Teachers' Perceptions Towards the Use of Mobile Augmented Reality

The Case of Greek Educators

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Abstract—This paper examines the perceptions of Greek Primary School teachers about the educational use of mobile augmented reality (MAR). The research of this study includes the design and development of an educational application which involves augmented reality and mobile learning. Additional information and digital features, following the school curriculum, were superimposed to the user's real world through the utilization of mobile devices. Primary school teachers were familiarized with the application and formed their opinions regarding mobile augmented reality in the teaching process after using it. Then, they filled out a questionnaire based on the technology acceptance model (TAM). The analysis of the data that were collected showed significant correlations between the variables. In particular, it was found that teachers' intention to use the mobile AR application that was designed is related both to perceived usefulness and to perceived ease of use. Teachers enjoyed the mobile augmented reality experience and considered the app as a useful and easy to use tool, which has a lot to offer to their teaching.

Keywords—Mobile Learning, Augmented Reality, teachers' perceptions, TAM

1 Introduction – Defining the Technology of Mobile Augmented Reality (MAR)

Augmented Reality (AR) refers to any case where the real environment is augmented with virtual objects and computer-generated graphics [1]. According to Azuma [2], AR combines the real with the virtual world, supplementing the existing reality and offering real-time interaction.

The increased use of augmented reality has enabled mobile learning [3]. Mobile devices, such as tablets and smartphones, are combined with AR, allowing users to interact with virtual content that is now part of their physical environment [4]. According to Henderson and Yeow [5], primary school teachers consider mobile devices, such as iPads, as useful learning tools. The great features and benefits that

mobile devices offer have caused their use for educational purposes [6]. Moreover, the advantages of mobile technologies have lead researchers examine their use within formal and informal learning environments [7].

The powerfulness and affordability of mobile devices have made them a suitable platform for AR, providing more authentic and engaging learning experiences [3]. Hwang, Wu, Chen and Tu's research [8] on elementary school students showed that game based learning through mobile augmented reality contributes to students' positive attitude towards learning and improves their performance. In addition, another positive aspect of mobile AR in education has been the creation of motivating learning environments for students [9].

Apart from that, the use of mobile devices implies quick and easy access to additional information, with students being able to collaborate and learn in different ways [10]. In particular, the ability of mobile devices to interact with users wherever and whenever they desire seems useful in teaching [11]. Through mobile computing, the information people get from their senses is combined with the augmented features in the real environment that they receive from mobile devices [12]. Their small size and variety of capabilities allow mobile devices to show augmented reality content, while their widespread use leads to the social acceptance of MAR [13].

The development of AR technology and mobile computing has resulted in their combination with pedagogical approaches, changing the existing conditions in the field of Education [14]. Mobile augmented reality applications for educational purposes are constantly being developed [15]. In the context of mobile and ubiquitous learning, students interact with the environment and have enriched rather than static lessons [16]. However, these technologies may cause students to be overwhelmed and confused with the amount of material and complexity of tasks [17].

2 Teachers and MAR Use in Education

Teachers' perceptions about ICT in education influence their adoption in the school classroom [18]. Similarly, it is expected that this will also be accurate about the integration of mobile augmented reality in education. Thus, this research studies Greek teachers' perceptions concerning mobile augmented reality technology. However, many researchers have pointed their interest at this direction.

Kamarainen and her colleagues [19] conducted a survey regarding the integration of mobile augmented reality in an educational excursion outside of the school. The project was called EcoMOBILE and through its implementation both students' and teachers' views on the usefulness and teaching value of the MAR technology were examined. Teachers found that this way of teaching seemed to be more effective and that the interaction between students and the environment was promoted.

In addition, Kerawalla et al. [20], in their comparative study used an AR interface, as well as traditional methods of teaching physics and came to the conclusion that flexibility, guided exploration and adaptation of the additional virtual content to the curriculum are necessary for effective teaching.

Another Augmented Reality system for learning was designed by Liarokapis and Anderson [21]. Through 3D models, images, texts, videos, and sounds students were able to gain a deep understanding of complex learning concepts and phenomena. The findings of their study showed that AR is a useful tool for learning with its impressive properties [21].

Mobile augmented reality can also enhance analog games with 3D objects, animations and other virtual content [22]. In this research, teachers filled out a questionnaire based on the TAM model. The findings showed that teachers seemed to maintain a positive attitude and consider the augmented educational games useful for the teaching practice [22].

In Huang, Li, and Fong's research [23], principals and teachers were asked to express their opinions about educational activities that utilized mobile devises and augmented reality. Participants were positive, interested and willing to integrate MAR in education, although they had some concerns [23].

The educational use of mobile devices concerned Zaranis, Kalogiannakis and Papadakis [24], who found them effective and valuable tools for teachers. The researchers examined the use of mobile devices to teach Mathematics to 4-6 year-old students. Additionally, Bozkurt [25] found that AR, emerging from ubiquitous technologies and mobile devices, provides enriched and unique learning experiences.

From the review of the literature it has been clear that mobile learning and AR offer new perspectives in the teaching practice [26]. According to Wu, Lee, Chang, and Liang, mobile augmented reality offers a variety of opportunities to support teaching and learning [27]. Given that, the integration of MAR in the classroom seems to be really close. For this reason, it is essential to further study the perceptions and aspects that define Greek primary school teachers' intentions and plans to improve their teaching through this relatively new technology.

3 Methodology

3.1 Participants

In this quantitative research, a sample of 206 Primary School teachers has participated (79 men, 127 women), coming from different age groups in order the sample to be more representative in terms of the teaching experience and familiarity of the participants with new technologies.

3.2 The instrument

For the purpose of this study a questionnaire has been used, based on Davis' Technology Acceptance Model [28]. The questions were closed-ended on a seven-point Likert scale (1: Strongly Disagree, 7: Strongly Agree). The questionnaire was translated to Greek by two certified translators and reviewed by qualified members of the University staff with expertise in the use of ICT in Education. A pilot study was conducted on 30 teachers.

The questionnaire that was used consisted of two parts. The first part included general questions, such as the participant's gender, age, years of experience, familiarity with mobile devices and the existence of previous experience with mobile augmented reality applications for educational purposes. The second part of the questionnaire had the Likert-scaled questions and examined three main variables; Perceived Usefulness, Perceived Ease of Use and Behavioral Intention. According to Davis [29], perceived usefulness refers to "the degree to which a person believes that using a particular system would enhance his or her job performance", meaning that if using the new system shows positive outcomes on the person's work, it will be perceived as useful. On the other hand, if using the system occurs with no difficulties and is free of effort, it is then perceived by the user as easy to use [29]. Those two factors are deemed to be of great importance, having an effect on the person's behavioral intention and willingness to use the system which is being studied.

The role of the acceptance of a technology that is introduced is determining for its future utilization. Most researchers have chosen the TAM model or extended versions of it in order to study the attitude which people hold towards a new technological system [30]. The validity of this widely used model has been examined by a variety of researchers [31], [32], [33], [34]. In this study we also proceeded in reliability and validity tests (Cronbach's a, Principal Component Analysis – PCA).

3.3 Research procedure and data processing

3.3.1 Design and development of an educational experience combining mobile learning and augmented reality

In this study, an educational mobile augmented reality application was designed, especially for the Greek primary school teachers. The app is about the near and far side of the moon, its rotation and the orbit around the earth. To view its augmented digital content, users scan the pictures that are found in 6th grade Geography school book. Each picture constitutes a marker that triggers the app to superimpose the visual objects to the real world (Fig. 1.). Users need a mobile device (either smartphone or tablet) to have this experience. Its use provides quick access to the additional information and digital content.

Taking advantage of mobile learning features, the educational experience about the moon can be implemented in any place, at any time, providing great flexibility. The augmented reality platform which was used to design the MAR application was BlippAR (www.blippar.com). The application works both for IOS and Android system. Teachers could and still can use it anywhere, anytime. The only requirements are; the markers of 6th grade Geography school book, internet connection and also to have downloaded the BlippAR app on the mobile device.

The application has been designed and developed in order to be suitable for this research. First of all, teachers were familiar with the content and educational material, as the additional digital information of the application was based on the school curriculum. Consequently, there was not any cognitive load added to the teachers. Also, teachers' experience, training and pedagogical knowledge made the assessment

of the mobile AR app easy. In this way, teachers could form an opinion about the capabilities and perspectives of mobile augmented reality in their teaching about the moon. Finally, the mobile AR app which was designed met the teachers' needs concerning the teaching of earth and sun relations.

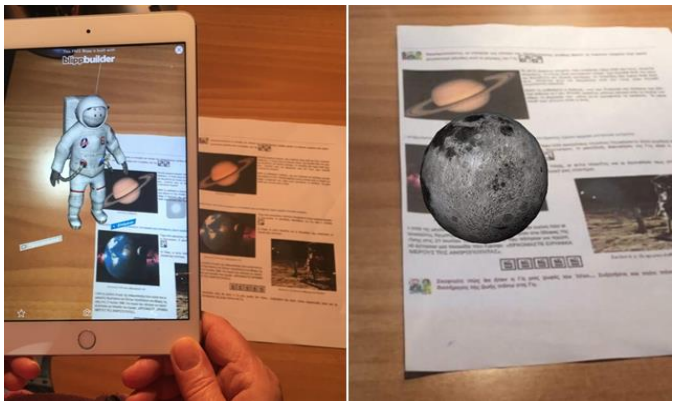

Fig. 1. Snapshots from the mobile AR app about the moon

3.3.2 Procedure

Primary school teachers who participated in this study to one of the researcher's place of work in order to take part in activities based on the use of educational technologies. Firstly, teachers were familiarized with the concept, while the mobile augmented reality application, which was designed especially for them, was explained. Questions that aroused were answered both at the beginning and during the use of the mobile AR app, as well.

Secondly, a mobile device (tablet) was provided to the participants along with the augmented part of the Geography school book. Teachers were called to interact with the mobile AR app and the digital features that were superimposed into their physical environment. Teachers scanned all the markers so that they successfully complete the AR experience.

Finally, after using the mobile AR application about the moon, participants were asked to fill out the questionnaire, concerning their perceptions toward their experience on mobile learning and augmented reality. The duration of the procedure was approximately 20 to 25 minutes for each participant. The data were collected during the academic year 2017 - 2018.

3.3.3 Data analysis

Data of this study were collected through the questionnaire and analyzed using the Statistical Package for the Social Sciences - SPSS Statistics 21.0. To conduct this research, both descriptive and inferential statistics were used in order to extract results and draw more accurate conclusions. More specifically, after conducting a Kolmogorov-Smirnov normality test in SPSS to determine the distribution of the data,

nonparametric Spearman's correlation coefficient was used. In addition, reliability analysis (Cronbach's a) and factor analysis for convergent and discriminant validity were implemented.

4 Results

According to the statistical analysis of the data, there are some results worth to mention. First of all, the participants of this study considered themselves quite (47.1%) or extremely (37.9%) familiar with mobile devices and adequate to use them in their everyday lives. Additionally, 67% of the Greek Primary School teachers who participated in the study stated that they had not had a similar experience with mobile learning and augmented reality for educational purposes in the past.

The majority of the participants believed that the educational mobile AR app which was designed enhanced their teaching performance, effectiveness and productivity. To be more specific, 98% of the teachers perceived the educational mobile AR app about the moon as useful for their teaching practice, while three (3) participants out of 206 disagreed with this statement and only one of them was uncertain about the usefulness of a tool such as the mobile AR app that was designed.

A percentage of 90.8% of the participants felt that learning to operate the mobile AR app is an easy task. The same percentage found that the interaction with this educational application is not difficult to understand. Actually, 185 teachers of the sample (n=206) considered the interaction to be quite clear, while 91.1% answered that the mobile AR app about the moon was easy to use.

The intention to utilize mobile learning and augmented reality application in the classroom was prominent, given that only 3 out of 206 participants held a negative attitude towards the use of the designed AR app in their teaching. A percentage of 3% seemed hesitant, while the majority showed that they intended (95.6%), would try (95.1%) and planned (89.7%) to integrate this mobile technology into their teaching in the future.

4.1 Reliability Analysis - Internal consistency reliability test

The internal consistency of this scale was evaluated by Cronbach's alpha. The value of the coefficient in each case was above 0.7, securing the desired reliability in order to continue into further analysis of the data.

Table 1. Reliability Analysis

	Cronbach's Alpha	**N of Items**
Perceived Usefulness	0.920	4
Perceived Ease of Use	0.932	4
Behavioral Intention	0.918	3

4.2 Convergent and Discriminant Validity

In order to test the validity of the scale, Principal Component Analysis was conducted. Three main components were found. Each component showed high loadings only with the items which, according to the questionnaire, refer to it and low loadings with the rest items.

Table 2. Validity test – Rotated component matrix

	Component		
	1	2	3
Item 1: The use of the mobile AR app can enhance my teaching performance	0.821	0.251	0.274
Item 2: The use of the mobile AR app can make my teaching more effective	0.845	0.221	0.305
Item 3: The use of the mobile AR app can enhance the productivity of my teaching	0.854	0.240	0.212
Item 4: Generally, I consider that the mobile AR app can be useful in my work	0.760	0.280	0.293
Item 5: Learning to use the mobile AR app in the classroom would be easy for me	0.139	0.855	0.285
Item 6: I find it easy to interact with the mobile AR app that was designed	0.385	0.790	0.244
Item 7: The interaction with the mobile AR app is clear and easy for me to understand	0.330	0.799	0.303
Item 8: Generally, I consider that the mobile AR app is easy to use	0.238	0.860	0.257
Item 9: I intend to use the mobile AR app that was designed in my classroom	0.307	0.349	0.791
Item 10: I will try to use the mobile AR app that was designed in the classroom	0.307	0.306	0.828
Item 11: I plan to use the mobile AR app that was designed in my teaching practice	0.366	0.315	0.796

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

4.3 Descriptive Statistics

As shown to Table 3 below, the mean of the variables being studied is around 6, referring to the participants' high level of agreement on usefulness, ease of use and possible integration of mobile learning and augmented reality application in Greek schools.

Table 3. Mean and standard deviation

	Mean	Std. Deviation
Perceived Usefulness	6.00	0.74
Perceived Ease of Use	5.80	0.89
Behavioral Intention	5.75	0.83

4.4 Inferential Statistics

After conducting the Kolmogorov-Smirnov test of normality in SPSS, it was found that the data were not normally distributed. As a result, nonparametric Spearman's correlation coefficient was used. Spearman's rho showed that all the variables being studied in this research were correlated with each other. The correlations were significant at the 0.01 level.

Table 4. Spearman's Correlations

			Perceived Usefulness (PU)	Perceived Ease of Use (PEU)	Behavioral Intention (BI)
Spearman's rho	**PU**	Correlation Coefficient		0.459**	0.585**
		Sig. (2-tailed)		0.000	0.000
	PEU	Correlation Coefficient			0.563**
		Sig. (2-tailed)			0.000
	N				206

** Correlation is significant at the 0.01 level (2-tailed)

Those correlations are consistent with Davis' TAM model [28], [35]. Both perceived usefulness (0.585) and perceived ease of use (0.563) indicated a positive and statistically significant correlation with Greek Primary School teachers' intention to take advantage of the great possibilities that the mobile AR application about the moon had to offer to their teaching. In addition, teachers' perceptions concerning the ease of use of the educational AR app seemed to correlate significantly with their opinions about its usefulness (0.459).

5 Conclusions

The present study used TAM to examine the factors that influence Greek teachers of Primary Education and their general behavioral intention to integrate the mobile AR app about the moon, which was designed to facilitate and enhance their teaching, in the classroom. The findings of this study showed that the participants were familiar with mobile devices and used them in their everyday lives. This finding is in agreement with Goggin's research [36], where it was stated that mobile devices and

wireless networks play an important role in people's daily lives. The widespread use and accessibility of mobile devices to the majority of the population, along with their new, developed capabilities, caused great potentials in their exploitation in mobile learning and in the support of Augmented Reality applications, as well [26]. Nowadays, mobile technologies are also applied in educational settings [25], changing the way students are being taught.

In the case of the Greek primary school teachers, although they considered themselves familiar with mobile technologies, they were not informed about educational applications which combine mobile learning, augmented reality and additional content, based on the curricular. During this study, teachers had the chance to interact with a mobile augmented reality app that was designed for primary education. The digital content which was superimposed to the user's real environment through a mobile device (compatible for both IOS and Android smartphones or tablets) was about the moon and its relation with the earth.

After interacting with the mobile AR app, teachers were asked to express their opinions through a written questionnaire. The questionnaire was based on the TAM model [29]. According to this model, there are two main aspects which can influence behavioral intention to use a new technology. Those are perceived usefulness and perceived ease of use [28]. Findings of this study confirmed Davis' theory on the acceptance of technology, emphasizing on the factors that will probably have a crucial role in the future utilization of mobile learning and augmented reality educational applications, such as the one shown in this study. Similarly, Koutromanos, Styliaras and Christodoulou, found that the components of TAM predicted in-service teachers' intention to use a spatial, hypermedia environment in their teaching [37].

According to Venkatesh, Morris, Davis & Davis [38], people tend to be more positive and willing to use a new technological means in their job when they believe it is easy to operate and at the same time it fulfills the purpose it is meant to accomplish [38]. In this study, the mobile AR app was found to be useful in teaching of this specific lesson about the earth and the moon. Moreover, Huang, Li, and Fong [23] came to the conclusion that teachers consider the technology of mobile augmented reality as a useful educational means which can increase teaching effectiveness, especially when it involves abstract or difficult-to-understand concepts [23]. Particularly, 3D virtual objects, superimposed via mobile augmented reality technologies, can have a positive outcome regarding students' learning and attention, enhancing the efficiency and effectiveness of teaching [39]. Recognizing those advantages, teachers become enthusiastic and impressed by the usefulness of mobile AR systems, providing additional information to the students in a different way [20].

The mobile AR app that was designed was characterized as easy to use by the majority of Greek primary school teachers. This fact increases the possibilities of it being used in education, since the easy manipulation and interaction with 3D virtual objects [40], along with the use of mobile technologies [41], can provide profitable learning experiences [15], [42].

In this study, teachers seemed positive, having the intention to utilize the educational AR application about the moon in the future. According to Alkhattabi [43], there is great willingness and acceptance of mobile augmented reality

technology for education [43]. This acceptance causes teachers' desire to use it for educational purposes [22], making it a part of their teaching practice.

Further research should be made, examining other factors that could affect teachers' willingness to use mobile and augmented reality technologies in their classroom. Another suggestion would be to focus on the aspects which discourage and create hesitations to teachers concerning the integration of those technologies in education, such as the lack of technological knowledge, the anxiety during their use and the long hours of preparation. Finding those aspects could generate solutions.

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