AUGMENTED REALITY FROM TURKISH RESEARCHERS' PERSPECTIVES

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ABSTRACT

Concept of augmented reality (AR) has been attracting the attention of researchers due to its feature of combining physical environment of students and digital presentation materials and offering them to users. AR applications have made a great impression among scientists working in a wide range of fields from engineering sciences to social sciences and become the subject matter of theoretical and experimental research and different kinds of studies in a process starting from the design and programming steps of AR applications to their usage by end-users. In this research, 191 different studies conducted by Turkish scientists on AR were subjected to a document analysis, and the studies were examined according to their fields, types, research designs and population and sample characteristics. These studies were also subjected to a content analysis and scrutinized. According to the research results, AR applications have become the subject matters of product design / development studies particularly in engineering sciences while their different effects have been tested with quantitative research designs in educational sciences.

Keywords: *Augmented reality, trend analysis, virtual reality*

INTRODUCTION

Use of instructional materials is observed in almost every setting where instructional activities are performed. Materials used in instructional environments vary from physical objects to computer-aided materials. Advancements in the computer technology have made it possible for us to use applications which we were not aware of a decade ago in instructional environments. Furthermore, scientists test dynamic and complex aspects of virtual worlds in educational settings (Squire & Klopfer, 2007). Developments in the computer science facilitated the combination of physical materials used in instructional environments and virtual environments (Bujak, Radu, Catrambone, Macintyre, Zheng & Golubski, 2013). Changes in mobile devices along with the computer technology provide learning environments with new opportunities with the portability, social interaction, connection sensitivity, individuality and connectivity features of mobile devices (Squire & Klopfer, 2007). In recent years, Augmented Reality (AR) applications have attracted the attention of educational scientists and teachers; however, the process of developing AR applications for different courses is difficult as teachers have limited knowledge of AR although it is anticipated that AR could put forth both affectively and cognitively effective applications (Cheng, & Tsai, 2013; Wei, Weng, Liu & Wang, 2015; Ibáñez, Di Serio, Villarán & Kloos, 2014). Meaning of the concept of AR is interpreted by researchers differently (Wei, Weng, Liu & Wang, 2015; Wu, Lee, Chang & Liang, 2013). AR can be achieved by benefiting from innovative technologies and combining these technologies (Wei, Weng, Liu & Wang, 2015).

Virtual Reality(VR) applications take students to an unnatural environment, in other words, to an environment constructed by the developers of the system (Martín-Gutiérrez, Saorín, Contero, Alcañiz, Pérez-López & Ortega, 2010). Therefore, students see with the eyes of individuals who form their learning environment in virtual reality environments. AR applications differ from VR applications with different software used and designs in them. AR applications can be defined as the display of digital objects through which context-based interaction can be achieved on real-world objects perceived via a camera or another input device (Sommerauer & Müller, 2014; Klopfer & Squire, 2008; Martin, Diaz, Sancristobal, Gil, Castro & Peire, 2011; Cuendet, Bonnard, Do-Lenh, & Dillenbourg, 2013). As can be understood from the definition, AR adds new information onto real-world objects without pulling its users off from the world. Azuma, Baillot, Behringer, Feiner, Julier, & MacIntyre(2001) talk about 3 features when defining an AR system: 1. combines real and virtual objects in a real environment; 2. runs interactively, and in real time; and 3. registers (aligns) real and virtual objects with each other.

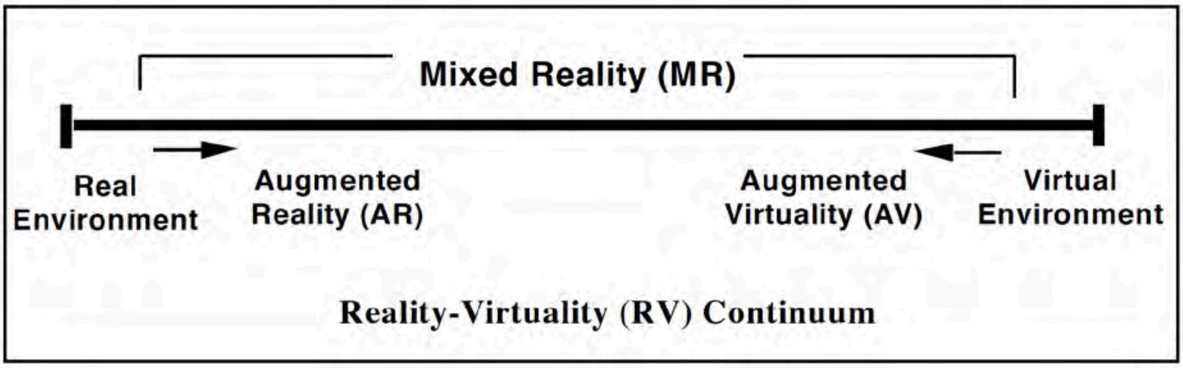

Figure 1. Real World to Virtual World (Milgram, Takemura, Utsumi, & Kishino, 1995).

Figure 1 shows the relationship introduced by Milgram, Takemura, Utsumi, & Kishino (1995) between AR, VR, real world and virtual worlds. As stated by Milgram, Takemura, Utsumi, & Kishino (1995), AR is closer to reality while VR is closer to virtuality. Through AR systems, students can interact with real world in ways that otherwise would not be possible (Cuendet, Bonnard, Do-Lenh, & Dillenbourg, 2013). In the simplest term, AR systems have started with trigger with QR codes, but display technology used in AR systems impacts the level of affecting the users and reinforces the potential which may lead students to better learning (Martin, Diaz, Sancristobal, Gil, Castro & Peire, 2011;Milgram, Takemura, Utsumi, & Kishino, 1995). AR has the potential to address all senses including hearing, touching and smelling (Azuma, Baillot, Behringer, Feiner, Julier, & MacIntyre, 2001). No matter which technology is used, instructional value of AR applications depends on the method followed in the design and implementation of system and its integration into instructional environments (Wu, Lee, Chang & Liang, 2013).

Research studies handle AR applications in two titles (Wojciechowski & Cellary, 2013; Cheng, & Tsai, 2013):

1. Image-based AR
2. Location-based AR

In image-based AR applications, objects, figures, etc. in real world present input for AR systems and data are mounted on the image processed and interpreted with image processing techniques (Wojciechowski & Cellary, 2013; Cheng, & Tsai, 2013). In location-based AR systems, data to be presented is chosen with the help of location information acquired from GPS, Wi-Fi systems of mobile devices or their service providers and presented to the user (Wojciechowski & Cellary, 2013; Cheng, & Tsai, 2013). Regardless of the system type, users experience the real world, and digital information is mounted on (Chen, & Tsai, 2012). AR brings new opportunities to learning environments to reinforce learning, and such opportunities are investigated by researchers (Huang, Chen & Chou, 2016; Wu, Lee, Chang & Liang, 2013). Since students' motor skills are set to work with AR, coding stage of cognitive processes is stronger (Bujak, Radu, Catrambone, Macintyre, Zheng & Golubski, 2013). According to the research, AR could enable (1) learning content in 3D perspectives, (2) ubiquitous, collaborative and situated learning, (3) learners' senses of presence, immediacy, and immersion, (4) visualizing the invisible, and (5) bridging formal and informal learning (Wu, Lee, Chang & Liang, 2013).

Developments in mobile devices enabled that AR has completed its experimental phase and been tested for usage in instructional settings (Huang, Chen & Chou, 2016). While advancements in the sizes of mobile devices have made it possible to bring more devices in the classrooms, developments in image-processing phases have enabled AR applications to run more efficiently. Regarding the studies on AR, it was observed that the users significantly learned more when provided with museum education via AR (Sommerauer & Müller, 2014), the group worked with AR had a more positive mood (Ibáñez, Di Serio, Villarán & Kloos, 2014), the participants developed better writing skills in the writing course (Wang, 2017), it took science education from memorizing sets of fact to a social process (Squire & Klopfer, 2007), and it was more effective than web-based applications in teaching the magnetism subject (Ibáñez, Di Serio, Villarán, & Kloos, 2014). Other than these studies, it was also found that the students preserved their attention and interest for longer with AR applications (Di Serio, Ibáñez & Kloos, 2013) and AR applications increased students' motivations to enable them to participate in learning activities more (Di Serio, Ibáñez & Kloos, 2013).

Azuma (1997) stated that AR applications reinforce reality, therefore enabling users to learn without parting from it. Yet, Wu, Lee, Chang & Liang (2013) stated that AR environments may present cognitive overload on students. In the same study, the researchers argued that AR may motivate students, but AR applications with quality content need to become widespread so that AR could become popular.

This study aimed to examine the studies performed by Turkish scientists on AR with a document analysis and explore the field, type, research design, and populations-samples of these studies. It also aimed to scrutinize the results of these studies and put forth their recommendations for implementers.

METHOD

The research used the document analysis which is a qualitative research method aiming to review printed documents. In a document analysis, documents such as books, newspapers, articles previously published are examined according to certain rules (Şimşek & Yıldırım, 2003). Proceedings, papers and theses published on AR were examined with document analysis.The documents were obtained from Higher Education Academic Search Engine (YÖKAKADEMİK) which can be found at http://akademik.yok.gov.tr. YÖKAKADEMİK is a search engine introduced in 2015 into which academics of universities in Turkey must upload their academic publications. A search was performed on YÖKAKADEMİK search engine with the keywords of "*arttırılmış gerçeklik*" and "augmented reality", and information on 315 proceedings, 146 papers, and 48 theses and dissertations was obtained in the beginning. As the details of studies with 2-3 authors needed to be omitted from the analysis, studies with more than one record were identified in the first place. 46 proceedings and 32 papers with more than one record were identified and omitted from the analysis records. Next, full texts of the studies were accessed in an effort. Some of the studies had no full text files in YÖKAKADEMİK's website. Proceedings and papers were searched on Google Scholar and YÖK Thesis Center (http://tez.yok.gov.tr) for full texts. Consequently, full texts of 194 proceedings and 32 papers could not be acquired. Moreover, it was found that 15 theses/dissertations was blocked for access following the search on YÖK Thesis Center. Finally, 76 proceedings, 82 papers and 33 theses and dissertations were included in the document analysis to be performed in the research.

FINDINGS AND INTERPRETATION

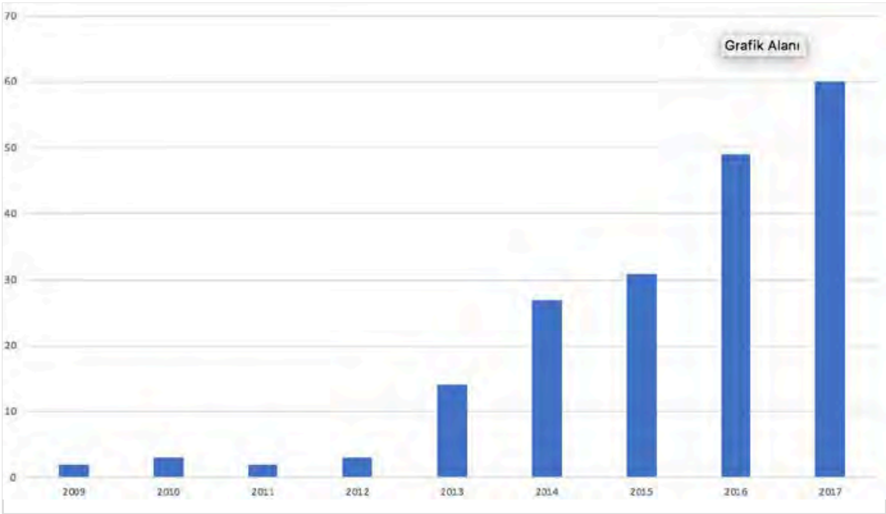

Figure 2.Distribution of analyzed studies by years

As can be seen in Figure 2, first studies on AR were conducted in 2009 among the studies examined in the analysis. With limited number of studies until 2012, there has been a significant increase as of 2013. Each year, number of studies AR has been increasing.

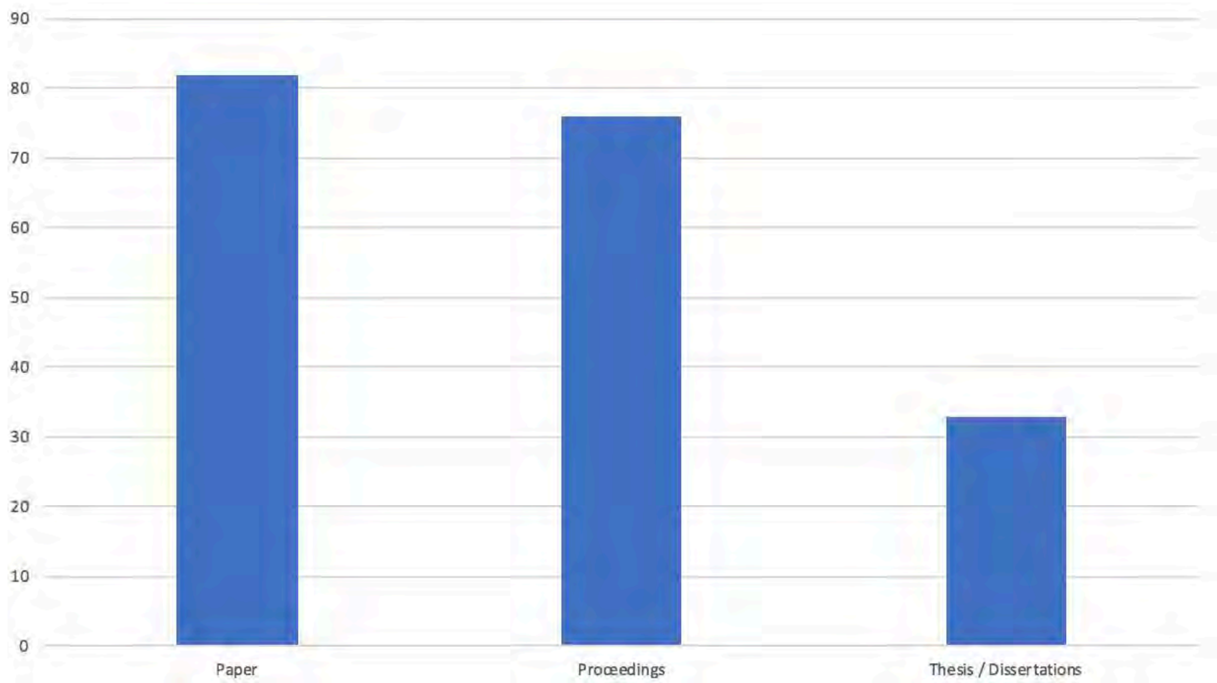

Figure 3. Distribution of analyzed studies by types

Distribution of the analyzed studies by type is shown in Figure 3. It was found that 82 of the analyzed studies are papers, 76 of them are proceedings and 33 of them are theses and dissertations.

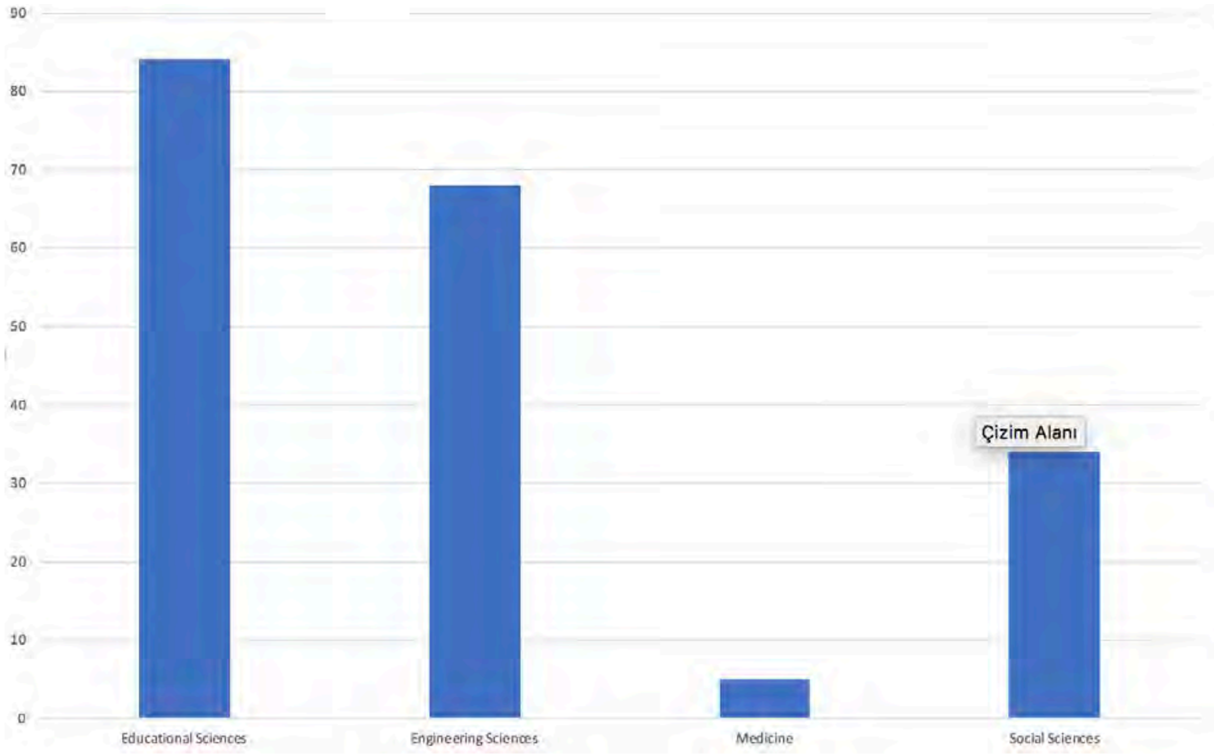

Figure 4. Distribution of analyzed studies by fields

Figure 4 shows the distribution of analyzed studies by their fields. While the fewest number of studies were conducted in medicine, the highest number of studies were conducted in educational sciences with 84 studies.

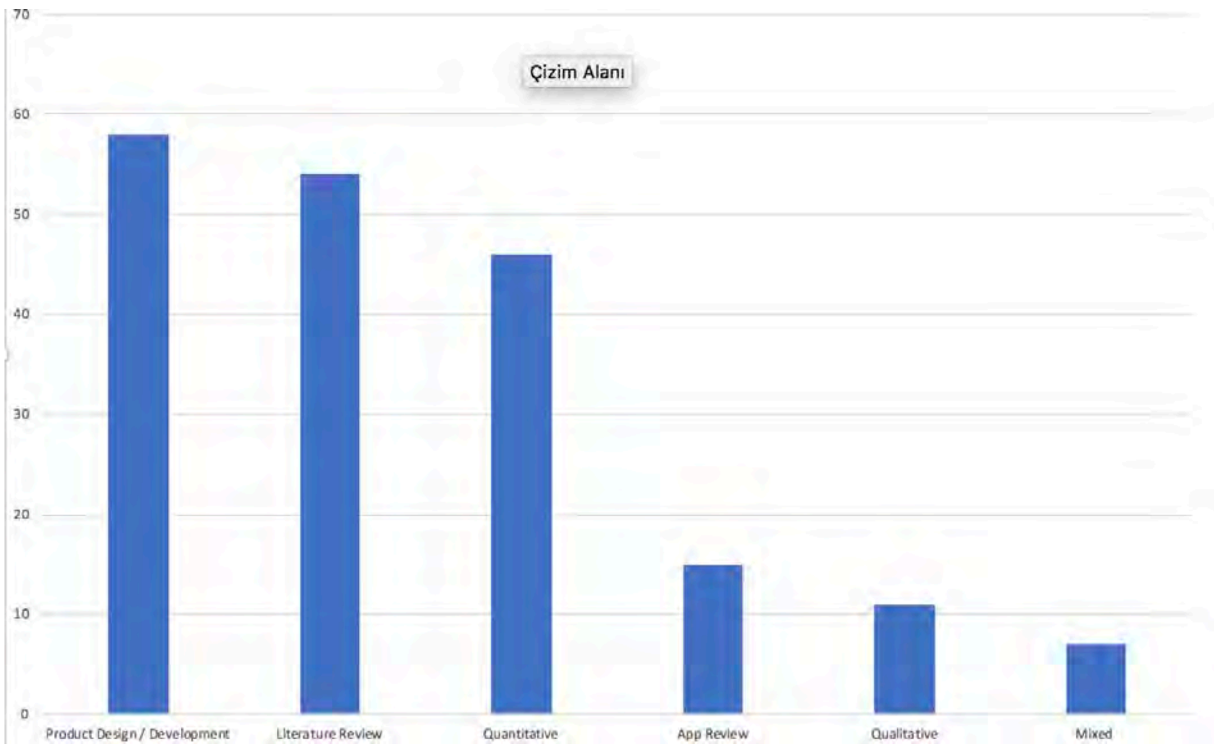

Figure 5. Distribution of analyzed studies by research designs

Figure 5 shows the distribution of analyzed studies by their research designs. Accordingly, most studies were designed as product design / development studies with 58 studies which were followed by 54 studies design as literature reviews. While 46 studies utilized quantitative research designs, 11 studies used qualitative research designs and 7 studies used mixed methods. 15 studies investigated readily available applications developed on AR.

Table 1. Distribution of analyzed studies by years and types

	Proceedings	Paper	Thesis/ Dissertation	Total
2009		1	1	2
2010	1	1	1	3
2011	1	1		2
2012	2	1		3
2013	4	5	5	14
2014	10	12	5	27
2015	10	13	8	31
2016	22	21	6	49
2017	26	27	7	60
Total	76	82	33	191

Table 1 shows the distribution of the studies by years and types. An increase was observed in all types of studies by years. However, the increase in proceedings and papers was higher than in theses and dissertations.

Table 2. Distribution of analyzed studies by years and fields

	Educational Sciences	Engineering Sciences	Social Sciences	Medicine	Total
2009		1		1	2
2010		2	1		3
2011		1	1		2
2012	2	1			3
2013	5	7	2		14
2014	14	9	3	1	27
2015	13	9	7	2	31
2016	22	16	11		49
2017	28	22	9	1	60
Total	84	68	34	5	191

Table 2 presents the distribution of studies by years and their fields. Accordingly, first studies on AR were carried out in engineering sciences. As the studies performed in engineering sciences are product design / development studies, it is an anticipated result that this is the field where the first studies were observed. It is also observed that studies have been performed in social sciences and educational sciences after the foreign literature as well as the literature in Turkey achieved a certain level.

Table 3. Distribution of analyzed studies by fields and types

	Proceedings	Paper	Thesis/ Dissertation	Grand Total
Educational Sciences	27	46	11	84
Engineering Sciences	39	13	16	68
Social Sciences	10	18	6	34
Medicine		5		5
Grand Total	76	82	33	191

Table 3 shows the distribution of the studies by their fields and types. It is also seen that papers were most written in educational sciences and social sciences, and proceedings and theses and dissertations followed papers, respectively. The most conducted type of study in engineering sciences were proceedings which were followed by theses and dissertations and papers, respectively.

Table 4. Distribution of analyzed studies by fields, types and research designs

		Mixed	Literature Review	Quantitative	Qualitative	Product Design / Development	Software Review	Grand Total
Educational Sciences	Proceedings		9	11	2	2	3	27
	Paper	4	17	18	4		3	46
	Thesis/Dissertation	2		7	1	1		11
	Total	6	26	36	7	3	6	84
Engineering Sciences	Proceedings		6	1		30	2	39
	Paper		4	2		7		13
	Thesis/Dissertation		2	1		12	1	16
	Total		12	4		49	3	68
Social Sciences	Proceedings		4			3	3	10
	Paper		8	3	3	3	1	18
	Thesis/Dissertation		2	2	1		1	6
	Total		14	5	4	6	5	34
Medicine	Paper	1	2	1			1	5
	Total	1	2	1			1	5

Table 4 shows the distribution of the studies by their fields, types ad research types. According to Table 4, product design / development studies and literature review studies were conducted most in engineering sciences and majority of them were proceedings. In educational sciences, studies were conducted as literature reviews and in quantitative research design, and these studies were published as papers. Majority of the studies in educational sciences were literature review studies and published as papers.

Table 5. Distribution of applications used in studies by their features

Development	34
Ready-made software	27
Grand Total	61

Distribution of AR applications used in the studies by whether being ready-made or developed by researcher(s) is presented in Table 5. It was accordingly observed that more than half of the studies used software developed by researcher(s).

Table 6. Distribution of applications used in the studies by objects with which they interact

	Developed material	Real world	Ready-made material	(n/a)	Grand Total
Development	17	13		4	34
Ready-made software	9	6	5	7	27
Grand Total	26	19	5	11	61

Table 7. Distribution of applications used in studies by their presentation materials

	Ready-made animation	Ready-made picture	Ready-made video	Picture developed by researcher(s)	Animation developed by researcher(s)	Video developed by researcher(s)	Text	(n/a)	Grand Total
Development		2		17	3	1	7	4	34
Ready-made software	1	5	1	7	1	1	3	8	27
Grand Total	1	7	1	24	4	2	10	12	61

Table 6 and Table 7 show distribution of studies used in AR applications by objects with which they interact and by AR application's presentation materials. It is accordingly understood that developed materials were preferred as trigger objects for ready-made software and software developed by researcher(s), and pictures or texts developed by researcher(s) were used as presentation materials.

Table 8. Distribution of applications used in studies by their features and type of study

	Proceedings	Paper	Thesis/ Dissertation	Grand Total
Development	9	11	14	34
Ready-made software	9	13	5	27
Grand Total	18	24	19	61

Table 9. Distribution of applications used in studies by their features and field of study

	Educational Sciences	Engineering Sciences	Social Sciences	Medicine	Grand Total
Development	18	14	2		34
Ready-made software	13	8	4	2	27
Grand Total	31	22	6	2	61

In Table 5 and Table 9, distributions of AR applications used in the studies by their features, type and field of the studies are presented. In theses/dissertations, the preference was mostly to develop software while there is an equal distribution between proceedings and papers. By the field of study, researchers studying in engineering and educational sciences preferred to develop software whereas researchers in social social sciences decided to use ready-made software.

Table 10. Distribution of studies by population and sample

Other	4
Primary Education	26
Secondary Education	3
Higher Education	28
Total	61

Table 10 shows distribution of the studies by their populations and samples. Accordingly, the highest number of studies were conducted in higher education with 28 studies which were followed by 26 studies performed in primary education.

Table 11. Average sample sizes of studies by their types

	Average Sample Size
Proceedings	72
Paper	85
Thesis/Dissertation	88

General Average	83

Table 12. Average sample sizes of studies by their fields

	Average Sample Size
Educational Sciences	76
Engineering Sciences	54
Social Sciences	150
Medicine	34
General Average	83

Table 13. Average sample sizes of studies by their research designs

	Average Sample Size
Mixed	39
Quantitative	100
Qualitative	44
Product Design / Development	69
General Average	83

Distributions of average sample sizes by type, field of study and research designs are shown in Table 11, Table 12 and Table 13. Accordingly, sample sizes did not differ by type of study. Regarding the fields of study, the highest average sample size was observed in social sciences which were followed by educational and engineering sciences. As for the research designs, the highest average sample size was found to be in quantitative studies, and quantitative and mixed research designs had similar sample sizes.

A content analysis was conducted on the results of the studies analyzed in the research, and the research results were examined. In the analysis of the data, positive and negative aspects of AR applications and researchers' recommendations for implementers were explored in an effort. According to the research results, AR usage facilitates instructional process, makes positive contribution to focus one's attention, increases in-class interaction, contributes to the quality of education, affects satisfaction with foreign language education positively, facilitates the structuring of information, enriches the instruction, improves problem-solving skills, materializes the subject, makes education entertaining, increases participation in the course and contributes to academic achievement. It was also observed that it contributes to the creation of positive brand recognition, affects purchasing decision positively and may increase brand loyalty in marketing and advertisement. As for the negative aspects of AR applications, they may limit physical activities of students, increase screen addiction, and problems may be experienced where Internet infrastructure is insufficient. Recommendations made for implementers in the analyzed research studies can be listed as follows: AR applications need to be suitable for target group's knowledge and skills, AR-supporting equipment should preferred when purchasing equipment, proliferation of applications triggered with real world would make AR applications more widespread, applications that would meet individuals' demands need to be developed, printed materials may be updated more easily with AR, AR applications may improve more rapidly with multi-disciplinary studies, and factory setting can be created in occupational trainings.

Conclusion and Recommendations

191 studies were analyzed in the research, and detailed information on the analyses are provided in the findings section. The conclusions achieved from the findings can be listed as follows: The first studies on AR were conducted in engineering sciences which were followed by social sciences one year later and

educational sciences three years later. While concept of AR attracts attention of scientists studying in engineering sciences particularly with product design / development, scientists studying in educational sciences conduct quantitative studies on AR. However, it was observed that there are very few product design / development studies conducted by scientists studying in educational sciences; similarly, no quantitative and qualitative studies which would test product design / development studies performed by scientists in engineering sciences in the context of end-user were observed. Even though literature review studies and detailed studies on AR applications have been conducted by scientists in social sciences, few studies testing the different aspects of AR applications using qualitative or quantitative research designs were observed in this study. Multi-disciplinary studies to be conducted in cooperation between scientists in engineering, social and educational sciences and cooperative studies to be carried out in qualitative or quantitative research designs by researchers in engineering sciences to test product design / development steps and different experiences of end-users would contribute to the development of culture-specific AR applications.

Concerning the research designs, the studies were mostly conducted in quantitative research designs. There are not many studies using qualitative or mixed research designs. Increasing number of qualitative studies and consequent studies conducted to improve AR applications in a field such as AR which has been recently developed and in which revealing the end-user experience is so important will facilitate the implementation of AR.

Despite significant position of AR applications particularly in the stores of mobile operating systems and specialization of presentation materials with trigger objects, use of ready-made AR applications was found to be limited in the research studies. Using ready-made software upon necessary customizations for the implementation environment will decrease implementation costs, and therefore, provide access to wider groups.

It was observed in the analyzed studies that developed materials were used as trigger objects in general. Given the definitions of AR, emphasis is mostly on that users are not separated from the real world. Hence, using real-world objects as trigger objects in AR applications will enable that end-users experience AR environments without drifting apart from their surroundings.

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