Augmented Reality as E-learning Tool in Primary Schools' Education: Barriers to Teachers' Adoption

Mona Alkhattabi
Al Imam Mohammad Ibn Saud Islamic University (IMSIU), Saudi Arabia
Mkhattabi@imamu.edu.sa

Abstract—Today, primary school teachers face challenges when dealing with digital natives. As a result of the explosion and rapid growth in information technologies that can be used in education, there are increasing demands to adopt technology in education, in order to influence students to learn actively and motivate them to gain an effective learning process. Augmented reality applications show good potential in giving students more active, effective and meaningful learning processes. Moreover, augmented reality attracts research attention for its ability to allow students to be immersed in realistic experiences. Therefore, this study reviews the main benefits of using augmented reality applications in education. It also aims to examine user acceptance of augmented reality applications within an e-learning environment in primary schools, from the teachers' perspective, as an initial experiment. Moreover, it explores the main barriers and benefits when adopting this technology.

Keywords—Augmented reality, e-learning, barriers to teachers' adoption. acceptance.

1 Introduction

The current level of expansion in technology, which is enhancing the interactivity and media content of the web and increasing the quality of delivery platforms, creates an ideal environment for an increase in the use of e-learning tools and solutions. In fact, technology has become recently embedded in education and the outcomes show a positive impact on learning and teaching results. Moreover, previous research has indicated that supporting education through technology leads to more innovative forms of teaching and learning [1]. Therefore, the requirement to enhance education with the latest technologies continues to increase to the point where it is becoming an essential part of good teaching. In fact, teachers are required to spend a good deal of personal time familiarizing themselves with innovative and emerging technologies to gain a high level of confidence for integrating them in lessons, as these could really enhance student learning and engagement [2]. This study reviews the main benefits of using Augmented Reality (AR) applications as a promising technology in education. It also aims to examine user acceptance of Augmented Reality applications within an e-learning environment in primary schools, from teachers' perspective, as an initial

experiment for further study. Moreover, it explores the main barrier and benefits when adopting this technology.

2 Augmented Reality

Augmented reality (AR) is one of the new technologies that has witnessed significant growth in recent years as a result of its effectiveness, especially in the educational field. Interestingly for educational researchers, the way in which the AR technologies support and afford meaningful learning is more important than technologies themselves [3].

Hence, AR can be considered as a concept, rather than a certain type of technology. So, currently the concept of AR is not limited to any type of technology and could be reconsidered from a broad view and should be conceptualized beyond technology only [4]. By this it is meant that AR plays a supplemental role, rather than replacing reality, where virtual objects could be added to a real environment and AR tools could exploit the affordances of the real world by providing supplementary and contextual information that augments learners' experience of reality [5, 6].

3 Advantages of AR in Education

In fact, AR offers an efficient way to visualize abstract concepts and support students' interaction and engagement [7-11]. Research in this regard has showed many advantages of AR in education, and indicated a significant potential to integrate AR in teaching and learning, especially for the subjects that need visualizing abstractions. For instance, AR could support seamless interaction between real and virtual environments and facilitate the use of a tangible interface metaphor for object manipulation [10]. AR could also enable learning outside class hours and outside school limits by creating a learning experience that is linked to the formal classroom [12]. Moreover, it allows augmenting physical props with virtual annotations and illustrations which could enhance students' understanding in the classroom [13]. Additionally, AR provides a new way of manipulating and interacting with abstract concepts in the real world which could open up a whole new horizon in learning many subjects [14].

4 AR Adoption in Schools

Although a lot of research has been conducted on AR and it has been proved to have potential application in education, limited studies have been conducted in regarding adopting AR in education field [15]. Although there were a excessive amount of research throughout the recent years, the level of adopting AR in education is still unsatisfactory[16]. However due to the promising features and a results of the enhancement in computer and information technology, AR in education is considered to play a more efficient role with wider user adoption than ever before [17]. Moreover, researchers stated that teachers did not adopt AR much into their classrooms due to

lack of the awareness of needs for AR in schools and many other barriers[18]. Recently, many studied have been conducted to develop practical models and frameworks for AR applications adoption in schools, but few research has been directed to understand the barriers of the adoption from the teachers' perspectives [19]

Therefore, this study aims to examine the feasibility of using augmented reality applications within an e-learning environment, and user acceptance from the teachers' perspective as an initial experiment. Additionally, it will explore whether teachers in primary schools in particular are willing to accept and use AR technologies with their students. For this study, 200 primary school teachers in Saudi schools, consisting of men and women between the ages of 25 and 55, took part in a survey that was developed to investigate the level of user acceptance towards AR applications within an e-learning environment.

5 Research Objectives

The main objective of this research is to provide an insight into the current level of familiarity with the concept of AR within the e-learning environment. Moreover, it aims to examine the acceptance level for this newly emerging technology in the educational context. In addition, it aims to discover the willingness of primary school teachers to use AR applications in their classrooms.
In order to accomplish these objectives, this study will examine the following hypotheses:

- Hypothesis 1: In general, primary school teachers are not very familiar with the concept of AR.
- Hypothesis 2: Primary school teachers will rapidly accept AR applications.

6 Methodology

In this section a brief overview of the research approach and methodology will be presented.

6.1 Methods

The survey was designed as an exploratory research study according to the methods established by Churchill [20]. Moreover, the experiment was designed with the intention of testing the hypotheses derived from the theoretical framework, following the Sekaran [21] and Bryman [22] recommendations for aggregated methods to explain data collection. According to Churchill's explanations for the main purposes of this kind of study [20], the main purposes of this study are to:

- Formulate a base for more precise investigation and for developing hypotheses in the area of using AR in primary schools.
- Establish precedence for further research in this area.

- Gather information about the practical problems of carrying out research on using AR in teaching primary school students.

6.2   Survey Instruments

The survey instruments are designed to measure ordinal variables, which are commonly used to measure attitudes [23]. Moreover, a Likert scale will be used to collect and summarize data efficiently, and to help in extracting meaningful information about the data and supporting the performance of statistical operations to enhance the validity of the collected data [24].

6.3   The Survey Design

The target population of this study is primary school teachers; the study was conducted in Saudi Arabia. The sampling frame targeted equal division of the genders. The investigation was a cross-section survey, which involves a set of data being gathered just once, perhaps over a period of time [25]. The purpose of this survey was to investigate a small number of people from the chosen population, and then draw conclusions from the results and apply these to the larger population in any further research or studies. Samples are examined with the aims of reducing costs, ease of testing, and time efficiency. This particular survey was deployed to participants using e-mail to reduce transfer time. This survey was developed to investigate the level of teacher acceptance towards using AR applications within an e-learning environment. Along with the survey, a detailed explanation of the AR concept was sent to the participants. During the investigation, if participants did not understand anything it was possible for them to contact the researcher via e-mail or ask for further explanation. The questionnaire was designed to take less than ten minutes and the questions were originally produced in English before being translated into Arabic by several multilingual professionals following an iterative process to ensure that both versions were alike. Moreover, question wordings were written as neutrally as possible. A pilot study was conducted with five participants as a pre-test for the survey. As a result, some revisions were conducted to make the questionnaire more understandable and answerable. The final version of the questionnaire consisted of three parts:

1. A brief demographic profile of the participated teachers (gender, age, years of experience…etc.).
2. Aims to investigate teachers' attitudes and usage of educational technologies and e-learning tools in general.
3. Where we examine the teachers' familiarity and perceptions of the concept of AR. To achieve that, we use series of five-point Likert scale questions (ranging from 1 "Very Important" to 5 "Not at all Important").about their understanding of AR and their willingness to adopt its application in different educational activities and subjects.

6.4 Overview of Participants

The actual study population consisted of 200 participants, of whom 115 (57.5%) were female and 85 were male. Their ages ranged from 25 to over 55 years, with 126 (63%) being between 25 and 35 years of age; 58 (29%) aged between 36 and 45 years, and 16 (8%) aged between 46 and 55 years. Of those who participated, 174 were already using e-learning systems and applications within their classrooms. The survey found that the female respondents were more likely to use e-learning applications and solutions.

7 Findings and Discussion

The Statistical Package for the Social Sciences (SPSS) was used to analyze the collected data using various statistical tests and methods. Initially, the research instrument items were examined for accuracy of data entry, missing values, outliers and normality. Then, a pre-analysis screening assessment for multivariate assumptions was carried out. Next, a more detailed discussion of the findings will be presented.

7.1 Results Regarding teachers' familiarity with AR

In contradiction with the first hypothesis, the results revealed that 71.3% of the female and 83.5% of the male participants were familiar with the concept of AR, as shown in figure 1.

As a result of considering diversity during participants' selection, the selected sample did not consist only of those with high levels of competencies in ICT. Therefore, the first result is an encouraging indication that the adoption of AR applications in an educational context in primary schools may be well-received by Saudi teachers. However, female teachers showed more confidence in their familiarity with AR applications. Unsurprisingly, the majority of positive responses regarding the familiarity of AR applications came from the youngest age group (25-35) as shown in figure 2.
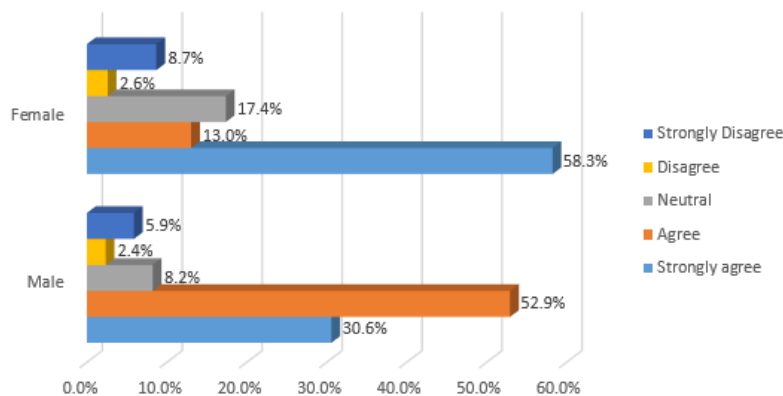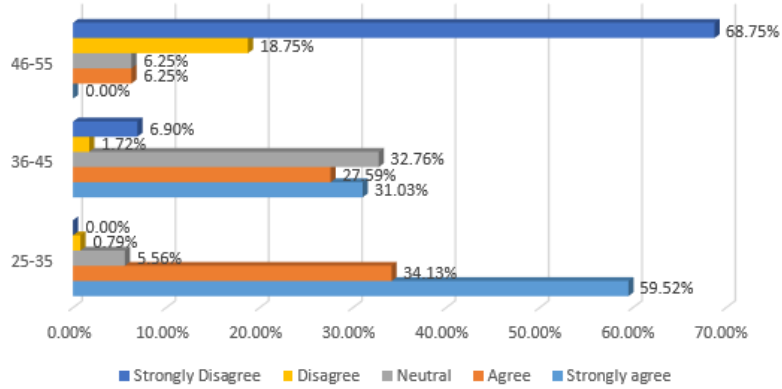

Fig. 1. Familiarity with AR by gender

Fig. 2. Familiarity with AR by age

7.2 Results Regarding teachers' acceptance of AR

The result showed a high acceptance rate (79%) of the use of AR applications within an e-learning environment in Saudi primary schools. Furthermore, female participants showed higher acceptance rates, as almost 62% of those who thought AR applications would be acceptable were women, as shown in figure 3.

Moreover, 80% of the female respondents and 76.4% of the male respondents said that they would try AR applications in their classrooms. While 78.5% of the respondents stated that they were eager to try the new technology within their teaching methods. In addition, 89.3% believed that AR applications would be easy to apply in their classrooms. Also, 96% of those enthusiastic respondents thought that using AR applications within the daily lessons would enhance their students' engagement and learning. Therefore, we found that the second hypothesis was supported by the findings, which indicates the possibility of acceptance of the use of AR applications in primary school classrooms in Saudi society.
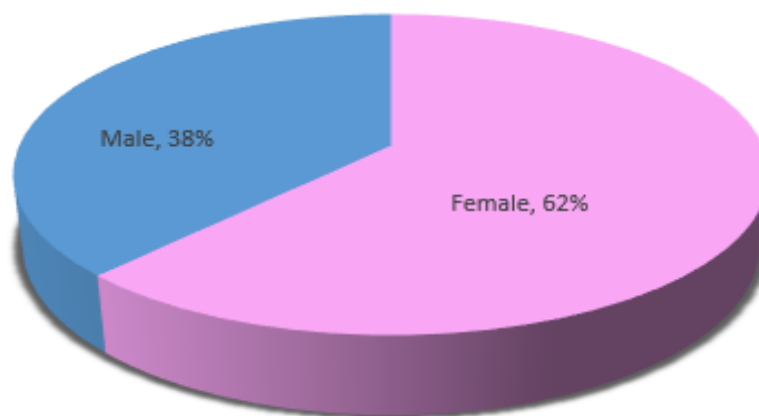

Fig. 3. Acceptance of AR applications use by gender

7.3 Results Regarding the barriers to teachers' adoption

In respect to these issues, the respondents were also asked one more question regarding their readiness to embrace AR applications in their teaching methods. The question was: "Do you think primary school teachers are ready to embrace AR applications in their teaching methods?" Fewer than 5% of the respondents thought that primary school teachers were not ready to embrace AR applications in their classrooms, while more than half said that they thought that teachers were capable of using AR applications and were willing to implement this technology in their teaching.

Moreover, the results shed some light on other important concerns related to the major obstacles and barriers facing the adoption of AR applications in primary school teaching.

Generally, the respondents perceived "lack of human infrastructure and IT skills", "lack of appropriate ICT infrastructure" and "resistance to change" as being the three main obstacles facing primary school teachers in using AR applications in their classrooms. More details on these and other types of barriers are provided in table 1.

The survey covered another important issue – the perceived benefits and advantages of adopting AR applications in primary schools' teaching. Respondents were asked to specify the main benefits that could be obtained when adopting AR applications as part of their teaching methods. Even though respondents named a number of different expected benefits, there was agreement regarding increased student engagement and visualization of abstraction concepts.

Table 1. Barriers to the adoption of AR application in primary schools in Saudi Arabia

Barriers to use AR applications in classrooms	score					Total
	Strongly Agree	*Agree*	*Neutral*	*Disagree*	*Strongly Disagree*	
Lack of appropriate ICT infrastructure	67	98	25	7	3	200
	33.50%	49.00%	12.50%	3.50%	1.50%	
Lack of human infrastructure and IT skills	58	93	29	12	8	200
	29.00%	46.50%	14.50%	6.00%	4.00%	
Resistance to change	54	85	23	20	18	200
	27.00%	42.50%	11.50%	10.00%	9.00%	
Low intention to use AR	41	74	32	31	22	200
	20.50%	37.00%	16.00%	15.50%	11.00%	
Device and software costs	38	60	29	43	30	200
	19.00%	30.00%	14.50%	21.50%	15.00%	

8 Summary and Conclusion

This study reviews the main benefits of using augmented reality applications in education. It also aims to examine user acceptance of augmented reality applications within an e-learnin environment in primary schools, from teachers' perspective, as an initial experiment. Moreover, it explores the main barrier and benefits when adopting

this technology. The overall conclusion from this study is that there is a willingness to use and high acceptance rate towards AR from primary school teachers. Moreover, the results indicated that the provision of an appropriate ICT infrastructure and the building of a strong human infrastructure and IT skills could act as strong motivators when present. Even though this initial experiment provided a good understanding of the likelihood of user acceptance in AR applications by primary school teachers, more in depth studies are needed to suggest a framework for adopting this kind of technology within daily teaching methods. Additionally, a number of issues with AR applications were identified. This study also helped to identify some of the factors affecting user acceptance of the AR application as an e-learning tool, such as IT infrastructure and skills, change resistance and willingness.

In fact, this investigation could form the base for another larger investigation and future work toward building a theoretical framework for applying AR applications within different teaching strategies, and methods for different subjects and age groups.

For the next phase, and to investigate user acceptance in a particular mode, we will create a laboratory experiment that actively tests an AR system in combination with user observation and a survey, and the Technology Acceptance Model (TAM) will be adopted as the theoretical basis on which to develop the research framework.

9   References

[1] Shapley, K., Sheehan, D., Maloney, C. and Caranikas-Walker, F. 2011. Effects of Technology Immersion on Middle School Students' Learning Opportunities and Achievement. The Journal of Educational Research 104, 299-315. https://doi.org/10.1080/00220671 003767615

[2] Pierson, M.E. 2001. Technology Integration Practice as a Function of Pedagogical Expertise. Journal of Research on Computing in Education 33, 413-430. https://doi.org/10.1080/08886504.2001.10782325

[3] Bronack, S.C. 2011. The Role of Immersive Media in Online Education. The Journal of Continuing Higher Education 59, 113-117. https://doi.org/10.1080/07377363.2011.583186

[4] Wu, H.-K., Lee, S.W.-Y., Chang, H.-Y. And Liang, J.-C. 2013. Current status, opportunities and challenges of augmented reality in education. Computers & Education 62, 41-49. https://doi.org/10.1016/j.compedu.2012.10.024

[5] Liu, W., Cheok, A.D., Mei-Ling, C.L. And Theng, Y.-L. 2007. Mixed reality classroom: learning from entertainment. In Proceedings of the Proceedings of the 2nd international conference on Digital interactive media in entertainment and arts, Perth, Australia 2007 ACM, 1306833, 65-72. https://doi.org/10.1145/1306813.1306833

[6] Martín-Gutiérrez, J., Luís Saorín, J., Contero, M., Alcañiz, M., Pérez-López, D.C. And Ortega, M. 2010. Design and validation of an augmented book for spatial abilities development in engineering students. Computers & Graphics 34, 77-91. https://doi.org/10.1016/j.cag.2009.11.003

[7] Cook, M.P. 2006. Visual representations in science education: The influence of prior knowledge and cognitive load theory on instructional design principles. Science Education 90, 1073-1091. https://doi.org/10.1002/sce.20164

[8] Di Serio, Á., Ibáñez, M.B. And Kloos, C.D. 2013. Impact of an augmented reality system on students' motivation for a visual art course. Computers & Education 68, 586-596. https://doi.org/10.1016/j.compedu.2012.03.002

[9] Martin, S., Diaz, G., Sancristobal, E., Gil, R., Castro, M. and Peire, J. 2011. New technology trends in education: Seven years of forecasts and convergence. Computers & Education 57, 1893-1906. https://doi.org/10.1016/j.compedu.2011.04.003

[10] Singhal, S., Bagga, S., Goyal, P. And Saxena, V. 2012. Augmented Chemistry: Interactive Education System. International Journal of Computer Applications. 49, 1-5. https://doi.org/10.5120/7700-1041

[11] Wu, H.-K., Krajcik, J.S. And Soloway, E. 2001. Promoting understanding of chemical representations: Students' use of a visualization tool in the classroom. Journal of Research in Science Teaching 38, 821-842. https://doi.org/10.1002/tea.1033

[12] Burton, E.P., Frazier, W., Annetta, L., Lamb, R., Cheng, R. and Chmiel, M. 2011. Modeling Augmented Reality Games with Preservice Elementary and Secondary Science

[13] Teachers. Journal of Technology and Teacher Education 19, 303-329.

[14] Coffin, C., Bostandjiev, S., Ford, J. And Hollerer, T. 2010. Enhancing classroom and distance learning through augmented reality. In World Conference on Educational Multimedia, Hypermedia and Telecommunications, 1140-1147.

[15] Kesim, M. and Ozarslan, Y. 2012. Augmented Reality in Education: Current Technologies and the Potential for Education. Procedia - Social and Behavioral Sciences 47, 297-302. https://doi.org/10.1016/j.sbspro.2012.06.654

[16] Saidin, N.F., Abd Halim, N.D. and Yahaya, N. 2015. A Review of Research on Augmented Reality in Education: Advantages and Applications. International Education Studies by Canadian Center of Science and Education 8, 1-8.

[17] K. Lee, "Augmented Reality in Education and Training," TechTrends, journal article vol. 56, no. 2, pp. 13-21, 2012.

[18] G. Chang, P. Morreale, and P. Medicherla, "Applications of Augmented Reality Systems in Education," presented at the Society for Information Technology & Teacher Education International Conference 2010, San Diego, CA, USA, 2010. Available: https://www.learntechlib.org/p/33549

[19] B. Shelton, "Augmented Reality and Education:Current Projects and the Potential for Classroom Learning," Copyright 2002 by New Horizons for Learning Vol. 9 No. 1 December 2002 For permission to redistribute please contact -- http://www.newhorizons.org.

[20] B. Shelton and N. Hedley "Exploring a Cognitive Basis for Learning Spatial Relationships with Augmented Reality," Technology, Instruction, Cognition and Learning, vol. 1, no. 4, pp. 323-357, 2004.

[21] Churchill, A.G.J. 1999. Marketing Research: Methodological Foundation The Dryden Press Hinsdale, IL.

[22] Sekaran, U. 2000. Research methods for business: A skill-building approach. John Wiley and Sons, New York.

[23] Bryman, A. 2006. Integrating quantitative and qualitative research: how is it done? Qualitative Research 6, 97-113. https://doi.org/10.1177/1468794106058877

[24] Stevens, S.S. 1946. On the Theory of Scales of Measurement. Science 103, 677-680. https://doi.org/10.1126/science.103.2684.677

[25] Likert, R. 1932. A technique for the measurement of attitudes. Archives of Psychology 22, 1-55.

[26] Sekaran, U. 2003. Research methods for business: A skill-building approach. John Wiley & Sons, Inc., new York.

10   Author

M. Alkhattabi is an assistant professor with College of Computer and Information Sciences, Al Imam Mohammad Ibn Saud Islamic University (IMSIU), Saudi Arabia. (e-mail: mkhattabi@imamu.edu.sa).