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Augmented reality in education researches (2012–2017): A content analysis

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Abstract

The purpose of this study is to investigate the specific features of the articles on augmented reality (AR) published in the journals of education indexed in the SSCI database between 2012 and 2017. In this context, the articles were examined in terms of their years of publication, number of authors, countries, educational disciplines/fields, types of AR, variables and methodological features. A total of 83 articles in 22 journals were analysed by content analysis. The results showed that the number of studies related to AR increased in 2014 and 2017 and they were predominantly carried out in the field of science education. Marker-based technologies were more preferred in the studies. The most examined variables in the articles were achievement and attitude. AR studies were mostly carried out by scientists working at universities in Taiwan. The sample size of 0–50 was mostly selected from university level, while the sample size of 50–100 was selected from primary school.

Keywords: Augmented reality, content analysis, educational research, article examination.

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1. Introduction

Augmented Reality (AR) is a technology that combines the real world with virtual objects (e.g., sound, text, video and 3D object; Klopfer & Squire, 2008; Yuen, Yaoyuneyong & Johnson, 2011). Through this technology, real environments are enriched with virtual objects or information generated by computer-based technologies (Carmigniani et al., 2011). Although the birth of AR technology dates back to 1960 (Sutherland, 1968), it was named as a concept by Tom Caudell in 1990 (Lee, 2012). AR supports the existing reality and contains these three features (Azuma, 1997): (i) real and virtual combination, (ii) real-time interaction and (iii) three-dimensional recording. In this regard, AR is a technology that enables the interaction between the real world and virtual objects. The contents of AR display environments by means of mobile devices, stationary units and a head-mounted display.

AR technology is divided into two categories as image-based and location-based in terms of monitoring properties (Cheng & Tsai, 2013). Image-based AR requires information through specific markers such as pictures, QR code or natural graphics recognition in the real world. Location-based AR presents virtual information by GPS technology. On the other hand, Gao (2013) has classified AR applications in terms of interaction characteristics based on various device components such as a keyboard, a display, a sensor and a gesture- /motion-sensitive recognition system.

1.1. AR in education

Developments and researches on AR technology have increased rapidly over the last few decades. Besides such sectors as advertising, marketing, architecture, entertainment and defence, research on AR has also begun to become popular in the field of education (Lee, 2012). AR is one of the potentially promising technologies in education (Johnson, Adams & Cummins, 2012). In particular, it has been used for the teaching of inaccessible or dangerous objects (Wojciechowski & Cellary, 2013), the concretization of abstract concepts (Sirakaya & Seferoglu, 2016) and the learning of invisible objects or events (Shelton & Hedley, 2002).

In literature, there are studies in various fields such as language (Ho, Hsieh, Sun & Chen, 2017; Kucuk, Yilmaz & Goktas, 2014), maths (Kaufmann & Dunser, 2007), science (Cai, Wang & Chiang, 2014; Cai, Chiang, Sun, Lin & Lee, 2016; Fidan, 2018), medicine (Ferrer-Torregrosa et al., 2015; Liu, Jenkins, Sanderson, Fabian & Russell, 2010) and geography (Carbonell & Bermejo, 2017) related to the use of AR applications in educational settings. AR increases students' attitude towards the course (Wojciechowski & Cellary, 2013), their motivation for learning (Clark, Dunser & Grasset, 2011; Di Serio, Ibanez ve Kloos, 2013) and their learning performance (Cai, Wang & Chiang, 2014; Hwang, Wu, Chen & Tu, 2016), and helps to make the course more enjoyable and fun by getting their attention (Chiang, Yang & Hwang, 2014; Kesim & Ozarslan, 2012).

On the other hand, besides respective studies, studies where the trends of the existing studies in the literature have been examined are important in terms of revealing the current state of a subject in the field (Kitchenham & Charters, 2007). In the related literature, the studies on more specific topics, such as AR (Akcayir & Akcayir, 2017; Bacca, Baldiris, Fabregat, Graf & Kinshuk, 2014; Korucu, Usta & Yavuzaslan, 2016), are relatively much less. Korucu et al. (2016) examined the tendencies towards AR studies in Turkey-addressed journals in their study. Similarly, Bacca et al. (2014) analysed the advantages and limitations of AR in the journals published from 2003 to 2013 in terms of certain criteria in their study.

In summary, there is a need for studies in which current articles on AR are examined in an international manner and trends in studies are identified. As a matter of fact, these respective studies are important in terms of making it possible to evaluate previous AR-related studies from a broad perspective and determining the needs for AR. These reasons constitute the starting point of this study. However, it is believed that it will serve as a guide for researchers about what should be focused on in future research on AR.

In the light of the information explained above, the purpose of this study is to investigate the specific features of the articles on AR published in the journals of education indexed in the SSCI database between 2012 and 2017. In this respect, the answers to the following sub-questions were:

i How is the distribution of the articles on AR by years?
ii How is the distribution of the articles on AR by the countries of origin?
iii How is the distribution of the articles on AR by author numbers?
iv How is the distribution of the variables examined in the articles on AR?
v How is the distribution of the articles on AR by educational fields/disciplines?
vi How is the distribution of the articles on AR in terms of the specifications of AR applications?
vii How is the distribution of the articles on AR by research methods and patterns?
viii How is the distribution of the articles on AR by sample level and sample number?
ix How is the distribution of the articles on AR by data analysis methods?

2. Method

The content analysis method used in this study covers the period during which the articles were categorised according to their specific features. The research population consists of the articles published in the journals indexed in the SSCI database from 2012 to 2017. Considering the NMC Horizon reports, the fact that AR technology is among the promising technologies in the journals of education especially after 2011 (Johnson et al., 2012) was influential in the selection of the given date range for this study. The following criteria were taken into account in the selection of the articles for the study: (i) the articles were published in education-related journals indexed in SSCI; (ii) they were published between 2012 and 2017; (iii) they were on the AR in education.

Access to the relevant articles was gained by using the keywords such as 'augmented reality', 'augmented reality in education', 'AR', 'mixed reality', 'virtual reality' and 'VR' through an advanced search function and by connecting to the Web of Science Core Collection database from the electronic library of a university in Turkey. A total of 691 articles were reached in the listing process in the database, and 83 articles in 22 different journals were selected and analysed within the scope of the research. The English versions of the full-text formats of all the examined articles were reached along with the Turkish versions of the three of them. Table 1 shows the distribution of the reached articles by journals.

Table 1. The numbers and the percentages of the articles on AR in SSCI-indexed education-related journals

Journal	*f*	%
Computers & Education	17	20.48
Interactive Learning Environments	8	9.64
Computers in Human Behavior	7	8.43
EURASIA Journal of Mathematics Science and Technology Education	7	8.43
Educational Technology & Society	6	7.23
British Journal of Educational Technology	5	6.02
Journal of Computer Assisted Learning	4	4.82
Education and Science	4	4.82
Journal of Science Education and Technology	4	4.82
Journal of Educational Computing Research	4	4.82
Educational Technology Research and Development	3	3.61
IEE Transactions on Learning Technologies	3	3.61
International Journal of Computer-Supported Collaborative Learning	2	2.41
Environmental Education Research	1	1.20
International Journal of Science Education	1	1.20
BMC Medical Education	1	1.20

Behaviour & Information Technology	1	1.20
Internet and Higher Education	1	1.20
Language Learning & Technology	1	1.20
Journal of Geography in Higher Education	1	1.20
Journal of Music Teacher Education	1	1.20
Educational Research Review	1	1.20
Total	83	100

When Table 1 is examined, it can be seen that most of the articles on AR are in *Computers & Education* (*f* = 17). The journals such as *Interactive Learning Environments* (*f* = 8), *Computers in Human Behavior* (*f* = 7), *EURASIA Journal of Mathematics Science and Technology Education* (*f* = 7) and *Educational Technology & Society* (*f* = 6) come right after the above-mentioned journal in descending order with respect to the number of the articles on AR. The articles published in these five journals constitute 54.22% of all the articles.

In this study, the data related to the articles were input through the 'Article Review Form' created over the Internet (via Google Forms). This form was prepared through revising certain properties of the article by examining similar studies in accordance with the relevant literature (Goktas et al., 2012; Sozbilir, Kutu & Yasar, 2012). In addition, the information contained in the electronic form was checked by three field specialists and corrected in the direction of feedback. In the study, the characteristics of the articles, such as the journal in which they are published, their author(s), sample numbers, sample levels, the country of study, the variables of study, the field of study and data analysis, were filled by ticking the description checkboxes on the electronic page of this form and by entering the necessary information into the text box. Finally, the file containing information about the articles was downloaded in excel format from the Google Forms database. The obtained data were analysed by content analysis using descriptive (percentage and frequency values) statistics. Due to the lack of relevant information, not all of 83 articles were evaluated in the categories of educational field/discipline (*n* = 65), types of AR (*n* = 44), educational level and sample size (*n* = 71). Furthermore, the frequencies of the diversity of the variables were considered in the categories of examined variables (*f* = 104) and analysis method (*f* = 186). The consistency between coders was checked through the analysis of the articles at different times by another expert who was experienced in qualitative research other than the researchers conducting the study. This ratio was calculated to be 95% using Miles and Huberman's (1994) reliability percentage, and the consistency between the coders was found to be reliable.

3. Findings

3.1. The distribution by years

When the distribution of the articles on AR which are within the scope of research is examined by years, it is seen that the least number of articles with the ratio of 4.82% (*f* = 4) was published in 2012, whereas the highest number of articles were published in 2017 with the ratio of 33.73% (*f* = 28). In the study, it is remarkable that there was a high level of increase in the number of studies about AR in 2017, while this number has been decreasing since 2014. Figure 1 shows the distribution of the published articles on AR by years.

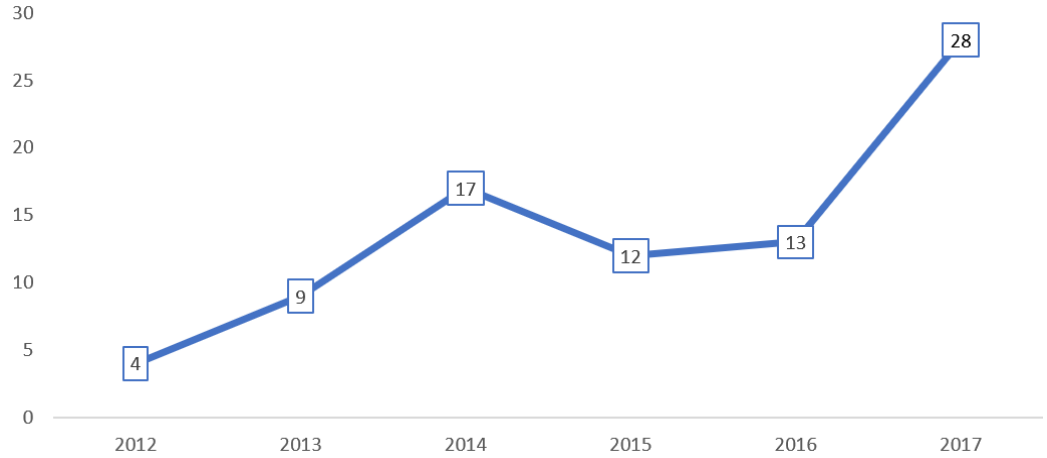

Figure 1. The distribution of the published articles on AR by years

3.2. The distribution by countries of origin

It can be seen in the study that the majority of the studies on AR were out by scientists (*f* = 29) working at universities in Taiwan. In this respect, Spain (19.28%), USA (12.05%), Turkey (9.64%) and China (7.23%) come right after Taiwan in decreasing order. Table 2 shows the distribution of the studies on AR by the countries of origin.

Table 2. The distribution of the articles on AR by countries

Country	Taiwan	Spain	USA	Turkey	China	Korea	Finland	Romania	Greece	Japan	Poland	Chile	Singapore	Liechtenstein	Croatia	Colombia	Pakistan	Kuwait	Total
f	29	16	10	8	6	2	1	1	1	1	1	1	1	1	1	1	1	1	83
%	34.94	19.28	12.05	9.64	7.23	2.41	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	100

3.3. The distribution by author numbers

When the author numbers of the published articles on AR in the research were examined, it was found that 27.71% (*f* = 23) of the articles had three authors. The articles with four authors (21.69%), two authors (21.69%) and five authors (14.46%) followed this ratio. The number of single-author and six-author articles was at a minimum level (7.23 %). Figure 2 shows the distribution of the articles on AR by the author numbers.

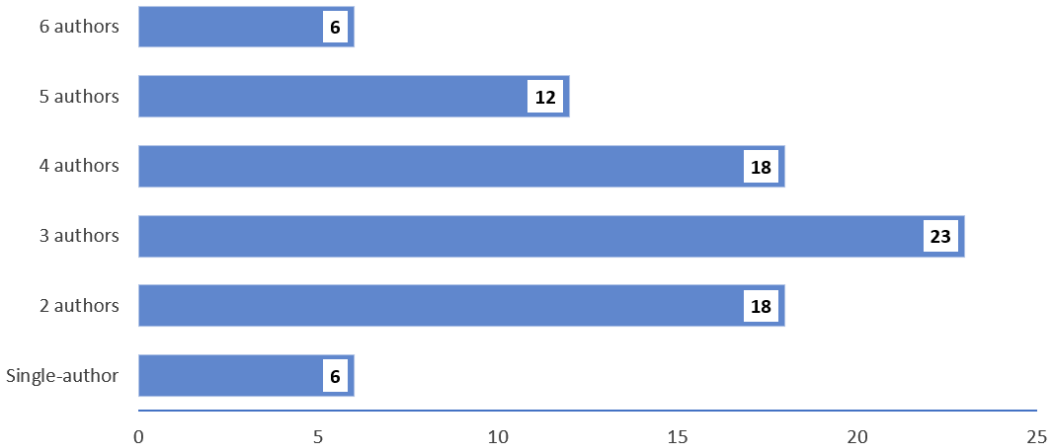

Figure 2. The distribution of the published articles on AR by the author numbers

3.4. The examined variables

In the study, the most analysed variable in the published articles on AR was the achievement variable with a ratio of 40.38% (*f* = 42). The variables of attitude (18.27%), motivation (8.65%), spatial ability (4.81%) and satisfaction (4.81%) followed this ratio. Other variables were examined in a fewer number of articles. Table 3 shows the distribution of the articles by the examined variables.

Table 3. The distribution of the published articles on AR by examined variable

Variable	Achievement	Attitude	Motivation	Spatial ability	Satisfaction	Cognitive Load	Technology Acceptance	Interest	TPACK skills	Curiosity	Laboratory Skills	Collaboration skills	Creativity	Stress	Self-regulation	Academic procrastination	Meta-cognition	Autonomous skills	Learning Style	Total
f	42	19	9	5	5	4	4	3	2	2	1	1	1	1	1	1	1	1	1	104
%	40.38	18.27	8.65	4.81	4.81	3.85	3.85	2.88	1.92	1.92	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	100

3.5. The types of AR

While it is seen that marker-based AR applications were used predominantly (70.45%), and location-based AR applications were used partially (22.73%) in the articles within the scope of research, it was determined that gesture- /motion-based AR applications were only preferred in a very small number (6.82%) of the articles. Figure 3 shows the distribution of the articles by AR characteristics.

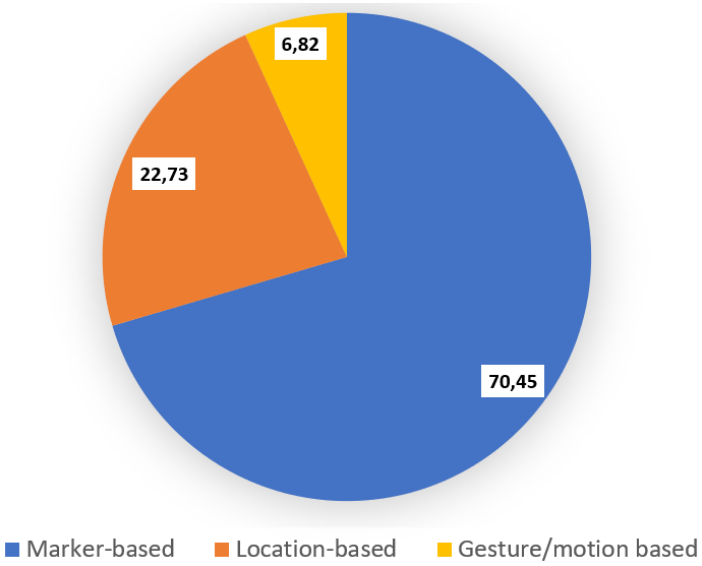

Figure 3. The distribution of the articles by the types of AR

3.6. Educational fields/disciplines

When the articles were examined in terms of the relevant educational fields/disciplines, it was seen that the highest number of studies related to AR was carried out in the field of science (49.23%). This ratio is noteworthy because it constitutes half of the AR-related studies conducted in other educational fields. It is seen that the highest number of study after the field of science was conducted in the fields of language (15.38%) and maths (7.69%). Table 4 shows the distribution of the published articles on AR by the educational fields/disciplines.

Table 4. The distribution of the published articles on AR by the educational fields/disciplines

Field/ Discipline	Science	Language	Maths	Medicine	Museum	Information Technologies	Architecture	Visual Arts	History	Library	Sociology	Tourism	Psychology	Music	Geography	Total
f	32	10	5	3	2	2	2	2	1	1	1	1	1	1	1	65
%	49.23	15.38	7.69	4.62	3.08	3.08	3.08	3.08	1.54	1.54	1.54	1.54	1.54	1.54	1.54	100

3.7. Research methods and patterns

It was determined that mostly the experimental design was used (49.66%) in the articles within the scope of this study. It can be seen that the relational design (10.84%), literature review (9.64%) and the explanatory design (7.23%) followed this ratio. The researchers preferred the quantitative research method (68.67%) more favourably than the qualitative (22.89%) and mixed (8.43%) research methods. In this respect, mixed research methods, in which quantitative and qualitative research methods are used together, were less preferred. The literature reviews were conducted mostly (9.64%) within the scope of the qualitative research, whereas the explanatory pattern (7.23%) was used with the mixed research method. Table 5 shows the distribution of the methods and patterns used in the articles on AR.

Table 5. The distribution of the methods and patterns used in the articles related to AR

Method	Pattern	Total		Sub-total	
		f	(%)	*f*	(%)
Quantitative	Experimental	39	49.66	57	68.67
	Relational	9	10.84		
	Survey	7	8.43		
	Causal-comparative	1	1.20		
	Scale development	1	1.20		
Qualitative	Literature review	8	9.64	19	22.89
	Case study	5	6.02		
	Meta-analysis	4	4.82		
	Action research	2	2.41		
Mixed	Explanatory	6	7.23	7	8.43
	Exploratory	1	1.20		
Total		83	100	83	100

3.8. Sample level and size

The samples in the articles consisted of students at the university level with the highest ratio (32.39%) and pre-school students with the lowest ratio (9.86%). On the other hand, when the sample size is taken into account in terms of sample level, it is seen that the sample size of 0–50 was mostly selected from the university level (29.03%) while the sample size of 50–100 was selected from the primary school. Table 6 shows the distribution of sample level and size in the articles on AR.

Table 6. The distribution of sample level and size in the published articles on AR

Level/Size	0–50		50–100		100–150		150–200		Over 200		Total	
	f	%	*f*	%	*f*	%	*f*	%	*f*	%	*f*	%
Pre-school	4	12.90	3	12.00	-	-	-	-	-	-	7	9.86
Primary school	5	16.13	7	28.00	1	9.09	-	-	-	-	13	18.31
Secondary school	6	19.35	6	24.00	3	27.27	1	100	-	-	16	22.54
High school	7	22.58	3	12.00	1	9.09	-	-	1	33.33	12	16.90
University	9	29.03	6	24.00	6	54.55	-	-	2	66.67	23	32.39
Total	31	100	25	100	11	100	1	100	3	100	71	100

3.9. Data analysis methods

Since quantitative research methods have been used predominantly in the articles, quantitative data analysis methods were more preferred. In this regard, it can be seen that frequency and percentage out of descriptive analysis methods were used mostly (35.36%). This was followed by a *t*-test (17.68%), an ANOVA/MANOVA test (9.14%) and an ANCOVA/MANCOVA (8.29%) test, whereas the least preferred data analysis methods in the articles were exploratory factor analysis and clustering analysis with a common ratio of 0.55%. Table 7 shows the distribution of data analysis methods used in the articles on AR.

Table 7. The distribution of the published articles on AR by data analysis methods

Data analysis method		Total *f* (%)	
Descriptive	Mean, standard deviation	64	35.36
	t-test	32	17.68
	ANOVA/ MANOVA	17	9.39
	ANCOVA/MANCOVA	15	8.29
	Correlation analysis	11	6.08
	Mann Whitney U	11	6.08
	Regression analysis	5	2.76
Predictive	Wilcoxon test	3	1.66
	Kruskal Wallis	2	1.10
	Chi-square analysis	2	1.10
	Confirmatory factor analysis	2	1.10
	Path analysis	2	1.10
	Exploratory factor analysis	1	0.55
	Clustering analysis	1	0.55
	Content analysis	8	4.42
Qualitative	Sequential analysis	3	1.66
	Descriptive analysis	2	1.10
Total		186	100

4. Discussion and conclusion

This study focus on the specific features of the articles on AR published in the journals of education indexed in the SSCI database between 2012 and 2017. The results showed that the highest number of articles related to AR was published in *Computers & Education*. Similarly, Bacca et al. (2014) reached at a conclusion in their study that the highest number of SSCI-indexed articles on AR was published in *Computers & Education* from 2003 to 2013. *Interactive Learning Environments* and *Computers in Human Behavior* come right after *Computers & Education* in this sense. The presence of more number of articles on AR in these journals may be due to the annual publication frequency and in relation to technology. It can be interpreted that this situation attracts the attention of the researchers. In addition, the content and scope of these journals are also suitable for educational research on AR.

In the journals examined within the scope of research, it was determined that the studies related about AR increased considerably in 2014 and 2017. It was seen that the number of publications in 2015 and 2016 decreased slightly. However, a notable increase was observed in 2017. The results obtained from some studies (Akcayir & Akcayir, 2017; Korucu et al., 2016) are consistent with this finding. In this respect, it can be said that the number of AR-related publications would continue evenly in the future. As a matter of fact, AR technology is still a new and improvable technology. Therefore, it is anticipated that the use of AR technology in education will continue in the future and it will contribute to learning (Martin et al., 2011). According to the *Horizon Report on Higher Education*, AR technology has been among the educationally promising technologies for the last 2 or 3 years (Adams Becker, Freeman, Giesinger Hall, Cummins & Yuhnke, 2016). Furthermore, AR technology is suitable for constructivist approach because it increases success, interest and motivation of students and provides effective participation, and this promotes its availability in education (Dunleavy, Dede & Mitchell, 2009; Wojciechowski & Cellary 2013).

It is a remarkable finding of the study that the majority of the scientists conducting research on AR are people working at universities in Taiwan. In addition, the number of scientists working in Spain and the USA carrying out the studies examined within the scope of this study is also in a considerable amount. This finding is also parallel to the findings obtained from the study carried out by Chen, Liu, Cheng and Huang (2017). The Taiwan government attaches importance to the use of technology in

education and supports the efforts to integrate technology effectively into educational environments (Tu & Twu, 2002). Moreover, Taiwan is at the forefront of productive countries in technology in educational research (Hsu, Hung & Ching, 2013). The fact that technology is so important in Taiwan can be influential in the extensive research on specific technologies, such as AR in education, than that in other countries. In relation to this finding, Kinshuk-Huang, Sampson and Chen (2013) reported in *Educational Technology & Society* that the most cited articles on trends in educational technology belong to the authors working at the universities in Taiwan.

When the number of authors in the articles is examined, it is seen that there is a significant amount of articles with three authors, but the studies with two and five authors are also in a considerable amount. In this respect, in the international context, it is seen that the studies on AR are performed in co-operation by a team of authors and there is a tendency in this direction because stages such as preparation, design and implementation in research on education technologies involve a systematic process (Kuzu, 2014, p. 58). In creating AR applications, the design team must have the necessary interdisciplinary knowledge (Karal & Abdulselam, 2015).

It was seen that the most investigated variable in the articles was mostly 'achievement'. The variables of 'attitude' and 'motivation', which had affective features, followed the variable of achievement in terms of the frequency of examination. Similar results were found in the studies on AR (Bacca et al., 2014; Saltan & Arslan, 2017). In addition, it was determined that affective variables such as spatial ability, interest, stress, curiosity and metacognition were examined in a limited number of studies, and the number of studies in this field is insufficient. On the other hand, the fact that 50% of the studies examined were conducted in the field of science education attracts attention. These findings can be due to the fact that science education is compatible with AR because of its nature (Cheng & Tsai, 2013). It was seen that the AR applications used in the articles, covered in the research, were predominantly marker-based (image-recognition features), whereas location-based and gesture-/motion-based applications were less preferred. Saltan and Arslan (2017), by examining the articles indexed in the ERIC database, found that mostly marker-based applications were integrated into the learning process in the studies on AR. This may be due to the fact that gesture- /motion-based and location-based applications require more software or hardware effort than marker-based applications (Thornton, Ernst & Clark, 2012).

When investigations are examined from a methodological point of view, it is seen that the number of studies using quantitative research methodology was far more than the ones using qualitative and mixed research methods. It was seen that the researchers predominantly carried out studies in an experimental format within the scope of the quantitative research method, whereas it was detected that mostly literature review research method was used in the qualitative dimension. Similar findings were also found in the study conducted by Chen et al. (2017) in which the trends of the studies conducted on AR technology were examined.

The fact that AR has its own unique qualities may have driven the researchers to experimental studies in testing the availability of AR as educational material. On the other hand, there is a need for further research on the development of data collection tools as well as the need for relational research which have been less carried out about AR in the quantitative dimension. It is also noteworthy that qualitative case studies and action research are less. When compared to quantitative research, qualitative research provides more profound information (Yildirim & Simsek, 2013). However, the fact that qualitative research takes a long time and the process is troublesome (Buyukozturk, Kilic-Cakmak, Akgun, Karadeniz & Demirel, 2012) may have driven the researchers to use the quantitative research method. However, there is a need for mixed research on AR in which both quantitative and qualitative research methods are used together.

When we look at the sample level of the articles, it is seen that they concentrate at the university level and this is followed by the primary school level. The reason that research samples are more at the university level may be due to the fact that the students at this level have more mobile devices than the students in other stages of education and they use information technologies more

effectively. It was determined in the study of Hsu et al. (2012) that mostly higher education students were preferred in the studies on technology-based learning. On the other hand, while the sample size selected in the studies concentrated in the ranges of '0–50' and '50–100', the sample size at or over 150 was less preferred. This finding suggests that groups with a fewer sample size are preferred to groups with higher sample size. The reason for this is that the data collection and analysis process takes place in a shorter period of time, and it makes convenient for the researcher in terms of speed and time. However, it is known that working with large groups, especially in relational studies, affects the validity and reliability of the study (Kilic-Cakmak et al., 2016). Finally, it was identified in data analysis of the articles on AR that mainly descriptive statistics were used in terms of quantitative data and *t*-test and ANOVA tests were also used; whereas mostly content analysis was used in the analysis of qualitative data. Similar results were obtained in some studies on technology (Gokmen et al, 2017; Kilic-Cakmak et al., 2016) in the literature. The absence of predictive statistics, such as Regression Analysis, Confirmatory Factor Analysis and Path Analysis, which provide detailed and robust findings, can also be regarded as a deficiency in the studies.

5. Limitations and recommendations

Although there are articles related to AR in many journals scanned in different indexes, the examination of the articles published in 22 journals indexed in the SSCI database in this study seems to be a limitation. Therefore, the other journals scanned in different indexes can be included in further research; furthermore, dissertation studies and reports can also be examined. Considering the fact that mostly marker-based applications have been used in educational studies, location-, gesture- or motion-based applications can be designed and studies can be conducted based on their efficiencies in educational fields. Importantly, when the lack of studies on the development of data collection tools related to AR is taken into account, scale development studies can be carried out to determine, especially, affective variables such as self-efficacy and attitude towards AR. In the future research, the educational stages other than higher education can be used more as sample level. In addition, the relationship between the variables can also be examined by choosing a larger number of samples.

References

Adams Becker, S., Freeman, A., Giesinger Hall, C., Cummins, M. & Yuhnke, B. (2016). *NMC/CoSN Horizon report: 2016 K-12 edition.* Austin, TX: The New Media Consortium.

Akcayir, M. & Akcayir, G. (2017). Advantages and challenges associated with augmented reality for education: a systematic review of the literature. *Educational Research Review, 20,* 1–11. doi:10.1016/j.edurev. 2016.11.002

Azuma, R. T. (1997). A survey of augmented reality. *Presence: Teleoperators and Virtual Environments, 6*(4), 355–385.

Bacca, J., Baldiris, S., Fabregat, R., Graf, S. & Kinshuk. (2014). Augmented reality trends in education: a systematic review of research and applications. *Educational Technology & Society*, *17*(4), 133–149.

Buyukozturk, S., Kilic-Cakmak, E., Akgun, O. E., Karadeniz, S. & Demirel, F. (2012). *Bilimsel arastirma yontemleri* (13. Baski). Ankara, Turkey: Pegem Akademi Yayinlari.

Cai, S., Wang, X. & Chiang, F.-K. (2014). A case study of augmented reality simulation system application in a chemistry course. *Computers in Human Behavior, 37,* 31–40. doi:10.1016/j.chb.2014.04.018

Cai, S., Chiang, F.-K., Sun, Y., Lin, C. & Lee, J. J. (2016). Applications of augmented reality-based natural interactive learning in magnetic field instruction. *Interactive Learning Environments, 25*(6), 778–791. doi:10.1080/10494820.2016.1181094

Carmigniani, J., Furht, B., Anisetti, M., Ceravolo, P., Damiani, E. & Ivkovic, M. (2011). Augmented reality technologies, systems and applications. *Multimedia Tools and Application*, *51*(1), 341–377. doi:10.1007/s11042-010-0660-6

Carbonell, C. C. & Bermejo L. A. (2017). Augmented reality as a digital teaching environment to develop spatial thinking. *Cartography and Geographic Information Science, 44*(3), 259–270. doi:10.1080/15230406.2016.1145556

Chen, P., Liu, X., Cheng, W. & Huang, R. (2017). A review of using augmented reality in education from 2011 to 2016. In E. Popescu, Kinshuk, M. K. Khribi, R. Huang, M. Jemni, N. -S. Chen, D. G. Sampson (Eds.), *Innovations in smart learning* (pp. 13–18). Singapore: Springer.

Cheng, K. H. & Tsai, C. C. (2013). Affordances of augmented reality in science learning: suggestions for future research. *Journal of Science Education and Technology, 22,* 449–462. doi:10.1007/s10956-012-9405-9

Chiang, T. H., Yang, S. J. & Hwang, G.-J. (2014). An augmented reality-based mobile learning system to improve students' learning achievements and motivations in natural science inquiry activities. *Journal of Educational Technology & Society, 17*(4), 352–365.

Clark, A., Dunser, A. & Grasset, R. (2011). *Interactive augmented reality coloring book*. Basel, Switzerland: 10th IEEE International Symposium on Mixed and Augmented Reality (ISMAR), 26–29 Oct 2011.

Di Serio, A., Ibanez, M. B. & Kloos, C. D. (2013). Impact of an augmented reality system on students' motivation for a visual art course. *Computers & Education, 68,* 586–596. doi:10.1016/j.compedu.2012.03.002

Dunleavy, M., Dede, C. & Mitchell, R. (2009). Affordances and limitations of immersive participatory augmented reality simulations for teaching and learning. *Journal of Science Education and Technology, 18*(1), 7–22. doi:10.1007/s10956-008-9119-1

Ferrer-Torregrosa, J., Torralba, J., Jimenez, M. A., Garcia, S. & Barcia, J. M. (2015). ARBOOK: Development and assessment of a tool based on augmented reality for anatomy. *Journal of Science Education and Technology, 24,* 119–124. doi:10.1007/s10956-014-9526-4

Fidan, M. (2018). *The impact of problem-based science teaching assisted with augmented reality applications on academic achievement, retention, attitude and belief of self-efficacy* (Unpublished doctoral thesis). Bolu Abant Izzet Baysal University, Institute of Education Sciences, Bolu. Retrieved from https://tez.yok.gov.tr/UlusalTezMerkezi/

Gao, L. (2013). *Natural gesture based interaction for handheld augmented reality* (Unpublished master thesis). Department of Computer Science University of Canterbury, Christchurch.

Gokmen, O. F., Uysal, M., Yasar, H., Kirksekiz, A., Guvendi, G. M. & Horzum, M. B. (2017). Methodological trends of the distance education theses published in Turkey from 2005 to 2014: a content analysis. *Education and Science, 189,* 1–25. doi:10.15390/EB.2017.6163

Goktas, Y., Kucuk, S., Aydemir, M., Telli, E., Arpacik, O., Yildirim, G. & Reisoglu, I. (2012). Educational technology research trends in Turkey: a content analysis of the 2000–2009 decade. *Educational Sciences: Theory and Practice, 12*(1), 191–199.

Johnson, L., Adams, S. & Cummins, M. (2012). *The NMC horizon report: 2012 higher education edition.* Austin, TX: The New Media Consortium.

Ho, S. C., Hsieh, S. W., Sun, P. C. & Chen, C. M. (2017). To activate English learning: listen and speak in real life context with an AR featured u-learning system. *Educational Technology & Society, 20*(2), 176–187.

Hsu, Y.-C., Ho, H. N. J., Tsai, C.-C., Hwang, G.-J., Chu, H.-C., Wang, C.-Y. & Chen, N.-S. (2012). Research trends in technology-based learning from 2000 to 2009: a content analysis of publications in selected journals. *Educational Technology & Society, 15*(2), 354–370.

Hsu, Y., Hung, J. & Ching, Y. (2013). Trends in educational technology research: more than a decade of international research in six SSCI-indexed refereed journals. *Educational Technology Research and Development, 61,* 685–705. doi:10.1007/s11423-013-9290-9

Hwang, G-J., Wu, P.-H., Chen, C.-C. & Tu, N.-T. (2016). Effects of an augmented reality-based educational game on students' learning achievements and attitudes in real-world observations. *Interactive Learning Environments, 24*(8), 1895–1906. doi:10.1080/10494820.2015.1057747

Karal, H. & Abdusselam, M. S. (2015). Artirilmis gerceklik. In B. Akkoyunlu, A. Isman & H. F. Odabasi (Eds.), *Egitim teknolojileri okumalari 2015* (pp. 149–176). Ankara, Turkey: TOJET.

Kesim, M. & Ozarslan, Y. (2012). Augmented reality in education: Current technologies and the potential for education. *Procedia-Social and Behavioral Sciences, 47,* 297–302. doi:10.1016/j.sbspro.2012.06.654

Kilic-Cakmak, E., Ozudogru, G., Bozkurt, S. B., Ulker, U., Unsal, N.O., Boz, K., … Gul, H. U. (2016). 2014 yilinda egitim teknolojileri alanindaki yayimlanan makalelerin incelenmesi. *Egitim Teknolojisi Kuram ve Uygulama, 6*(1), 80–108.

Kitchenham, B. & Charters, S. (2007). Guidelines for performing systematic literature reviews in software engineering. Evidence based software engineering technical report. Retrieved from https://userpages.unikoblenz.de/~laemmel/esecourse/slides/slr.pdf

Klopfer, E. & Squire, K. (2008). Environmental detectives—the development of an augmented reality platform for environmental simulations. *Educational Technology Research and Development, 56*(2), 203–228. doi:0.1007/s11423-007-9037-6

Kinshuk-Huang, H. W., Sampson, D. & Chen, N-S. (2013). Trends in educational technology through the lens of the highly cited articles published in the journal of educational technology and society. *Educational Technology & Society. 16*(2), 3–20.

Korucu, A. T., Usta, E. & Yavuzaslan, İ. F. (2016). Using augmented reality in education: a content analysis of the studies in 2007–2016 period. *Journal of Subject Teaching Research, 2*(2), 81–92.

Kucuk, S., Yilmaz, M. R. & Goktas, Y. (2014). Augmented reality for learning English: achievement, attitude and cognitive load levels of students. *Education and Science, 39*(176), 393–404. doi:10.15390/EB.2014.3595

Kuzu, A. (2014). Coklu ortam uygulamalarinin kuramsal temelleri. In O. O. Dursun & F. H. Odabasi (Eds.), *Coklu ortam tasarimi* (pp. 2–33). Ankara, Turkey: Pegem Akademi Yayinlari.

Lee, K. (2012). Augmented reality in education and training. *TechTrends, 56*(2), 13–21.

Liu, D., Jenkins S. A., Sanderson P. M., Fabian P. & Russell, W. J. (2010). Monitoring with head-mounted displays in general anesthesia: a clinical evaluation in the operating room. *Anesthesia Analgesia, 110,* 1032–1038. doi:10.1213/ANE.0b013e3181d3e647

Martin, S., Diaz, G., Sancristobal, E., Gil, R., Castro, M. & Peire, J. (2011). New technology trends in education: seven years of forecasts and convergence. *Computers & Education, 57*(3), 1893–1906. doi:10.1016/j.compedu. 2011.04.003

Miles, M. B. & Huberman, A. M. (1994). *Qualitative data analysis: an expanded sourcebook* (2nd ed.). Thousand Oaks, CA: Sage.

Saltan, F. & Arslan, O. (2017). The use of augmented reality in formal education: a scoping review**.** *EURASIA Journal of Mathematics Science and Technology Education, 3*(2), 503–520. doi:10.12973/eurasia. 2017.00628a

Shelton, B. E. & Hedley, N. R. (2002). *Using AR for teaching earth-sun relationships to undergraduate geography students*. Paper presented at the 1st IEEE Int. ARToolkit Workshop, Darmstadt, Germany.

Sirakaya, M. & Seferoglu, S. S. (2016). Ogrenme ortamlarinda yeni bir arac: Bir egitlence uygulamasi olarak artirilmis gerceklik. In A. Isman, F. Odabasi & B. Akkoyunlu (Eds.), *Egitim teknolojileri okumalari 2016* (pp. 417–438). Ankara, Turkey: TOJET.

Sozbilir, M., Kutu, H. & Yasar, M. D. (2012). Science education research in Turkey: a content analysis of selected features of papers published. In D. Jorde & J. Dillon (Eds.), *Science education research and practice in Europe: retrospective and prospective* (pp. 341–374). Rotterdam, The Netherlands: Sense Publishers.

Sutherland, I. E. (1968). *A head mounted three dimensional display.* Proceedings of the Fall Joint Computer Conference (AFIPS). Washington DC: Thompson Books.

Thornton, T., Ernst, J. V. & Clark, A. C. (2012). Augmented reality as a visual and spatial learning tool in technology education. *Technology and Engineering Teacher, 71*(8), 18–21.

Tu, C. H. & Twu, H. L. (2002). Educational technology in Taiwan. *Education Media International, 39*(2), 153–164. doi:10.1080/09523980210153444

Wojciechowski, R. & Cellary, W. (2013). Evaluation of learners' attitude toward learning in ARIES augmented reality environments. *Computers & Education*, *68*, 570–585. doi:10.1016/j.compedu.2013.02.014

Yildirim, A. & Simsek, H. (2013). *Sosyal bilimlerde nitel arastirma yontemleri* (9th ed.). Ankara, Turkey: Seckin Yayinevi.

Yuen, S., Yaoyuneyong, G. & Johnson, E. (2011). Augmented reality: an overview and five directions for AR in education. *Journal of Educational Technology Development and Exchange, 4*(1), 119–140. doi:10.18785/ jetde.0401.10