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Research Paper

A CONTENT ANALYSIS OF AUGMENTED REALITY STUDIES PUBLISHED IN 2017

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ABSTRACT

Augmented reality is one of the state-of-the-art technologies, which is utilised for educational purposes, in a wide variety of fields. Each year the frequency of academic publications on augmented reality use in education has increased. This study aims to study content analysis of augmented reality studies, used for educational purposes, published in 2017. Appropriately to the research aims, sources, which consist of PhD dissertations, master`s thesis, journal articles and conference papers, have collected from Google Scholar, and Aberystwyth University library services online database system using keywords "Augmented Reality" and "Augmented Reality in education" in English. Data has been collected and classified by the researchers using a classification form, which contains information about, authors, institutions, study methods, samples, variables, data collection tools and analysing methods and study results. In the total of 103 studies have been examined in accordance with the research questions. The findings demonstrated that the USA hosted the largest number of studies, with Turkey in second place with 19 augmented reality studies in an educational context. It was seen that most of the studies used augmented reality as a visualisation tool, with interaction being the second most common approach used for augmented reality studies for educational purposes.

Keywords: *Augmented reality, Content analysis, Educational Technology, Technology Enhanced Learning, Education*

INTRODUCTION

The second generation of web, web 2.0, has created new opportunities for the use of existing technologies (Birisci, Kul, Zeki, Akaslan & Celik, 2018; Hung & Yuen, 2010). Furthermore, a wide variety of technologies have gained capabilities, which has led to new device developments and new fields for utilisation, as a result of developments to the Web 2.0 (Almenara, & Osuna, 2016). One of those technologies, which has developed potential by Web 2.0, is known as Augmented Reality (AR). Academics have traditionally drawn upon two definitions of augmented reality; those made by Milgram and Kishino (1994) and Azuma (1997). Milgram and Kishino (1994) have defined augmented reality using Reality-Virtuality (RV) Continuum. According to their definition, augmented reality is a part of mixed reality, and an environment in the mixed reality area could define its position in the continuum. Another common definition has been made by Azuma (1997), according to his definition augmented reality is a technology which allows users interactivity with a blended version of the real world which is then overlaid with computer-generated objects. Augmented reality creates an environment by using virtual objects for supporting real conditions (Erbas & Demirer, 2015). Although augmented reality has gained popularity with Web 2.0, it is not a new technology, but its educational possibilities have been started to investigate recently (Billinghurst, 2002).

Augmented reality has been a part of research conducted on learning and training for more than two decades (Cheng & Tsai, 2013; Klopfer & Squire, 2008). Some augmented reality studies (Bower, Howe, McCredie, Robinson & Grover, 2014; Uluyol & Eryilmaz, 2014) have suggested new research should be conducted on augmented reality in education because of its unique features, which give a lot of new possibilities to lecturers, teachers and students. As a result of that attention and suggestions, numerous researchers have conducted research about the uses of augmented reality for educational purposes such as improving learning outcomes and raising motivation (Chen, Liu, Cheng & Huang, 2017). In addition to that, researchers also have developed literature review studies, which centred

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augmented reality in education (Bacca, Baldiris, Fabregat, & Graf, 2014; Chen et al., 2017; Ozdemir, 2017).

Recent literature review studies have demonstrated extensive information about augmented reality studies in education. When we look closer to those literature review studies, we can see that they have some shared points such as sample years and sample methods. For example, Santos et al. (2014) study found 87 augmented reality learning environment studies, which have been published before 30th May 2012, in the IEEE Xplore Digital Library and other learning technology publications. Their study shows and illustrates augmented reality learning environment advantages, for example, real-world observations or visualisation. Santos et al., (2014) conducted a meta-analysis and qualitative analysis on 87 journal articles which were about augmented reality learning experiences. The results show that augmented reality studies have a moderate effect on student performance. Besides this effect, augmented reality has three advantages, which are the real-world presentation, visualisation and vision-haptic visualisation, learning experiences. In another literature review study, Bacca et al., (2014) investigated augmented reality studies in education with a focus on their uses, advantages, limitations, effectiveness, challenges and feature. In that study, Bacca et al. (2014) examined 32 journal articles, which published between 2003 and 2016 from 6 indexed journals, which are indexed by Social Sciences Citation Index (SSCI) and Science Citation Index (SCI). Results show that the number of studies has been gradually increased, while Science and Humanities & Arts were the most applied fields, higher education was the most studies level, and while augmented reality has a positive effect on achievements and motivation, it also needs further researches (Bacca et al., 2014). Chen et al. (2017) summarised 55 studies, which were published between 2011 and 2016 in a journal which is indexed by SSCI, in focus on augmented reality uses, advantages, features, and effectiveness in education. In that study, results show that science, social science and engineering were the most empirically studied fields between 2011 and 2016, and also those studies generally made with quantitative methods (Chen et al., 2017). In 2017 another study, which outlined literature pertaining to experimental augmented reality, was published by Ozdemir (2017). In that study, Ozdemir (2017) has investigated 25 journal articles, which were published between 2011 and 2016 from journals which are indexed by SSCI, about augmented reality studies which conduct an experimental structure. The effects of augmented reality on the learning process and students were discussed in that study (Ozdemir, 2017). According to the results, Ozdemir (2017) found that augmented reality was mostly used on teaching natural science, mathematics and statistics, besides the fields augmented reality was mostly used for its effect on the learning outcomes and also motivation was another common variable in those studies. Another study which was published in 2017 by Akcayir and Akcayir (2017) noted the advantages and disadvantages of augmented reality in education. In their study, 68 articles were found, which were published before 15 January 2016, from a journal which indexed by SSCI. Akcayir and Akcayir (2017) explained some controversial points, such as cognitive load and usability, for augmented reality studies in education in their systematic review study. We can see that literature review studies, outlined above, have some mutual points which can be categorised by research periods, sample groups and variables. It is evident that some of the literature review studies have examined the same sample of papers because of the sample selection criteria and periods. This study aims to engage with a content analysis of augmented reality studies, which were published in 2017, and were developed for educational purposes. In this way, it aims to fill the one year gap between this study and previous studies and also investigate augmented reality studies in the narrow time-period with wider journal scope. This study aims to analyse and discuss studies on augmented reality in education published in 2017 and seeks to answers to the following questions:

1) What fields of augmented reality are used for educational purposes?
2) In the studies on augmented reality in educatıon;
3) In the studies on augmented reality in education;
   a) What were the research methods employed?
   b) What were the data collection tools employed?
4) Regarding the sampling of augmented reality studies;
   a) What was the sample sizes employed?
   b) What was the sample selection method used?
   c) What were the sampling methods employed?
5) What were the data analysis methods employed?
6) What were the variables addressed by these studies?

METHOD

Research Design

In this study, content analysis was used to analyse augmented reality studies which were published in 2017. Content analysis is defined as a method, which is systematic, objective and replicable, analyses text-based or visual representation (Stemler, 2001). Content analysis categorises sentences, words and other common points. This categorisation refines all information and converts them short and intense form (Cavanagh, 1997).

Research Sample

The sample of this study consists of the articles, conference papers and thesis published in 2017. The sample population of the study is constituted of databases accessible to the Aberystwyth University's library services and the Google Scholar.

Research Instrument and Procedure

Review and selection criteria were established to determine the studies to be analysed in the study. In the study, the keywords "Augmented Reality" and "Augmented Reality in education" was used in English into the Aberystwyth University's library services, and the Google Scholar.

Following the search, a total of 63 journal articles in 50 different journals, and 32 conference paper in 25 different conferences were identified. Four Masters theses and four PhD theses were found about augmented reality in education on the Aberystwyth University's library services, and the Google Scholar. Finally, 103 studies, which were published in 2017, were analysed and evaluated in the scope of the study. Studies examining augmented reality for educational purposes were chosen for the analyses. Data obtained from the studies were recorded in the "Publication Classification Form for Augmented Reality in Education" (Appendix-A) developed by the authors utilising the "Publication Classification Form" (Sozbilir, Kutu, & Yasar, 2012) and the "The Educational Technology Publication Classification Form" (Goktas et al., 2012).

Data Analysis

During the content analysis process, one faculty member and one Postgraduate Research student worked together. In the process of analysis and categorisation of studies; the stages of naming, developing category, ensuring validity and reliability, calculating frequencies and clarification were carefully carried out. In order to reach the validity and reliability of studies were analysed by the researchers' mutual understanding. Finally, the data were organised according to the research questions. The data obtained from the content analysis were analysed using descriptive statistics. The results were organised, classified and presented in tables and charts, and findings were explained.

FINDINGS

One hundred and three studies, which include journal articles, conference papers and dissertations, developed by researchers from 31 different countries institutions were analysed. Development studies without participants and literature review studies were examined during the content analysis.

Content Analysis Results

Organisational distribution of the research institutions by country

The organisational distribution of the studies on educational purposes augmented reality studies are presented in Figure 1. Authors who were working 130 institutions, governmental organisations, and commercial companies from 31 countries have published more than a hundred study of augmented reality on educational purposes in 2017.

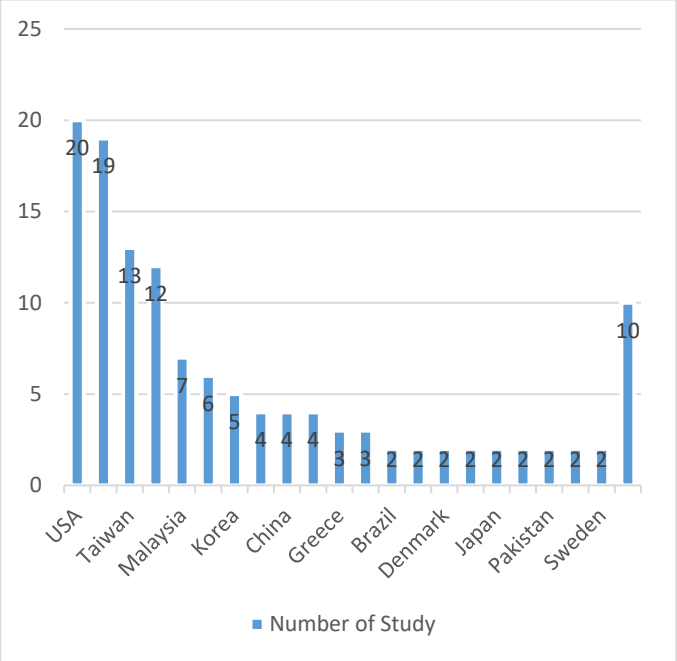

Figure 1. Distribution of the research institutions by country

Content analysis shows that the USA (f=20) was hosting the highest number of organisations where AR studies conducted on educational purposes in 2017. Turkey (f=19), Taiwan (f=13) and Spain (f=12) were other countries where AR studies have been made on educational purposes by institutions, governmental organisations, and commercial companies. Malaysia (f=7), Australia (f=6), Korea (f=5), Canada (f=4), China (f=4), and the UK (f=4) were some other countries where AR studies were made for educational purposes. Also, some other countries hosted 34 organisations which have been studies AR on educational purposes.

Fields of Selected in the Augmented Reality Studies

Table 1 shows detailed field distribution of educational purposes augmented reality studies which were published in 2017. Among the six main areas, it was seen that education (f=55) were the biggest field in augmented reality studies. Thus, the most studied topics

in education were science education (f=20) which contains biology, chemistry and physics. Language education (f=11), social science education (f=7) which contains history, and geography, geometry education (f=3) and mathematics education (f=3) studied more than compared to the others. Using augmented reality in teaching computer is the second common field in those researches. In this field, computer science studies (f=5) have been following programming (f=2) and ICT studies (f=1). Health was the third biggest field of educational purposes augmented reality studies. In the health education, it was seen that medicine (f=5) was the biggest portion of the studies. Dentistry (f=1) and physiotherapy (f=1) were other areas where augmented reality used in health education. Engineering (f=8), architecture (f=3) and cultural studies (f=3) were other areas that augmented reality used for educational purposes. Besides, marketing, journalism and design, art and STEM other fields of educational augmented reality studies. Although 112 studies were reviewed, only 92 studies were analysed because some studies were not specified in their study field.

Table 1. Augmented reality used by field

Fields	Number of Studies (f)	Percentage (%)
Education		
Science	20	21.73%
Language	11	11.95%
Social Science	7	7.60%
Geometry	3	3.26%
Math	3	3.26%
Writing	2	2.17%
Preschool	2	2.17%
Reading	2	2.17%
Others	8	8.69%
Computer		
Computer Science	5	5.43%
Programming	2	2.17%
ICT	1	1.08%
Health		
Medicine	5	5.43%
Dentistry	1	1.08%
Physiotherapy	1	1.08%
Engineering	8	8.69%
Architecture	3	3.26%
Cultural	3	3.26%
Others	5	5.43%
Total	92	100%

Approaches of Selected in the Augmented Reality Studies

Table 2 shows the use of augmented reality by each approach for educational purposes. It was observed that the visualisation approach (f=71) was mostly used in the studies then interaction (f=33) and vocalisation (f=13) studies were used, respectively. While a total of 103 studies were reviewed, only 81 studies were analysed in order to identify educational approaches because of some of the studies published as the literature review studies. Table 2 shows a total number of 117 approaches because some of the studies had more than one augmented reality using approaches.

Table 2. Approaches of Selected in the Augmented Reality Studies

Approaches	Number of Studies (f)	Percentage(%)
Visualisation	71	60.68%
Interaction	33	28.20%
Vocalisation	13	11.11%
Total	117	100%

Applications of Selected in the Augmented Reality Studies

The content analysis results show that in more than half of the augmented reality studies (f=25) used an application which has been developed for that study on purpose. On the other hand, in the almost half of augmented reality studies (f=21) used commercial or existing applications during the studies. It was also observed that Aurasma, now titled HP Reveal, was the most common commercial augmented reality application on those studies. However, in 35 studies, researchers did not specify the augmented reality application.

Research Methods and Data Collection Tools

Table 3 shows the distribution of research methods for educational purposes augmented reality studies published in 2017. It was observed that t quantitative methods were mostly used in the studies, and then literature review, mixed and qualitative studies were used respectively. It was further observed that quantitative methods were used in 41 studies, the literature review research methods were used in 22 studies, mixed research methods were used in 17 studies, and qualitative research methods were used in 14 studies. In 9 studies augmented reality technologies have been developed for educational purposes.

Table 3. Distribution of methodologies used in the studies

Methodology	Number of Studies (f)	Percentage (%)
Quantitative	41	39.80%
Literature Review	22	21.35%
Mixed	17	16.50%
Qualitative	14	13.59%
Development	9	8.73%
Total	103	100%

Data Collection Tools

Data collection tools used in the studies on educational purposes augmented reality studies are presented in Figure 2. As the data collection tool, “Questions” (f=40), “Tests” (f=30), “Observations” (f=12), “Interviews” (f=12), “Scales” (f=8), “Surveys (f=8)”, “App Logs” (f=5) and “Forms” (f=4) were used in the studies. In addition, other data collection instruments (f=11) were used such as "Video Records", "Audio Records", "Health Information" and "Coding Scheme". Also, it was found that data collection tools were used only in 73 studies. Figure 2 shows 130 tools as some of the studies used a few types of data collection tools in the same study.

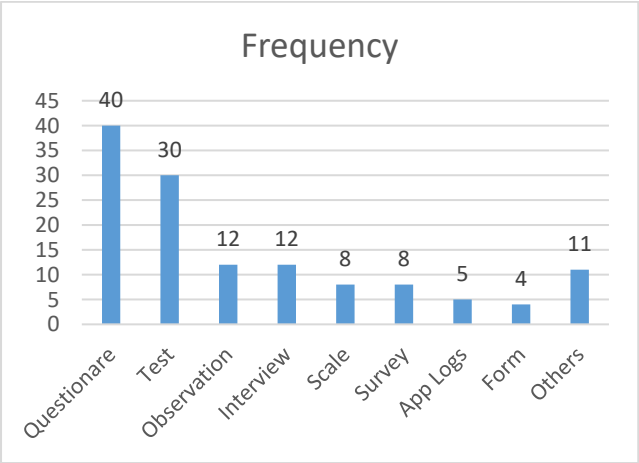

Figure 2. Distribution of the data collection tools

Sample Size

Table 4 shows the distribution of the 70 studies with sample details. It is seen that the most preferred sampling ranges are "31-100" "0-30", "101-300" and "301 and above" respectively. Although 73 studies were reviewed, only 70 studies were analysed because three studies were not mentioned sample size information.

Table 4. Distribution of sample size

Sample Size	Number of Studies (f)	Percentage (%)
0-30	25	35.71%
31-100	31	44.28%
101-300	10	14.28%
301+	4	5.71%
Total	70	100%

Sample Level

Table 5 shows the distribution of education levels. As seen in Table 5, mostly university students (49.35%) were chosen as sample groups in the studies. However, elementary school, secondary school and high school students were preferred least often as sample groups respectively. For dedicated studies, sample levels, 73 studies were reviewed were analysed nut, 77 sample group identified because, in some of the studies, more than one participation group joined.

Table 5. Distribution of sample level

Sample Level	Number of Studies (f)	Percentage (%)
Elementary School	23	29.87%
Secondary School	9	11.68%
High School	7	9.09%
University +	38	49.35%
Total	77	100%

Sample Selection Method

In the study, 68 studies with sampling method details were analyzed and details are given in Table 6. The most common sample selection methods were the purposeful (52.94%) and easily accessible group (41.17%) sampling. However, voluntering (4.41%) and random sampling (4.8%) were preferred least often as sample selection method in the studies.

Table 6. Distribution of data sample selection method

Sample Selection Method	Number of Studies (f)	Percentage (%)
Purposeful	36	52.94%
Easily accessible	28	41.17%
Volunteering	3	4.41%
Random	1	1.47%
Total	68	100%

Data Analysis Methods

Table 7 shows the distribution of data analysis methods. 72 studies that provided information on the data analysis method were analyzed. Quantitative Descriptive data analysis method (40.81%) was the most common data analysis method. Besides the quantitative descriptive data analysis method, quantitative inferential (34.69%), qualitative (19.38%) and non-parametric (5.10%) data analysis methods were also used in the studies. Although 73 studies included data analysis methods, the total number of data analysis methods in Table 7 is 98 because some of the studies used more than one data analysis methods.

Table 7. Distribution of data analyses method

Data Analysis Methods	Number of Studies (f)	Percentage (%)
Quantitative Descriptive	40	40.81%
Quantitative Inferential	34	34.69%
Qualitative	19	19.38%
Non-Parametric Analysis	5	5.10%
Total	98	100%

Variables Explored in the Studies

Table 8 shows the distribution of the variables studied in the educational purposes augmented reality studies. Among the 34 variables, it was seen that academic achievement (f=31) were the biggest variable group in augmented reality studies. The motivation was the second common variable in this research. In this variable motivation (f=17) have been following perception (f=13), usability (f=11) and satisfaction (f=8). Cognitive load (f=5) and learning style (f=4) were the common variables of educational purposes augmented reality studies. It was seen that attitude, interest, effectiveness and reading and writing (f=3) less common variables. In addition to them, spatial ability, engagement, participation, time, experience and use of technology (f=2) were the second least frequent variables in the educational purposes augmented reality studies. The analysis of the studies revealed that other variables (f=17) which were not used more than one times in augmented reality studies. Although 79 studies included data analysis methods, the total number of data analysis methods in Table 9 is 130 because some of the studies used more than one variable.

Table 8. Distribution of variables

Variable	Number of Studies (f)	Percentage (%)
Academic Achievement	31	23.85
Motivation	17	13.08
Perception	13	10
Usability	11	8.46
Satisfaction	8	6.15
Cognitive Load	5	3.85
Learning Style	4	3.08
Attitude	3	2.31
Interest	3	2.31
Effectiveness	3	2.31
Reading/Writing	3	2.31
Spatial Ability	2	1.54
Engagement	2	1.54
Participation	2	1.54
Time	2	1.54
Experience	2	1.54
Tech Use	2	1.54
Other	17	13.08
Total	130	100%

DISCUSSION AND CONCLUSION

In this paper, studies conducted on the educational purposes of augmented reality studies published in 2017 were explored through content analysis. When the literature was examined, five related studies have been found (Akcayir & Akcayir, 2017; Bacca et al., 2014; Bower et al., 2014; Chen et al., 2017; Ozdemir, 2017; Ozdemir, Sahin, Arcagok & Demir, 2018; Yilmaz, 2018). Content analysis results show some similarities and differences with existing literature review studies. The USA (f=20) hosted the most significant number of organisations where AR studied in education in 2017. The USA was followed by Turkey (f=19), Taiwan (f=13) and Spain (f=12) respectively. This result shows some similarities with Altinpulluk (2018) and Hantono, Nugroho and Santosa (2018) studies. According to Altinpulluk (2018), AR has been explored mostly in Taiwan, the USA and Spain between 2006 and 2016. Similarly, Hantono et al. (2018) study demonstrated that papers about AR in education mostly were written by authors from Taiwan, Spain and the USA since 2013.

The content analysis results demonstrated that science education (f=20) was the most studied topic in educational augmented reality studies in 2017. Similarly, the literature review studies show that science education is the most common topic in AR in education studies (Altinpulluk, 2018; Chen et al., 2017; Ozdemir, 2017; Yilmaz, 2018). Language education (f=11), social science education (f=7), math (f=3) and geometry education (f=3) were other common topics in those studies, respectively. However, the existing literature does not show consistency in language learning via AR. While Bacca et al. (2014) found that language education was the third most common field in educational purposes augmented reality studies, other reviews, for example, Altinpulluk (2018) found engineering education, and Chen et al., (2017) found mathematics and geometry education in third place. According to the results,using AR for teaching computer was the second-biggest field in AR in education studies in 2017. AR has been used different topics of teaching computer which was computer science (f=5), programming (f=2) and ICT (f=1). Health (f=7), engineering (f=8) and architecture (f=3) were other common fields in AR studies. In contrast, according to Ozdemir, (2017) previously AR has not been used for teaching ICT while the content analysis results found a study which used AR on educational purposes in education. Also, like other studies (Bacca et al., 2014; Ozdemir,2017) any studies in agriculture, forestry, veterinary and fishery have not been found yet.

It has been identified that in AR studies, visualisation (60.68%) was used more than interaction (28.20%) and

vocalisation (11.11%). Santos et al.`s (2014) meta-analysis study shows that AR had been used three different way of visualisation. Similarly, Altinpulluk`s (2018) study shows that visualisation (43%) was the biggest portion of AR studies. However, visual and audio based studies (41%) cover more studies than visual, audio and interactive studies (9%) (Altinpulluk, 2018). Hantona et al. (2018) concluded that recent developments of mobile technologies allow using different varieties of display settings easily and are more cost-effective.

The content analysis results show that generally, researchers developed their AR applications for their research specifically. Besides those non-commercial apps, HP Reveal which has mostly known as Ausrasma or Aurasma Studio was the most used commercial application in AR studies. Ozdemir`s (2017) results show that in the significant part of the augmented reality studies, the application which supplies augmentation did not specify, although, according to results aurasma is the most common commercial augmented reality application in the literature.

It has been identified that quantitative (f=41) research methods were the most prefered research methods in educational purposes AR studies in 2017. Further analysis shows that the literature review (f=22), mixed (f=17), qualitative methodology (f=14) and developments were other research methods in those studies. In contrast, other studies (Altinpulluk, 2018; Bacca et al., 2014; Chen et al., 2017) found that the mixed research methodology used more than others.

It is observed that questionnaires are the most common data collection tool. Similarly, studies by Altinpulluk (2018) and Bacca et al., (2014) indicate that the most common data collection tools employed in educational purposes AR studies were questionnaires. On the other hand, a study shows that the most prefered data collection tool was using test (Chen et al., 2017). This may cause of the studies mostly focus on examining the effects of augmented reality on academic achievement, so generally, researchers using tests to gathering information. In addition, studies on educational purposes AR studies which published in 2017 further show that test, observation, interview, scale, survey, app logs and form are used as data collection tools respectively besides questionnaires.

The results of the content analysis show that the most common sample size is the 31-100 range. Likewise, Bacca et al. (2014) concluded that the most common sample size was between 30 and 200. It could be argued that the selected sample size is relatively similar for both studies. Also, it was observed that in the AR studies, some of the sample selection criteria were defined before the process of sample selection, and predominently a purposive sampling method is used. Furthermore, the critical reason to select elementary school students as a sample is that the academics could use AR as a demonstration tool for abstract contents.

In the study, it is concluded that the most common studied variable in educational purposes AR studies are academic achiecement and then motivation, perception, usability and satisfaction, respectively. The diversity of the variables is generally consistent with studies conducted in the field of education. The findings of the studies show that AR general has a positive influence on the variables examined in the educational purposes studies. Similarly, Bacca et al., (2014), Chen et al., (2017) and Ozdemir (2017) show that academic achievement was the most common variables in augmented reality studies; also motivation was the second common variables in those studies. Besides literature review studies, meta-analyses studies (Ozdemir et al., 2018; Santos et al., 2014; Satpute, Pingale & Chavan, 2015) show that augmented reality has a positive low or moderate effect on academic achievement.

RECOMMENDATIONS

These results seem essential to look into the current situation of educational purposes augmented reality studies, which were published in 2017. The opinion is that the findings of this study may guide researchers aiming to employ AR in education. The main limitation of the study is that AR is a developing technology, so some characteristics and opportunities could change in time. According to these results, some suggestions and further areas of study have been identified.

This paper has identified that AR has been employed with different approaches and variables, in a wide variety of fields, for educational purposes. In the future, AR could be used in different fields and topics in education with different technologies and variables, such as 21st century skills. Furthermore, researchers may conduct new studies to discover the long term influence of AR on learning outcomes. Moreover, it is likely that academics will develop measures and scales to fully assess the impact of Augmented Reality on learners. It is likely that these scales will have to be more focused on AR than current measures that assess the impact of technology on learning. Scales to be used in field studies can be developed to evaluate the effect of augmented reality. Finally, longitudinal studies will have been conducted to explore the long-term influences of AR on educational purposes on extensive samples.

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Appendix-A. Publication Classification Form for Augmented Reality in Education

Publication Classification Form for Augmented Reality in Education	
References: Example:Goktas, Y., (2017)	**Research institutions:**
Fields:	**Approaches: Visualisation, interaction etc.**
AR applications:	**Research methods:**
Data collection tools:	**Sample sizes:**
Sample level:	**Sample selection method:**
Data analysis method:	**Variables: Academic achievement, motivation etc.**