use of handheld computers within the classroom during regular lessons, but also outside the classroom, (Motiwalla, 2007) any hour of the day. Regardless of whether it is called “anywhere, anytime”, (Liaw et al., 2010), or “Here and now”, (Martin & Ertzberger, 2013), while other researchers call it “ubiquitous”, (Shanmugapriya & Tamilarasi, 2011), distance learning and m-learning have a huge variety of ways that can be implemented. During the last decade, there are many research studies published that refer to the vast potential of m-learning. (Matzavela & Alepis, 2017). On the contrary, there are very few studies that refer to mobile assessment (m-assessment). (Nikou & Economides, 2017a). Provided that students are familiar with the use of portable devices in general and specifically while learning, the obvious next step is to use such devices to assess their progress. After thorough research in the related scientific

literature, it was found out that there is a shortage of papers in that field, thus, the need for more research emerges. This paper discusses in detail the current trend of m-learning, a notion that has come up before the revolution of smartphones took place. (Gikas & Grant, 2013). As Motiwalla analyzed in his study, m-learning could be facilitated with the use of feature phones, that is phones with a keyboard and a small screen, but capable of accessing the internet (Motiwalla, 2007). Both electronic devices and internet connection protocols of that era may seem primitive compared to the respective technologies a few years later, nevertheless, students had already expressed a positive attitude towards m-learning. (Tsihrintzis & Virvou, n.d.).

2.1 Investigating the acceptance of m-learning

In an effort to explore the parameters that contribute to accepting an m-learning procedure, we found out that generally there is a positive attitude towards it. It is crucial to define whether a process of m-learning will be accepted and for that purpose several tools have been used, such as TAM and the theory of planned behavior, among others. TAM is one of the most frequently used tools, which extracts the tendency of adopting m-learning, in comparison to other theories and models that have been developed. It can be used to find the variable (Mobile Readiness, Interaction, Ease of Use, Usefulness, Attitude to Use) that is more effective, (Almasri, 2014) in the decision of adopting m-learning. According to Sek, et al. (Sek et al., 2010), TAM is a practical tool and it was evaluated in their study. They concluded that the perceptions and attitudes of the user have a major impact on the intention and use of smartphones. The attitude was also denoted as the most important factor in accepting m-learning, followed by relevance and subjective norm, as it was presented by Park et al. (Park et al., 2012). On the other hand, Liu et al. in their paper (Liu et al., 2010), claimed that the most significant parameter in adopting an m-learning procedure is the long-term usefulness. Another field where TAM is utilized is for investigating whether there are differences based on gender. Padilla-Meléndez et al., (Padilla-Meléndez et al., 2013) provided evidence that differences do exist, with females being influenced by the contribution of playfulness on attitude, whereas males are influenced by perceived usefulness. On the contrary, according to Bao et al., there are no significant differences in perceived usefulness and computer self-efficacy (CSE), but there are gender differences in perceptions of general CSE, perceived ease of use, and behavioral intention to use. (Bao et al., 2013). TAM is not only used for investigating the adoption of new technologies in an educational environment. It could be extended to study the intentions of employees to participate in an e-learning process, also. Lee et al. (Lee et al., 2011) used it, combined with the innovation diffusion theory, to define the attitude of employees towards learning with the assist of modern devices. Another type of learning, where TAM can be employed in order to extract conclusions about the acceptance, is called procedural learning. Although procedural learning is not based on m-learning, nevertheless,

it could be exercised using YouTube, which is available on various types of electronic devices, including of course portable ones. (Lee & Lehto, 2013). Sánchez-Prieto et al., (Sánchez-Prieto et al., 2017), established a system based on the TAM which was used while studying the adoption of mobile devices by students of a university of primary education teachers. On the other hand, the research to determine the learner's acceptance towards m-learning can be conducted without necessarily using the TAM. For example, Cheon et al., (Cheon et al., 2012) used a model based on the theory of planned behavior to investigate whether the acceptance of m-learning is influenced by the students' beliefs. In their paper, they presented the factors that contribute to adopting m-learning which are attitude, subjective norm, and behavioral control. (Torres et al., 2019). Other factors that increase acceptance can arise based on the activity theory approach, such as enhancing learners' satisfaction, encouraging learners' autonomy, empowering system functions, and enriching interaction and communication (Liaw et al., 2010). The variety and the diversity of the m-learning procedures give room for experimenting with different aspects of technology. For instance, a Virtual Reality Learning Environment is an interactive and innovative system based on 3D technologies, that stimulates the imagination of the learner. (Huang et al., 2010). Together with the expansion of mobile devices that include Virtual Reality (VR) capabilities, new opportunities for acceptance emerge. In addition, a greater level of acceptance can be achieved by using tools with social interaction. Therefore, using web-video conferencing systems can have a positive effect on the learner's engagement and his/her motivation. (Giesbers et al., 2013).

2.2 Mixed methods of studying through mobile computing devices

There are literally countless ways to implement new technologies in learning. The use of modern electronic devices with access to the internet, (Suanpang, 2012), combined with other teaching techniques, can lead to different models of m-learning, that can be equally effective. (Sha et al., 2012). In some cases, social media are used to enhance the learning procedure, whereas in other cases, not only portable devices but also common computers are used. (Sharples et al., 2009). Social media sites have emerged almost simultaneously with smartphones, while both of them are very attractive to young people. Thus, it makes perfect sense to use a combination of those two technologies in learning in order to enrich the procedure and make it more engaging for young learners. In the paper of Jin Mao, it is indicated that students have a positive attitude towards the use of these technologies in learning, but there are important issues that need to be taken into consideration, such as the complexity of the designing and how students will interact. (Mao, 2014). Furthermore, the usage of a specific micro-blogging site (Twitter), combined with traditional assignments can lead to a positive result. By posting tweets publicly, students interact with each other, while at the same time, a better perspective towards the technologies was observed. (Hsu & Ching, 2012). The different options

for implementing mobile learning solutions are numerous, allowing the creation of many versions. Mobile devices could be used for online surveys, while at the same time teachers can develop activities in the classroom to obtain better observations. (Kissinger, 2013). For instance, students in an elementary school may have the opportunity of using different devices for different tasks, such as searching for information or listening to podcasts, on one hand. On the other hand, they can select plain paper for traditional activities such as drawing. (Crichton et al., 2012). Mobile devices can pose a temptation for students, that is because there are various applications other than educational. That's why teachers must be careful to avoid improper use and to ensure an effective learning procedure. (Henderson & Yeow, 2012). The vast advantage of mobile devices is the fact that they are portable. That means, learning does not have to be restrained in the classroom, especially when the purpose is to discover an area. It is impossible for people to get familiar with their surroundings without getting out of the classroom. (Pérez-Sanagustín et al., 2012a). Consequently, students can use portable devices as well as computers while they are in the classroom, at home, and also around the city, (Pérez-Sanagustín et al., 2012b), thus combining technologies. An example of a system that allows learning in and out of the classroom is the Student Response System. (Stav et al., 2010). They relied on XML technologies and web services, with the usage of modern mobile devices, in order to create a flexible service. There are parts of the world where it is a necessity to turn to mobile learning, due to lack or unreliability of infrastructures. For example at the paper of Han et al., (Han & Shin, 2016), students suffer from power losses, so the use of portable devices and not having to depend on computers with short battery life can be crucial for their academic progress. Thus, mobile learning was added to the existing learning process, augmenting the overall procedure. (Jan et al., 2016).

2.3 User modeling

In the following subsections, parameters that concern personalized learning and are part of the field of user modeling are analyzed. Specifically, those parameters consist of gender differences, individual knowledge of learners, active learning methods, and user behavior.

2.3.1 Gender differences and individual knowledge management

Each person has its own preferences about every aspect of life. All people are different from each other and everybody wants to be able to regulate his/her time according to his/her approach. Learning is not an exception to that fundamental principle. Therefore it is of great interest for researchers to study whether there are differences among learners based on their gender and how learners will be able to adjust their learning process according to their needs. (Panadero et al., 2017). According to Diemer et al., (Diemer et al.,

2013), there were no differences due to gender, during classroom activities using iPads. But, analyzing the acceptance of m-learning in separate parameters, can lead to better insight. With the structural equation user modeling approach, conclusions about the computer self-efficacy (CSE) regarding the gender of university students can be drawn. For instance, at a university in the Arab Gulf region, students who participate in an m-learning procedure answered a questionnaire about their attitude towards it. Several factors were taken into consideration, but no differences were found based on gender, while on the contrary, there were significant differences in other factors, like country and age. (Al-Emran et al., 2016). Similarly, the study of Sabah on students' awareness and perceptions led to the conclusion that there are no major differences, considering gender. (Sabah, 2016). The results of the research of Bao et al. were to some extent contradictory because in some cases it was shown that there were no differences and that in others differences do exist. (Bao et al., 2013). Specifically, there are differences in general CSE, perceived ease of use, and behavioral intention to use, whereas there are no differences in specific CSE and perceived usefulness. On the other hand, significant differences were found based on gender, during research on the impact of podcasting on student motivation in online courses. (Bolliger et al., 2010). Furthermore, in the paper of Padilla-Meléndez et al. it is considered that gender differences do exist. (Padilla-Meléndez et al., 2013). More specifically, males are not influenced by playfulness in order to accept a modern learning system but by perceived usefulness, whereas females are keen on accepting the system due to playfulness. The hypothesis that gender differences exist was also confirmed by the research of Han and Shin, who studied the adoption of mobile learning management system by students of an online university. (Han & Shin, 2016). Obviously, a huge advantage of m-learning is that it allows learners to regulate their learning process according to their wishes. The notion of self-regulation was investigated by Liaw and Huang (Liaw & Huang, 2013), while Simonova and Poulouva dealt with cloud and m-learning and specifically with teaching based on the learner's preferences. (Simonova & Poulouva, 2015). To enhance the potentiality of individual knowledge management, there are several systems that have been introduced. Systems like that include features such as the delivery of learning content, reporting student progress, the interaction between students and teachers, etc. (Saračević et al., 2011). There have been developed several variations of the system that helps students manage their knowledge. Some approaches may be referred to as Personal Knowledge Management, while usually it is called Learning Management System or LMS. The prospective evolution of LMS is called mobile LMS and it was studied by Joo et al., (Joo et al., 2016), who focused on the actual usage of the system, in an online university. In the effort of implementing such a system, some problems emerge that should be taken into account, according to Zhuang et al. (Zhuang et al., 2011). The integration of knowledge management can be achieved with different models and different criteria, according to each instance, (Judrups, 2015) and even the color is a

significant parameter when designing the interface of a relevant application. (Pelet & Uden, 2014).

2.3.2 Active learning methods and user behavior

In most cases, students are of young age and in the majority, they are fond of playing video games. While playing, people tend to be more concentrated and have a better attitude and behavior towards learning online. (Faiola et al., 2013). During the engagement with a video game, the player is very immersed and focused, a status called “flow”, which leads to improved learning. Thus, playing games can be utilized as an active learning method combined with the capability of adapting to a student’s learning style. (Soflano et al., 2015). The notion of learning by playing games is referred to as game-based learning (GBL), but it has not been studied to a great extent yet. Furthermore, in order to create learning systems that will adapt, there are several factors considering the user behavior that should be taken into account. (Seufert, 2018). One of the most important factors is attitude, (Cheon et al., 2012; Park et al., 2012), while perceived usefulness and ease of use, behavioral intention (Park et al., 2012) and control, beliefs, (Cheon et al., 2012), personalization (Wang & Wu, 2011), performance and effort expectancy, personal innovativeness, (Abu-Al-Aish & Love, 2013) could be accounted as important too, among other factors. To enhance the experience of a student during a teaching procedure, different approaches have been proposed. Receiving rapid feedback with rich content about the curriculum on handheld devices is the key concept according to Chen et al., (Chen et al., 2010). On a similar basis, the process of learning via mobile phones could take advantage of the short messaging system. By sending messages frequently, the connection between the tutors and the students is increased, leading to increased interaction and more motivated students. (Van Rooyen & Wessels, 2015). Another efficient model of active learning is the flipped classroom, which is a combination of using a smartphone app and the traditional tutoring in the class. The study of Chen et al., (Chen Hsieh et al., 2017) shown that the flipped classroom leads to increasing the students’ motivation and improving their knowledge acquisition. The Student Response System, which is based on web services and mobile devices, also supports active learning, providing intuitive control interfaces and flexible response services, in the classroom or from distance. (Stav et al., 2010). One of the oldest learning methods is the “Socratic method”, which is based on the collaboration of students, where they ask each other questions, resulting in better acquiring knowledge. Entering the modern era, the aforementioned method could be combined with the use of smartphones, allowing teachers to interact with their students and also students with their peers. Thus, collaboration is increased, leading to improved academic performance. (Awedh et al., 2015). Probably the most radical approach, but not a very efficient one, is based on the concept that the students should participate more actively in the procedure of m-learning. Specifically, instead of just using portable devices with existing applications installed, students taking part in the study of Garaj (Garaj,

2010) expressed their ideas of how m-learning should be, leading eventually to the development of ad hoc smartphone apps. The problems that arise with that approach, are two: a) not all students are capable of programming and b) developing applications could be time-consuming.

2.4 M-assessment

Turning our attention to m-assessment, it was observed that there is a remarkable shortage of studies in that field. Very few researchers until today have dealt with m-assessment, which is the evolution of m-learning. (Nikou & Economides, 2017b). On the other hand, the main portion of the surveys that have been published over the past years makes reference to the evaluation of the m-learning process that it is referring to. In fact, the evaluation is carried out using traditional methods, such as a static questionnaire. (Parsazadeh et al., 2018). Combining learning and assessment has resulted in the Fully Online Learning Community, which addresses the demands of all entities that are involved in the educational system. A unified system for learning with embedded assessment can lead to beneficial results for everybody, constituting a democratized model. (Blayone et al., 2017). Also, the question of the excessive use of technology during teaching has been raised. That issue was addressed by Anshari et al. (Anshari et al., 2017) in their paper. They conducted research, investigating the fact that the use of portable devices while learning, may cause a distraction to the students. Given that the implementation of m-assessment will extend m-learning, there is a possibility that the problem of interference will be increased. Therefore, corresponding studies should be conducted. In order to develop an effective m-assessment procedure, this new approach of evaluation should also be assessed. Some of the factors that have been studied already are whether the achievement and the attitude of the student are affected while using m-assessment. (Sahin, 2015). Nikou and Economides utilized TAM in their study, in an effort to explain if the attitude influences the adoption of m-assessment. They prepared a survey questionnaire that was answered by the students and the results led to the conclusion that competency, autonomy, and relatedness are three significant factors that should be taken into consideration when developing the procedure. (Nikou & Economides, 2014). A more thorough examination of the evaluation of m-assessment is presented in the paper of Nikou and Economides (Nikou & Economides, 2017a). The authors proposed a specialized model based on TAM, called the Mobile-based Assessment Acceptance Model (MBAAM). When using this model, more factors are taken into accounts, such as ease of use, usefulness, and behavioral intention, leading to increased understanding. The result is a better experience for the students, that promotes learning. Although it is not based on assessment via mobile devices, in the paper of (Ćukušić et al., 2014), the assessment is based on a computer. The importance of this study is that modern assessment is compared to traditional methods, suggesting that there are positive effects on students' performance. Further

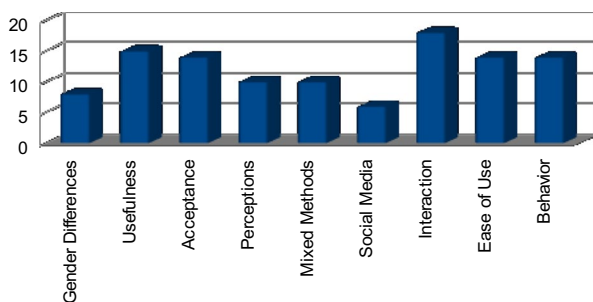
analysis, with the inclusion of m-assessment in the comparison between traditional assessment and computer-based, shows that both computers and mobile devices have positive effects on learners' motivation and that they could replace old-fashioned ways of assessment. (Nikou & Economides, 2016). While investigating the field of m-assessment, it was observed that until today questionnaires have been employed to measure the effectiveness of m-learning to students, whether they prefer learning without a physical presence or not. In addition, questionnaires are being employed, in order to evaluate the performance of university students, the educational staff, as well as the facilities. Also, questionnaires based on static content have spread widely throughout the educational sector, allowing the assessment of the curriculum. (de-Marcos et al., 2010). M-assessment with the use of dynamic questionnaires can form an interesting and useful expansion of m-learning. (Matzavela et al., 2017). Students consistently show a positive attitude towards mobile devices and smartphones, which they wish they could use for reasons that may vary from gaming to learning. In this survey, the significance of learning with portable devices was studied. Education is making progress, from a technological scope, while class lessons are taking new dimensions. Focusing on dynamic questionnaires for education is an essential move, because of the fact that they are innovative and flexible. The aforementioned characteristics are attractive to young users, who are willing to make changes in the learning procedure. Most questionnaires that are used in education do not focus on examining students. As traditional learning is leaving space for m-learning, (Chrysafiadi & Virvou, 2015), similarly, dynamically changing questionnaires should be developed. The tendency is to move from exams with static questionnaires, to dynamic questionnaires, through m-assessment.

3 Empirical study

This specific empirical study was based on real data that were extracted from students and lifelong learners during the pandemic of COVID-19. The lessons stopped for all in the physical classroom and continued in digital classrooms with educational adaptive platforms. In subsection 3.1 the most popular parameters of m-learning are employed, in 3.2 the composition of the questionnaire is described and in subsection 3.3 the results of the empirical study that were noted, are analyzed.

3.1 Parameters of the study

Based on the data collected from the reviewed papers, it was notable that there are some characteristics of m-learning that concerned many researchers. The most important of them, which were referred to in many papers, were used to form the parameters of the questionnaire. These parameters are demonstrated

Fig. 1 Allocation of papers per parameter

in Fig. 1, where each one of them is represented with a column. Gender differences were studied in 8 papers and it was concluded that there are differentiated preferences according to gender. Many researchers, (Pedaste et al., 2015), have pointed out that it is important to consider the usefulness of the system while implementing an m-learning process. This parameter, which was highlighted in 15 papers, can be the key factor in order to create a flexible and attractive to students process. Based on 14 studies that were concentrated majorly on the acceptance of m-learning, it is concluded that the acceptance is increasing over the past years and that people are becoming more and more familiar with the idea of learning without being physically present in a classroom. The perceptions of the students have been altered in a positive direction lately, which has been the subject of 10 studies. Concerning the use of mixed methods of learning, that is by combining a modern technique like m-learning with a traditional one, optimum results can be achieved. The number of papers that referred to mixed methods was 10. Social media, e.g. Facebook, Instagram, offer more capabilities that would not have been possible with traditional methods. 6 papers explored the communication between students and teachers via social media. One of the most significant parameters is the interaction between the students and the teachers, which was encountered in 18 papers. The ease of use in the m-learning environment and friendly to learners was surveyed in 14 papers. Finally, the students' behavior has also been analyzed and measured by researchers in 14 studies.

3.2 Settings of the empirical study

During the general lockdown due to COVID-19 pandemic (March 2020) in Greece, m-learning was a one-way solution. Schools and universities were closed, while lessons continued normally in all educational levels, forcing learners to utilize their mobile devices in order to attend courses.

M-learning supported all students through various platforms, covering all educational needs. Students were connected by mobile devices and the interaction of m-learning can be analyzed with specific data derived from

Table 1 Number of participants per age group

Educational level	Delivery of questionnaire via	Participants
High school students	Social media	29
University students	e-mail	11
Long-life learners	e-mail	12

their feedback. The criteria for the composition of the questionnaire were the parameters that emerged from the analysis of the literature. By classifying the most frequently displayed parameters in papers, a set of the following parameters was extracted: gender, usefulness, acceptance, perception, methods, social media, interaction, ease of use, and behavior. The questionnaire was created based on this set of parameters, which was sent to the students via social networks or e-mail, in the midst of the COVID-19 pandemic (Tables 1, 2, 3 and 4).

The people that answered the questionnaire were divided into 3 age groups, the first group consists of 29 students of high school, the second group includes 11 students of a University and the composition of the third group is 12 adults that were participating in life-long learning, reaching a total of 52 people. The following figure illustrates the number of participants in all papers that were researched. The length terms 9 to 2732 participants (Fig. 2).

The first question concerned the gender of students and there is a suitable column with the preferences of an individual participating in distance learning. Question number 2 concerned the usefulness of m-learning with

Table 2 The questionnaire

Q	Attributes/Parameters	Questions
Q1	Gender differences	Gender
Q2	Usefulness	How useful did the m-learning procedure seem to you?
Q3	Acceptance of completed courses	Did you like the learning through your computer or mobile phone?
Q4	Acceptance of future m-learning courses	Will you prefer m-learning in upcoming courses?
Q5	Perception	How easy was it to understand the lesson?
Q6	Mixed methods	Which teaching method do you prefer?
Q7	Social media	Did you find it easy to send/receive content via social media?
Q8	Interaction	Did you like the interaction with the teachers via the screen?
Q9	Ease of use	How user friendly was the access to the online platform?
Q10	Behavior	Were you enthusiastic about m-learning?

Table 3 The percentages of the level of attitude of the participants

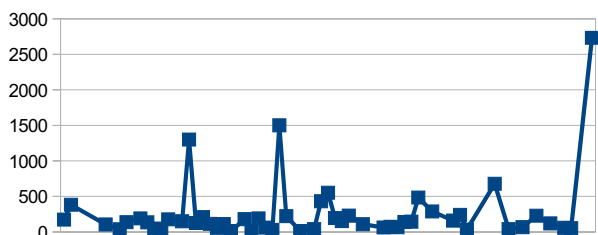
	Very	Moderate	Little
High school students	77.30%	18.40%	4.30%
University students	58.60%	29.30%	12.10%
Long-life learners	65.70%	30.50%	3.80%

Table 4 Comparison of the preferred method between age groups

	M-learning		Traditional	
High school students	5	17.24%	24	82.76%
University students	5	45.45%	6	54.55%
Long-life learners	2	16,67%	10	83.33%

a proportional column of options. The 3rd and 4th questions concerned the acceptance of m-learning which is a parameter of high importance in m-learning, hence 2 questions were applied. Question number 5 was a reference to the perceptions of participants. Question number 6 was related to the mixed methods which are the combination of traditional and digital class or not. The seventh question concerned the social networks and the increasing use from year to year. Question 8 was based on the interaction between students and teachers. Question 9 referred to the ease of use of mobile devices or laptops for connection. The tenth question concerned the behavior of the learners.

Apart from these parameters that were found to be the most important of m-learning and which were matched with a question, there was another one taken into consideration, the attitude of learners. The attitude of learners provides a novel framework that moves further away from traditional classes, while incorporating a wide range of recent advances to provide personalized solutions to future challenges. (Alepis et al., 2017). These parameters can improve and assist the learning process with individual results and utilization of them, from authors and researchers.

Fig. 2 Number of participants per paper

3.3 Results of the empirical study

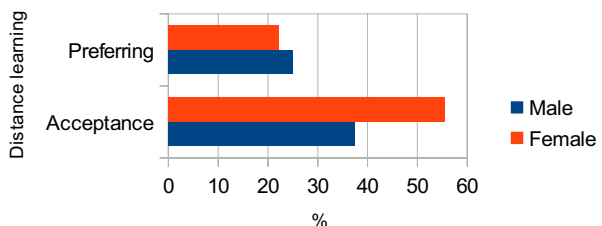
The classification method assisted to extract results and the categorization was achieved indirectly or directly. In view of them, the questionnaire was created, with specific parameters and shared in 3 target groups learners. The answers were collected via social networks or mails. The first target group was students of high school, the second target group was students of a university and the third target group was adults of long-life learning. Each question was matched with a parameter of the aforementioned and the answers were demonstrated in figures and tables with percentage ratios. The attitude of learners was evaluated by the teachers during the distance learning and after the conclusion of each lesson when the connection was interrupted. The results of the aforementioned parameter will be demonstrated in the following table.

The most widespread method for the production of predictive models is the Classification method utilized in this approach. The classification method in education based on specific features for supporting the learning process. The categorization is applied to the parameters in order to draw a predictive model. In the first question of the questionnaire, the participants determined their gender, with approximately 69% of the participants being female and 31% male. As for the gender differences, after analyzing the data, the acceptance and the preference of the participants towards m-learning are depicted in Fig. 3. In order to distinguish whether there are gender differences among the participants, their answers on whether they prefer distance learning and on acceptance were taken into consideration. There was no significant difference in the percentages that reflect the preference towards m-learning of the male (25%) and female participants (22%). On the contrary, there was a notable difference between the two genders, with 55.56% of women accepting m-learning, whereas only 37.5% of men are accepting it, as it is demonstrated in Fig. 3.

In the question for the usefulness, 48.08% of the people, almost half of them, found it very useful, 44.23% answered moderate and 7.69% answered that distance learning was a little useful. Almost half of the learners believe that the lessons were very useful. If the percentage of the learners who answered “Moderate” is added with the previous, the combined percentage reaches an impressive 92%, leaving a small minority who believe that m-learning was not useful.

The parameter of acceptance was investigated with two questions, in the one question participants were asked directly if they liked m-learning and 40.38% answered very much, but the majority, 44.23% answered moderate and 15.38% showed little acceptance towards m-learning. The other question regarding acceptance was

Fig. 3 Gender differences



indirect, with participants being asked whether they would like to attend again a course via m-learning, where the opinions of the participants were divided equally, ie 50% in favor and 50% against. One possible explanation might be the fact that none of the participants had attended m-learning courses in the past, which means that there should be an adaptation period until everybody gets familiarized with it.

More than half of the participants, which is 51.92%, answered they have a very good perception towards m-learning. A large part of the participating learners had a moderate perception in m-learning, specifically 42.31%, and only 5.77% answered they had low perception. On the contrary, the method which is preferred by 76.92% of the participants is the traditional class. To get a better insight into this aspect, the following table was created, which enumerates the learners and the percentages per age group.

The remarkable fact is that the vast majority of teenagers students prefer the traditional class and the physical presence over m-learning. Their percentages are similar to those of adults attending long-life learning courses, who are expected to be inexperienced and not familiarized with mobile devices. On the other hand, the University students who are young adults and very keen on using mobile devices, are divided between digital and traditional class.

Social media is a widespread way of communication nowadays, with which almost everybody is familiarized. During the lockdown and the online courses, social media were used to post exercises for all students, instead of sending them via email, in order to achieve high engagement. In the question for utilization of social networks, 38.46% liked using social media very much, 36.54% answered moderate and 25% found little utilization. Despite the usefulness of social networks, students' views about them were almost equally divided into the 3 available answers, with approximately one-third of the students (38.46%) being very positive in using them.

The overall satisfaction of the students about the capability of interacting with each other and with their tutors was surveyed. In that question, 44.23% answered very much, 38.46% answered moderate and 17.31% believed there was little interaction in m-learning. The conclusion is that almost half of the participants were very satisfied and 38% were moderately satisfied, leaving a small percentage of 17% who were a little satisfied.

Concerning the ease of use, 63.46% answered m-learning was very easy, 28.85% answered moderate ease, and 7.69% believed ease of use was low. It is observed that most of the learners (63.46%) found high ease of use while using mobile devices, namely smartphones and tablets, and relative apps. The last question concerned the behavior of learners and 26.92% felt very enthusiastic, whereas 42.31% answered that their behavior was moderate. In addition, a large part of the learners, 30.77%, was not fond of the idea of online lessons, which were mandatory.

4 Discussion

This paper aims to analyze the parameters of m-learning with published papers in quality journals or significant international conferences (Virvou et al., 2012, 2020) and the second step was the creation of a questionnaire for 3 different

educational groups, that continued their lessons in the COVID-19 era, and the results are useful for tutoring systems which based in adaptive learning, providing important information to researchers, educators for e-learning and m-learning systems. (Alepis & Virvou, 2011). Also, this paper can be used as a guide for making decisions about the techniques of student models. The similarities or differences between learning in digital or physical classrooms and the reflections of learners were analyzed while was employed specific data from popular parameters referring to m-learning. Moreover, learning analytics enabled the increase of understanding of the students' learning needs.

The presented system provides an adaptation of the instructional material, taking into account the individuality of learners in terms of background, skills, and pace of learning. The innovation of the presented approach is the student model. It is a mixed student model that combines 3 different student groups: high school students, university students and long-life learners. In particular, the student model is based on focusing on the parameters of m-learning, while the learning analytics are incorporated into the student model. Also, the student model includes a mechanism of rules over the questionnaire which is triggered after any change of the value of the parameters. The presented novel approach shows the benefits of m-learning, whereas the student preferences were influenced the learning in the physical classroom.

The student model of the particular system has 3 layers. The first layer includes the educational data, which was extracted from the students with specific parameters. The second layer includes the learning analytics, where the answers of the learners were utilized. The third layer includes the categorization of the results and evaluation of them. Consequently, the presented educational model contributes significantly to adaptive learning in m-learning environments, while an educational effective process in a traditional classroom is promoted. The ability of the presented educational system to recognize the attitude and behavior of learners renders the particular approach a novel useful tool for instructors and institutes. The encouraging results could be evaluated and utilized for the effectiveness of individual learning in a digital or physical class.

5 Conclusions

Researchers increasingly use technological advancements emerging from learning analytics to support digital education, whereas a surprisingly big interest has the global community for adaptive learning in the online educational systems. Learning analytics can be employed to provide educators with information to reflect on their patterns of students' behavior concerning others, or to identify students requiring extra support and attention, or to help teachers plan supporting interventions for functional groups such as course teams. Given the above, this paper employs learning analytics and presents the measurement, collection, analysis, and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it

occurs. The conclusions that are drawn by the system concerning the aspects of students' characteristics seem to be satisfactory valid and can be utilized for the enhancement of personalized education.

In this approach, the utilization of m-learning, on days of the pandemic COVID-19 and afterward, is presented. This paper discusses important research issues such as: to maximize the educational benefits of distance learning, while based on the needs and preferences of individual learners. The aspects of m-learning were analyzed extensively, including unique features, and the data generated a set of parameters of m-learning. The most important parameters are gender, usefulness, acceptance, perceptions, mixed methods, social media, interaction, ease of use, behavior, and attitude. Each of these parameters is presented and analyzed separately in this paper and is focused on the synthesis of the questionnaire for extracting specific results was achieved. The major percentage of learners of all different groups prefer adaptive learning in a physical class, whereas digital education influence the student's attributes. It is within the future plans of authors to create a dynamic questionnaire for self-assessment or student academic performance with random tests supported by decision tree learning. The benefits of the above approach could be effective in the individualization of m-learning according to students' features, the limitation of drop out and the concretization of a predictive model, which categorizes the answers of each student, to be able was incorporate in an algorithm for tutoring systems.

Authors' contributions All persons who meet authorship criteria are listed as authors, and all authors certify that they have participated sufficiently in the work to take public responsibility for the content, including participation in the concept, design, analysis, writing, or revision of the manuscript.

Data availability Data are available upon request.

Declarations

Competing interests There is no conflict of interest with any of the suggested reviewers.

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