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# A content analysis of studies published in the field of augmented reality in education

Mahmut Emre Turhan [a] *, Mustafa Metin [b], Ebru Ezberci Çevik [b]

[a] Ministry of Education, Turkey
[b] Erciyes Universty, Turkey

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**Abstract**

This review study was carried out using content analysis and it was aimed to analyze the articles published in national journals in the field of augmented reality. The sample of this study, in which the content analysis method was used, consists of 87 academic studies conducted in the field of augmented reality in education in Turkey between 2012 and 2020. Studies obtained as a result of scanning were analyzed according to some variables such as the publication year, purpose, subject area, approach / method, sample group, sample number, data collection tool of study. As a result of the analysis of the research, it was observed that the first studies started in 2012 and increased with each year. It has been determined that most of the studies are aimed at determining the effect of augmented reality on students' achievement. In addition, it was seen that the vast majority of researches were carried out in the field of science education, using the experimental research method with 40-60 university students. Furthermore; it has been determined that the achievement test in quantitative studies and interview form in qualitative research is more preferred as a data collection tool.

## 1. Introduction

The focus of human-interest changes periodically, and the inventions obtained on the way that started with curiosity and research lead to technological development and a new competition. Human insatiability with science causes rapid development of new technologies. Especially towards the end of the twentieth century, the development in digital technologies (Artificial Intelligence (AI), robotic coding, etc.) has initiated a digital transformation process in people's lives. The latest point of these advancements is the industry 4.0 concept and technologies (Yiğitol & Sarı, 2020).

In the definition of Society 5.0 which resonated in Japan, cyber space and physical space are fully integrated, and the foundations of the future society have begun to be laid with virtual reality, augmented reality and mixed reality applications. Although these applications are encountered in all areas of life, they have started to be used frequently in the field of trade and tourism. Especially the concept of augmented reality has created great expectations in the field of education and medicine, and studies in these areas have increased in recent years.

The first thoughts about augmented reality can be seen in the book "The Master Key" by L. Frank Baum, famous for his novel The Wizard of Oz, published in 1901 (Baum, 1901). In the novel, a boy named Rob, who has an interest and curiosity in electricity, finds the main switch of electricity by chance and summons

* Corresponding author. Ministry of Education, Kayseri/ TURKEY;
e-mail address: memret13@hotmail.com

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the Demon of Electricity, and the gifts of electrical devices given to him and Rob's adventures with these devices. One of these gifts is the glasses called "Character Marker". When looking at a person with these glasses, the glasses make markings such as bad, good, intelligent, rude, showing the character structure of the other person. While doing this, it shows the initial letter of the character structure on the person's forehead. It is stated that the glasses work by interpreting the electrical vibrations found in all humans. These glasses in the book are considered as one of the first ideas about the use of augmented reality (Baum, 1901; Woods, 2014). One of the important steps in the development of augmented reality, which emerged as an idea in 1901, is the Mark VIII Airborne Interception Radar Gun sighting project implemented by the British army during World War II, thanks to the radar information screen displayed on the windshield of the warplanes, the system where various information about flight is provided to the pilot (Vaughan-Nichols, 2009).

Considering the augmented reality applications after the 1950s, cinematographer Morton Heilig made Sensorama, a multi-perceptual machine in 1957 to activate the five senses. In 1968, Ivan Sutherland designed the first head mounted imager, which he called the Sword of Damocles. Very simple graphics are used in the system, which works with head turning and eye movements, but the mechanism is suspended from the ceiling of the laboratory since it is too large to be carried on the user's head. Nevertheless, it has been deemed valuable in terms of being the first example for viewers used in different fields today (Altınpulluk & Kesim, 2015).

In general terms, augmented reality can be defined as supporting the real-world environment in harmony with virtual objects in the process of viewing the real-world environment with different technological devices (Demirer & Erbaş, 2015; Maulana, Asrowi & Suryani, 2020). According to Azuma (1997), there are three basic features that should be in augmented reality technologies. These; combining virtual objects and real world, presenting virtual objects and real world at the same time and using three dimensions. It is possible for augmented reality technology to appeal to all five senses of human beings in that it includes digitally created audio, visual and video elements. However, when the studies conducted today are examined, it is understood that such applications focus more on visual perception (Kipper & Rampolla, 2012).

Augmented reality technology is used in different areas. It can be used in risky training activities such as dressing virtual objects in a forest and training forest fire workers (Özaydın Aydoğdu & Eryılmaz 2019), in military training practice for fighter pilots (Yeh & Wickens, 2001) when a practice of risky surgeries in the medical field can be provided with lower costs. Another of these areas is education.

Augmented reality technology is used in many different areas in education, as well as at different learning levels such as preschool, primary school, middle school, and high school (Sirakaya & Alsancak Sirakaya, 2018). Augmented reality technologies enable the transformation of textbooks, classrooms and stationary objects in learning environments into multimedia possibilities, increasing the functional richness of the environment and enabling different cognitive areas to work in learning. It offers environments where augmented reality helps students to understand abstract concepts in the learning and teaching process and where students can share information within the group (Lave & Wenger 1991). It is also stated that these environments cause a positive increase in students' learning (Freitas & Campos 2008). In addition, it was stated that augmented reality increases students' interest, motivation and experience, plays a role in integrating the knowledge and skills acquired in the virtual environment into the real environment, therefore it is preferred (Abdüsselam & Karal, 2012).

There have been studies showing the tendencies of augmented reality in the national literature (İçten & Bal, 2017; Kapucu & Yıldırım, 2019; Korucu, Usta & Yavuzaslan, 2016). Among these studies, in the study conducted by İçten and Bal (2017), 34 academic studies on augmented reality published in 27 international and national journals between 2010 and 2016 were examined. In the study conducted by Kapucu and Yıldırım (2019), 75 studies, which were conducted between 2010 and 2018, were accessed in Google

Academic, Tübitak, ULAKBİM, and DergiPark databases, and with the terms "virtual reality" or "augmented reality" in their titles were examined. The studies examined by Korucu, Usta and Yavuzaslan (2016), published between the years 2007-2016, the keyword "augmented reality" is located, have reached their full text, Turkey addressed, contained in Google Scholar and DergiPark website. The primary difference of the current study from these studies is that it includes not only those published in journals but also papers and thesis. Besides, in the current study while the sample of the research was selected; it was taken into consideration criteria such as "augmented reality" and "education" in their keyword. In this sense, it is aimed to include education-oriented augmented reality studies.

Certainly, such studies should be repeated periodically in order to determine current trends. Hart (1998) emphasizes that among the reasons for conducting such research is to discover which aspects of the field have been studied and which aspects and variables of the field have not yet been investigated. In this context, articles, papers and theses published by Turkish researchers on augmented reality between 2012 and 2020 were selected according to certain criteria and examined in terms of various variables in the study. Such a content analysis could help us to classify studies under different sub-purposes, to develop an understanding status of augmented reality research in Turkey, and to provide more detailed information on what could be done about augmented reality in the future. In this context, the aim of the study is to analyze the content of the studies conducted by Turkish researchers on augmented reality in education. The studies examined in the study were analyzed in terms of year, purpose, area, method, design, study group, sample size and data collection tools to examine the development of augmented reality in Turkey, reveal the current situation of the studies done and put that guidance for future work. For this purpose, the studies were analyzed according to the following research questions.

1. What is the distribution of the studies by year?
2. What is the distribution of the studies according to the research aim?
3. What is the distribution of the studies according to the field of study?
4. What is the distribution of the studies according to the research approach?
5. What is the distribution of the studies according to the method?
6. What is the distribution of the studies according to the sample?
7. What is the distribution of the studies according to the sample size?
8. What is the distribution of the studies according to the data collection tools?

## 2. Methodology

This review study was carried out using content analysis and it was aimed to analyze the articles published in national journals in the field of augmented reality between 2012 and 2020. Content analysis is evaluated under three categories in the literature: meta-analysis, meta-synthesis, descriptive content analysis (Çalık & Sözbilir, 2014). Meta-analysis is expressed as summarizing the data obtained from quantitative studies on a specific subject by statistical means (Field, 2001). On the other hand, meta-synthesis is a method used to reveal the similarities and differences of qualitative studies on the same subject by examining them according to the theme, template or criteria determined by the researchers (Polat & Ay, 2016). Descriptive content analysis is used to determine what the general tendency is in studies using both qualitative and quantitative research methods on the same topic (Cohen, Manion & Morrison, 2007; Selçuk, Palancı, Kandemir & Dündar, 2014).

Within the scope of this study, descriptive content analysis method was used to determine the general tendency of the studies conducted in the educational field of augmented reality between 2010 and 2020. The method of descriptive content analysis is to gather similar data within the framework of certain

concepts and themes, and to organize and interpret them in a way that the reader can understand (Yıldırım & Şimşek, 2013).

### *2.1. Research Sample*

The sample of this study consists of articles and theses published on the field of augmented reality in education between 2012 and 2020. While the sample of the research was selected; it was taken into consideration criteria such as achieving the full text, take place in the National Thesis Center, Ulakbim, Google Scholar, DergiPark, TR index and including concepts such as augmented reality and education in their keyword. As a result of the examinations made by taking these criteria into account, the sample of the research consists of 87 academic studies. Information about these studies examined within the context of the research is presented in Appendix-1.

### *2.2. Data Collection Tool*

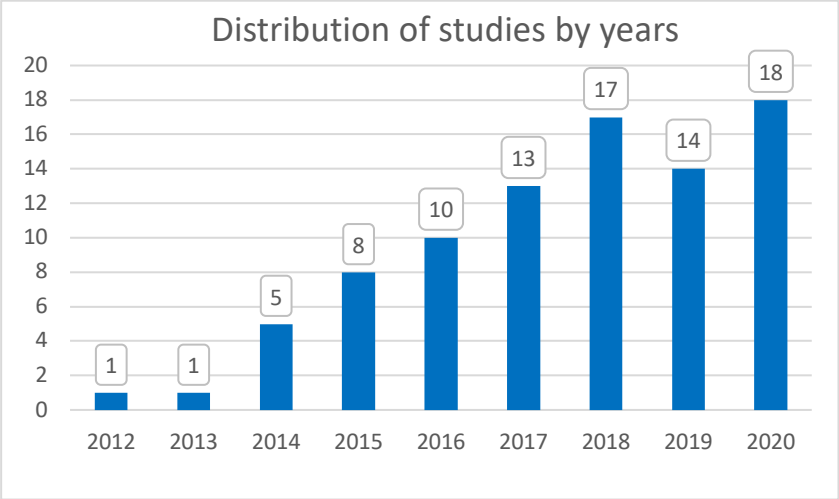
"Research Classification Form" was developed in order to evaluate the articles about the augmented reality field in education and this form was used as a data collection tool in the context of the study, While developing the research classification form, the studies conducted in the literature using descriptive content analysis were examined (Çiltaş, Güler & Sözbilir, 2012; Elçiçek, 2021; Oğuzman, Metin & Kaya, 2021; Sözbilir, Kutu & Yaşar, 2012; Yavuz, Kayalı & Tutal, 2021; Selçuk et al., 2014) and the features that should be found in a scientific article were examined (Çepni, 2005; Cohen et al., 2007; Büyüköztürk, Kılıç Çakmak, Akgün, Karadeniz & Demirel 2011). In the research classification form in line with the examinations made; There are seven sections, namely the identification, year, purpose, subject area, approach / method, sample group, sample size and data collection tools. The categories in this classification form and the options given under this category were presented to the opinions of two experts published article in the field of content analysis. The form was adjusted in line with expert opinions. Research Classification Form Appendix 2 is presented.

### *2.3. Data Analysis*

87 studies in accordance with the criteria determined within the context of the study were analyzed with the Research classification form developed by the researchers. During the analysis process of the articles, two different researchers evaluated the determined studies separately by considering the categories determined in the form. The researchers categorized the findings obtained from the articles in the framework of research questions by saving them in Microsoft Excel file. After the analysis of all the articles was completed, analyzes made by the two researchers were compared and the analysis data were arranged in line with a common opinion. Findings obtained are then presented in the form of tables and graphs. After the analysis, the data were organized and inferences were made. In order to ensure internal reliability, the findings obtained in the current study were presented without subjective interpretation. Besides, to increase the external reliability of the research, the results were discussed in relation to the relevant literature. In order to ensure the validity of the study, detailed explanations on data collection and analysis methods were provided. In addition, to ensure external validity, the limitations revealed in the research were clearly stated.

## 3. Findings

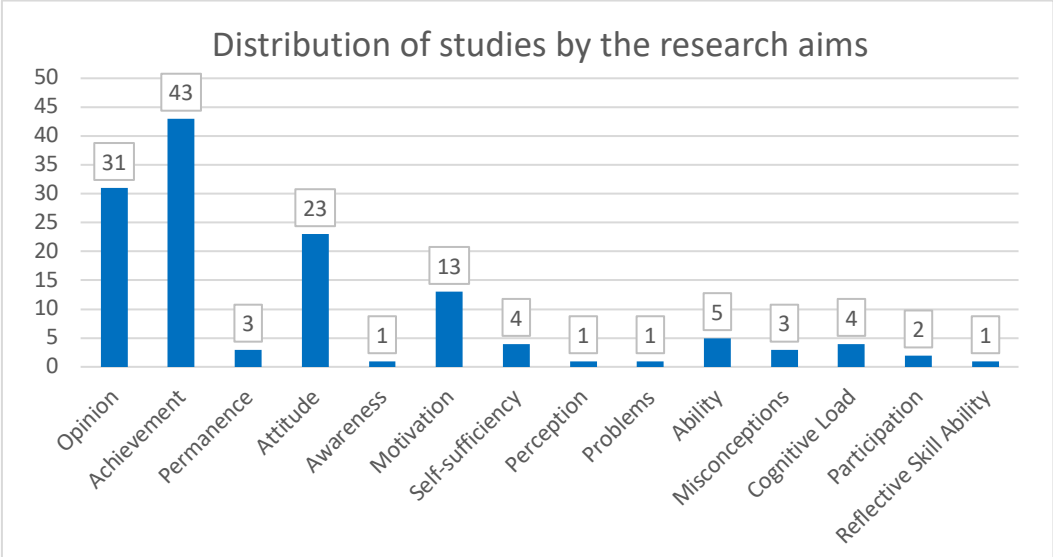
87 studies published and accessible in the field of augmented reality in education between 2010 and 2020 were analyzed and presented separately within the specified categories. Distribution of studies in the field of augmented reality in education by years is presented the graphic 1.




Graphic 1. Distribution of studies in the field of augmented reality in education by years

When Graph 1 is analyzed, it is seen that studies on augmented reality in education were first published in 2012 and then increased gradually. It is understood that the publications have shown an important shot in the last three years. In the analysis, it was determined that 18 studies were conducted in 2020, 14in 2019 and 17 in 2018. However, it was carried out a few studies in 2012 and 2013.

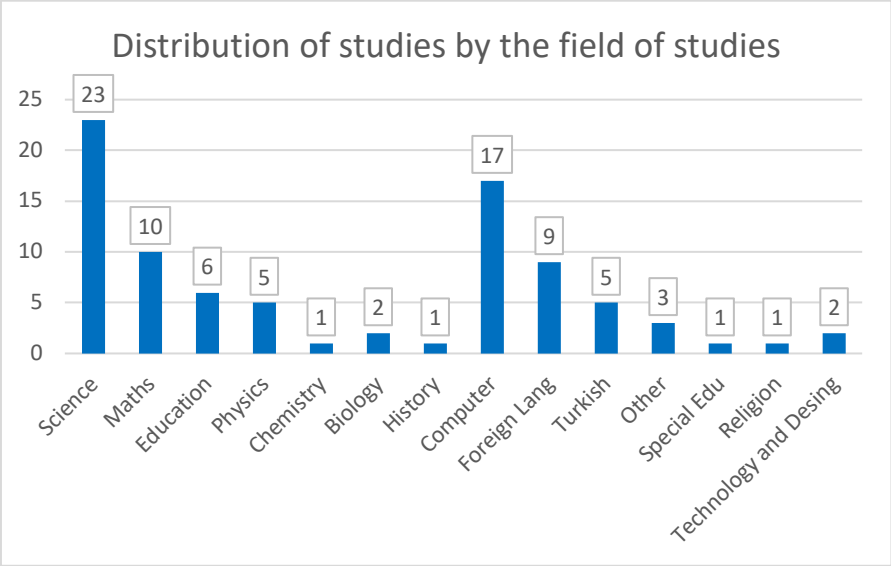
Distribution of studies in the field of augmented reality in education by the research aim is presented in the graphic 2.




Graphic 2. Distribution of studies in the field of augmented reality in education by the research aims

When Graph 2 is examined, it was seen that 43 of the studies are aimed at determining the effect of augmented reality application on students' achievement. It was also determined that 31 studies were aimed at revealing students' opinions about augmented reality applications and 23 studies were investigating students' attitudes towards augmented reality applications.

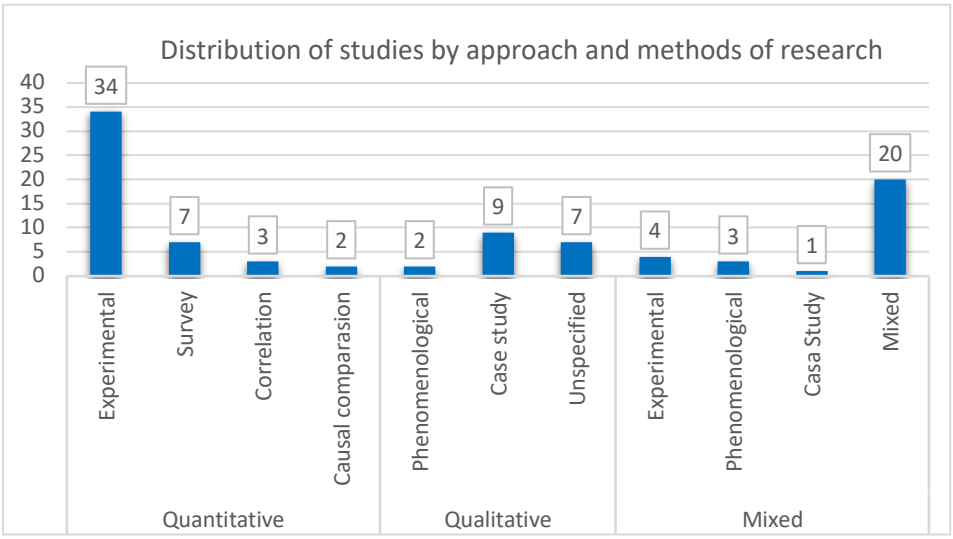
Distribution of studies by the field of studies is presented in the graphic 3.




Graphic 3. Distribution of studies by the field of studies

Looking at Graph 4, it is seen that most of the studies on augmented reality in the field of education are in Science, with 23 studies. In addition, it has been determined that 17 of the studies were conducted in the field of Computer Technologies, 10 studies in Mathematics, and 9 studies in the Foreign Language.

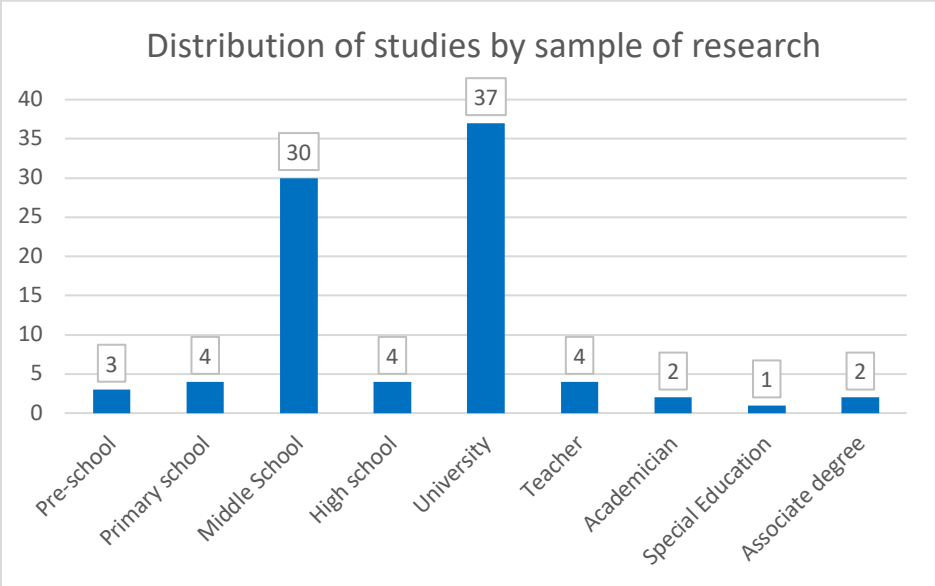
Distribution of studies in the field of augmented reality in education by the research approach and methods is presented in the graphic 4.




Graphic 4. Distribution of studies by approach and methods of research

When Graph 4 is analyzed, it is seen that 45 studies were conducted using quantitative research, 18 studies using qualitative research and 24 studies using mixed research approach. It has been determined that the most preferred method in studies used quantitative research approach is experimental research method. In addition, it is understood from the graph 4 that the case study method is the most used method in the qualitative research approach. However, in mixed studies, it is seen that methods are generally not specified and they are expressed only as "mixed method was used".

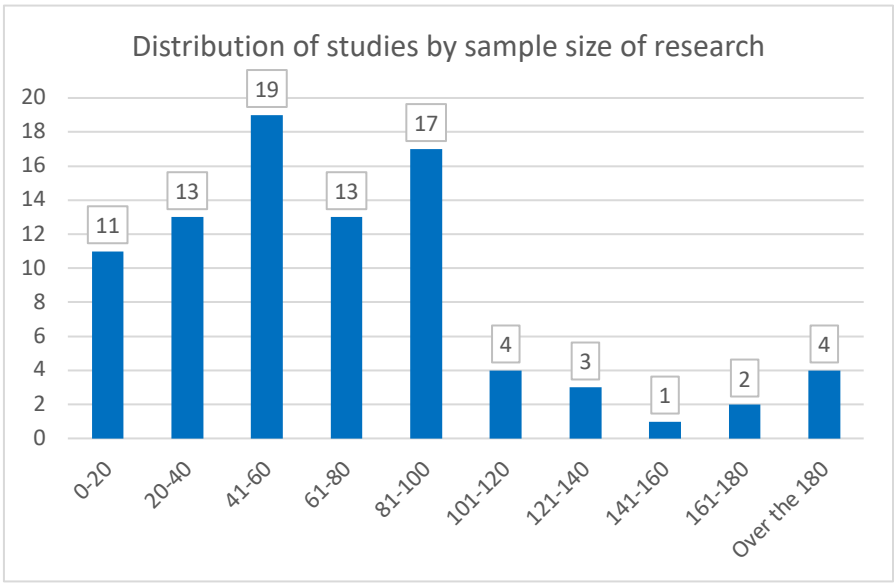
Distribution of studies in the field of augmented reality in education by the research sample is presented in the graphic 5.




Graphic 5. Distribution of studies by sample of research

Looking at Graph 5, it is seen that 37 of the studies were conducted on university students. Furthermore, it was determined that 30 studies were conducted with middle school students. In addition, it is seen that primary school in 4 studies, high school in 4 studies and teachers in 4 studies were preferred as samples in the research.

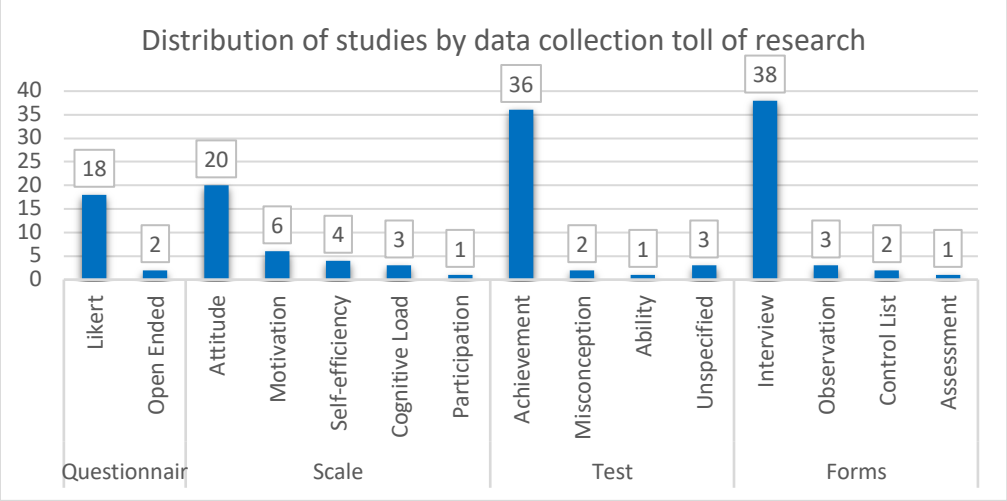
Distribution of studies in the field of augmented reality in education by the research sample size is presented in the graphic 6.




Graphic 6. Distribution of studies by sample size of research

When Graph 7 is examined, there are 19 studies with 41-60 participants, 17 studies between 81-100, 13 studies between 0-20 and 61-80 and 13 studies between 21-40. It can be said that the majority of the studies (73 studies) have been carried out on the sample size in the range of 0-100.

Distribution of studies in the field of augmented reality in education by the data collection tool is presented in the graphic 7.




Graphic 7. Distribution of studies by data collection toll of research

When looking at Graphic 7, it is understood that questionnaire in 20 studies, scale in 34 studies, test in 42 studies and forms in 43 studies were preferred. It is seen that in studies using the questionnaire, Likert type questionnaires are used mostly, and attitude scales are used the mostly in studies in which scales are used. Besides, while achievement tests were preferred in studies where the test was used, interview forms were mostly used among the forms.

## 4. Discussion, Conclusion and Suggestions

This study is to examine the development of the augmented reality studies of Turkey; published between 2012 and 2020 years, include the keyword "augmented reality" and "education" with the concept and can achieve their full texts, is composed of academic studies of Turkish researchers.

As a result of the statistical analysis made for the first question of the study, it has been determined that the researches included in the study have increased especially in recent years. In the study of Sünger (2019), it was stated that there was an increase in the theses made in Turkey on augmented reality as of 2015. The reason for this situation can be thought as supporting technological developments and increasing the opportunities of access to information every day. On the other hand, Wojciechowski and Cellary (2013) also stated that learning in image-based augmented reality environments is attractive and reminding especially for young generations, and as a result, people have gained more familiarity with this technology in recent years. In this sense, augmented reality has gained significant momentum in educational technologies.

In the distribution of the study by the aim stated in another research question, the result was obtained that the majority of the researches were conducted to determine the effect of augmented reality application on academic achievement. In addition, determining the students' views about these practices and examining their attitudes were also among the most targeted aims. Considering that the researches are in the field of education and that academic success is the primary criterion in education in Turkey, it is thought that most of the studies examine the effect of augmented reality applications on academic achievement, and researchers are working in line with expectations in education.

According to the results obtained from the researches made according to the field of study, it is seen that the studies on augmented reality are the most in the field of Science. In addition, computer technologies, mathematics and foreign languages, which are among the fields that benefit the most from educational technologies, have also been the most studied fields. Wojciechowski & Cellary (2013) and Korucu, Usta & Yavuzaslan (2016) also stated in their studies that augmented reality is widely used in the field of education. In the present study, only the areas of augmented reality used in education are focused on.

Different from the current study, Wu, Lee, Chang & Liang (2013) stated that augmented reality is used in fields such as military, pharmacy, engineering, tourism and advertising as well as education. Tülü & Yılmaz (2012) stated that these applications can be used as educational materials at all levels from primary school to university. As an example, it is stated that the design of a mechanical system in an engineering course, the introduction of an organ of the human body can be explained with the application developed in a medical course. In the current study, it is possible to say that this application is carried out in many fields. In this sense, the relevant study supports the current study.

Considering the distribution findings according to the approach and method of the research stated in another research question, it was seen that the quantitative research approach was mostly adopted in the studies. Sırakaya & Alsancak Sırakaya (2018) stated in their study that quantitative approach is often preferred in studies on augmented reality. Different researchers also stated that the quantitative method is used more frequently in their research on trends in recent years on different subjects (Eyüp, 2020; Şahin & Kaya, 2020; Zhu, Sari & Lee, 2018). Yavuz (2016) also stated that quantitative research is more preferred in qualitative research because of its fast and easy data collection. The relevant findings are in line with the current study. In the studies examined, it was observed that the experimental design was frequently preferred in the quantitative research approach. Later, it was seen that the survey method was used. Demirer & Erbaş (2015) also stated that the studies of the educators in Turkey on augmented reality appear as literature review studies prepared for the introduction of this new technology and experimental studies on the use of augmented reality applications in education. A similar result was obtained in the present study. It was noted that besides the frequent use of the experimental design, the case study model was the most used qualitative research approach. It is thought that the increase in the use of augmented reality applications in educational environments has been effective in common use of case studies. It is an important result that the method used was not specified in seven qualitative studies. It is valuable to give this information in studies, which is very important for readers and researchers who will do similar studies later. In addition, mixed-method research approach in which qualitative and quantitative methods are used together was preferred in terms of providing in-depth information on the participants (Creswell, 2012).

In the studies, the most university student group was preferred as a sample. Lee (2012) stated that augmented reality technologies provide a great advantage in university students 'learning, especially in the learning of complex information, and they are important for improving students' knowledge and skills. In this sense, it can be said that the fact that students at the university level are included in the study group is often preferred. Another group preferred frequently in the present study was middle school students. It was concluded that the studies on augmented reality were also carried out on different study groups. It is possible to say that augmented reality technologies can be used at most levels in educational environments. Besides, as the number of participants, it was found that there were mainly participants in the range of 0-100. It can be said that this may be due to the high cost of using this technology in large samples.

When data collection tools used in researches for another research question were examined, it was concluded that interviews, achievement tests and attitude scales were used predominantly. When these results are examined, it means that mostly aiming to determine academic success in studies increases the use of such data collection tools. In order to achievement tests were used to measure the participants' intelligence or to test knowledge of an individual in a particular area (Frankel & Wallen, 2006; Metin, 2014). Researchers, for example in experimental design, may have used these data collection tools to measure the effect of treatment on the intended variable. Another frequently used data collection tool is interviews. Considering the purpose of the interview method, it can be said that the researchers preferred this data collection method to discover the subjects' thoughts and feelings towards augmented reality. Besides, it was determined that different data collection tools were also used in the researches. It is stated that augmented reality has an increasing effect on students' motivation towards the lesson, and in a study conducted by Di Serio, Ibáñez & Kloos (2013) on the effect of augmented reality on students' motivation, it was concluded that students' attention, interest, confidence and satisfaction towards the lesson increased.

In the present study, it was determined that this type of scale was used in only six of the researches. In this sense, it can be said that it is important to determine how this technology affects the elements that support learning in studies.

The suggestions presented in line with the results obtained within the scope of the research are given below.

- Teachers and high school students may be preferred more as the sample group in researches to be conducted on augmented reality.
- More researches can be done on augmented reality in the fields of Technology Design and Physical Education.
- Researches can also be applied to groups with a larger number of participants.
- Different data collection tools (observation, motivation scale, etc.) can be used more in researches.
- It is suggested that the method sections of the studies on mixed research approach should be written more descriptively.
- It has been determined in the present study that there are deficiencies/not specified in the method section of some of the studies. In future studies, it is suggested that researchers pay more attention to this section.

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## Appendix-1. Information about the research

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## Appendix 2. Research Classification Form

**A. Description Information**

Title:

Identification of the research:

Year of research:

1.☐2010 4.☐2013 7.☐2016 10.☐2019
2.☐2011 5.☐2014 8.☐2017 11.☐2020
3.☐2012 6.☐2015 9.☐2018

**B. Aim of Research**

1.☐Opinion 5.☐Awareness 9.☐Problems 13.☐Participation
2.☐Achievement 6.☐Motivations 10.☐Ability 14.☐Reflective Skill Ability
3.☐Permanence 7.☐Self-Sufficiency 11.☐Misconceptions
4.☐Attitude 8.☐Perception 12.☐Cognitive Load

**C. Sample Size**

1.☐0-20
2.☐20-40
3.☐41-60
4.☐61-80
5.☐81-100
6.☐101-120
7.☐121 -140
8.☐141-160
9.☐161-180
10.☐181 and over

**D. Approach/Method**

| a) ☐Quantitative | b)☐Qualitative | c)☐Mixed method |
|---|---|---|
| 1.☐Experimental | 1.☐Phenomenological | 1.☐Experimental |
| 2.☐Survey | 2.☐Case Study | 2.☐Phenomenological |
| 3.☐Correlation | 3.☐Unspecified | 3.☐Case Study |
| 4.☐Causal comparation | | 4.☐Mixed Method |

**E. Sample**

1.☐Pre-school 7.☐ Teacher Candidate
2.☐Primary school 8.☐Teacher
3.☐Middle School 9.☐Academician
4.☐High school 10.☐Special Education
5.☐University 11.☐Associate degree
6.☐Graduate 12.☐ Other

**F. Field of Study**

1.☐Science 8.☐Computer
2.☐Math's 9.☐Foreign Lang
3.☐Education 10.☐Turkish
4.☐Physics 11.☐Special Education
5.☐Chemistry 12.☐ Religion
6.☐Biology 13.☐ Technology and Design
7.☐ History 14.☐ Other

**H. Data Collection Tools**

| a) Questionnaire | b) Scale | c) Test | d) Forms |
|---|---|---|---|
| 1.☐Likert | 1.☐ Attitude | 1.☐ Achievement | 1.☐ Interview |
| 2.☐Open Ended | 2.☐ Motivation | 2.☐ Misconception | 2.☐ Observation |
| | 3.☐ Self-efficiency | 3.☐ Ability | 3.☐ Control List |
| | 4.☐ Cognitive Load | 4.☐ Unspecified | 4.☐ Assessment form |
| | 5.☐ Participation | | |