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Review Article

Augmented Reality Applications in Postgraduate Education Studies: 2010-2023 Türkiye Example

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Abstract

Augmented reality applications are spreading at an increasing pace in all areas of life, and many academic studies are being conducted on the effects of this new technology in all dimensions. The effects of this innovative technology, which promises great opportunities, on educational processes, have also created an important research field. In this context, 135 thesis studies conducted in the field of augmented reality in the field of educational sciences between 2010 and 2023 within the scope of postgraduate research in Türkiye were examined by using the descriptive analysis method in the research. These studies were analyzed at the level of publication year, type of theses, writing language, university where they were conducted, field where they were conducted, research method, research design, participant type and size, data collection tools used and keywords. The studies accessed through the Council of Higher Education Thesis Center were examined under relevant headings with frequency and percentage analysis. Relevant data were interpreted and evaluated with other studies in the literature. This study is important in terms of providing an overview of augmented reality applications in educational research at the graduate level. It reveals the current status of the field for new studies to be conducted in this field and offers suggestions for researchers to address the subject in more original dimensions. As a result of the study, it was seen that augmented reality applications were concentrated especially in the field of natural sciences, mixed method was mostly used as a research method and experimental studies were conducted, and the target audience was mostly secondary school level.

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Introduction

Rapidly evolving technological tools, which are increasingly prevalent in every aspect of our lives, are also gaining more ground in the field of education day by day. However, the effectiveness of these technological tools in the educational process depends on educators possessing the knowledge and skills to effectively integrate these technologies (Çetinkaya-Aydın & Çakıroğlu, 2019; Kaya et al., 2023). Rather than directly incorporating technology

into education, it should be associated with a learning model, approach, or method (Akgündüz, 2019). In recent years, research on educational technologies has been among the leading trends in educational sciences. This development is driven by the acceptance of new opportunities offered by technology for learning and teaching by educators (Erbaş & Demirer, 2015). Designing learning and teaching processes in a student-centered manner and providing students with opportunities for thinking, questioning, researching, and applying are considered fundamental features of modern educational systems (Adıgüzel & Kırmızıoğlu, 2019). Due to their supportive capabilities for these fundamental processes, educational technologies are increasingly gaining importance in educational processes. Especially during the Covid-19 pandemic, educational technologies have become essential elements of the educational process rather than merely supportive tools. All these developments have also enhanced research trends towards maximizing the utilization of current technologies in education. However, it is essential to recognize that the meaningful impact of educational technologies can only be achieved when both components, education, and technology, are used together (Akgündüz, 2019). Therefore, it is crucial to examine the educational effects of technological developments before integrating them into educational processes. In this regard, it is essential to examine the process leading to the use of this technology in education before looking at the applications of augmented reality technology in educational processes.

Advancements in technology have also led to the emergence of new approaches in learning theories. One of these is Mayer's (1998) cognitive theory of multimedia learning. This theory offers principles on how learning occurs in multimedia environments. Mayer (1998) broadly defines multimedia as the presentation of information through text and pictures. Mobile learning and cognitive load theory, associated with multimedia learning theory, are among the important theories used in studies where technology and education are combined in recent years. Mobile learning is defined as the educational use of mobile devices (Keegan, 2005). Cognitive load theory consists of elements forming human cognitive architecture, long-term memory, and working memory (Mousavi et al., 1995). According to cognitive load theory, meaningful learning requires reducing extraneous cognitive load, increasing effective cognitive load, and balancing intrinsic cognitive load. Therefore, all these theories and models are crucial in the process of integrating augmented reality technology into education.

Augmented reality applications are fundamentally based on simulation technology. Therefore, augmented reality applications are a subtype of simulations used in education, theoretically. The roots of this technology date back much further compared to augmented reality. Simulations, also known as modeling in educational sciences, describe how a system develops in certain situations, while models represent a set of rules representing the behavior of a system (Namdar, 2019). Simulation has long been used in education. For example, in the past, a baby model was created for heart massage for babies, but these models have been replaced by simulations. With the advancement of technology, simulations prepared in computer environments have emerged. Simulations should not be directly defined as scientific models (Namdar, 2019). However, there are opinions in the literature that argue against this view. Akgündüz (2019) defines simulations as modeling systems that provide the same outputs for all real inputs, cheaply and easily.

Through simulations, training is provided in a simulator rather than directly in a real tool. The simulator simulates the training content of any lesson, giving similar feelings to real experiences. Simulations used in education enrich teaching. Moreover, they allow difficult and dangerous situations to be repeated safely, accessibly, and economically. For example, conducting a dangerous science experiment using conventional methods may pose significant safety risks and may not be economical. Or impossible situations such as the fission of an atom can be made visible through simulations. Therefore, simulations have been used in educational processes for many years. Of course, developments in technology have also created development and transformation on simulations. In this context, simulation development software and tools, as well as the variety of devices operated by using simulations, have increased.

Augmented reality (AR) is achieved by adding a digital layer onto real-world images. AR is a technology where computer-generated sound, video, graphics, barcodes, and GPS location information are combined with the real world (Zachary et al., 1997). AR applications have interesting, entertaining and learning facilitating effects (Nizam & Öner-Armağan, 2023). AR applications are used to actively engage students in the learning process and facilitate their meaningful learning. The use of augmented reality in education is noteworthy for providing learners with enriched, enjoyable learning environments, promoting knowledge and experience sharing among students, facilitating collaboration, increasing

motivation, and providing experiential learning environments. The advantages of augmented reality, as stated by Akçayır and Akçayır (2017), are as follows:

- Increases learning success and motivation
- Positive attitude promotes high satisfaction and trust
- Reduces cognitive load
- Improves spatial ability
- Increases the level of participation and interest
- Provides co-operative learning environments for students
- Facilitates communication between student and teacher
- Encourages individual learning, learning by doing
- Combines physical and virtual worlds
- Enables multi-sensory learning
- Allows students to receive information quickly
- Increases student-student, student-teacher, student-material interaction
- Provides visualisation of invisible concepts, events and abstract concepts
- AR is easy to use for students, reduces the cost of training.

The recent intense interest in AR applications has caused studies with similar content and purposes to be seen frequently. In this context, our study is important in terms of showing researchers the current status of AR applications in postgraduate theses and allowing more original studies to be conducted in the subject area.

Looking at the research trends in the international literature on augmented reality technologies in recent years, education (Kaya et al., 2023), medical education (Menon et al., 2022), tourism (Diamante, 2023), sports sciences (Doskarayev et al., 2023) When the subject areas of the studies are examined, it is seen that augmented reality applications are used as a supportive tool in subjects based on experimentation and observation in educational processes. Augmented reality applications make it possible to create knowledge actively and autonomously by providing information that students cannot access or may be missing, thus facilitating practical learning (AlNajdi et al., 2020). It is seen that studies in the fields of medical education, engineering and science education and movement-based sports have gained intensity and experience-based applications have gained intensity in the field of tourism.

Since augmented reality is a new topic in the scientific field, it is important for future studies to know which studies, which methods, techniques and target group have been studied in the field. When the international literature is examined, many systematic review studies are found (Omarow, et. al., 2022). In this context, in our study, the topic of augmented reality in thesis studies conducted at the national level was examined by systematic analysis method. It is thought that the study will provide important contributions to those who will conduct research in this field in terms of the method, target group and scope of their studies.

Method

This study is a systematic literature review. A systematic literature review is a research method used to compile existing knowledge about a specific topic in a comprehensive and methodical way (Davis et al., 2014). This study was designed with a systematic literature review method in accordance with the research question and purpose as suggested by Snyder (2019). The steps of "designing the literature review", "implementing the literature review", "analyzing the selected articles" and "writing the results" were followed in order, taking into account the stages identified by Snyder (2019).

Data Set and Database Selection

The researches used in this study were accessed through YÖK national thesis center. The information obtained was collected under subheadings using spreadsheets in the augmented reality thesis screening form created by the researchers. The coding of the subheadings of the study is as follows:

- Year of publication of the studies,
- Type of studies,
- The written language of the studies,
- The university where his work was done,
- The area where the work is being carried out,
- The research method preferred in the studies,
- Preferred research design in the studies,
- Participant type and size of studies,
- Data collection tool used in the studies,
- The keywords used in the studies were determined as keywords.

Inclusion / Exclusion (Elimination) Criteria

In the research process, the studies conducted between 2010 and 2023, which included the word augmented reality in the title or abstract field, were scanned in the detailed search section of the electronic site of YÖK National Thesis Center. As a result of the search, 278 theses were found. This search was limited to the field of education and training. Among the theses that emerged as a result of the search, 135 theses in the field of education and training were examined within the scope of the study.

Data Analysis

As a result of the review, descriptive analysis method was used to examine the studies. Descriptive analysis is a research method used to obtain summary and systematic information about the phenomenon or phenomena (Büyüköztürk et al., 2008). In this framework, the research includes the analysis of augmented reality applications according to learning and teaching practices studies using descriptive analysis method. The data obtained were tabulated as frequency (f) and percentage (%).

Findings

This section presents the findings obtained from the documents analyzed according to the research questions related to augmented reality. The findings are presented under created subheadings.

The Findings Regarding the Distribution of Studies by Publication Years

The distribution of theses according to the years they were conducted was examined within the scope of the research. The distribution of studies on AR by years is shown in Table 1.

Table 1. Distribution of studies by years

Year	*Master's*	*Doctoral*	*Total*	
	f	*f*	*f*	%
2013	0	1	1	0.74
2014	1	1	2	1.48
2015	1	2	3	2.22
2016	5	2	7	5.19
2017	3	3	6	4.44
2018	12	2	14	10.37
2019	24	3	27	20.00
2020	10	1	11	8.15
2021	7	1	8	5.93
2022	17	5	22	16.30
2023	25	9	34	25.19
Total	**105**	**30**	**135**	**100.00**

Upon examination of the table, it is observed that there were no AR theses in the field of education and teaching between 2010 and 2013. When the data is examined, there is an increasing trend in this field with each passing year. Although there was a decrease between 2020-21, which were most affected by the Covid-19 process, the number of studies has continued to increase each year. This situation is clearly shown in Figure 1.

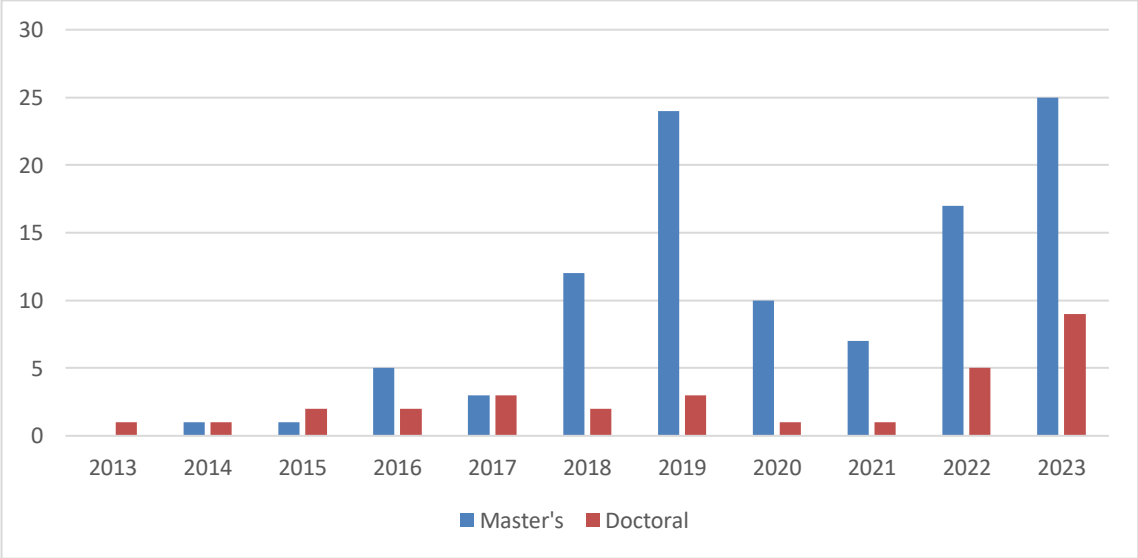

Figure 1. Changes in studies by years

Upon examination of the data, it is observed that the highest number of studies were conducted in 2023 (%25.19). This trend indicates that AR is becoming an increasingly important subject area in education and teaching in Türkiye. The number of studies conducted at both doctoral and master's levels has increased, except for the years affected by

Covid-19. The decrease in 2020-21 may be attributed to the fact that AR studies were more experimental, and there was a suspension of face-to-face education during these years.

The Findings Regarding the Types of Theses

The distribution of theses according to the types of publications they were conducted was examined within the scope of the research. The distribution of studies on AR by theses type is shown in Figure 2.

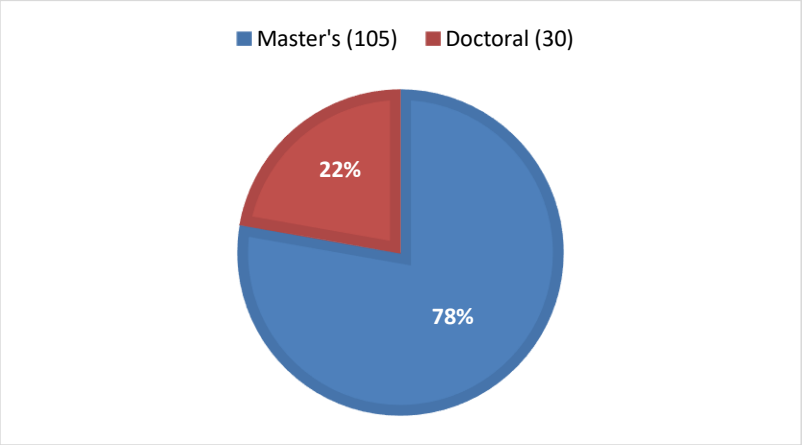

Figure 2. Values of studies according to theses types

Upon examination of Figure 2, it is observed that out of the 135 theses conducted, 78% were at the master's level and 22% were at the doctoral level. Accordingly, out of the total 135 thesis studies, 105 were master's theses and 30 were doctoral theses. As a result of the evaluation, it was determined that the most studied publication type in the field of AR was a master's thesis. Factors such as the lengthy doctoral process and the application-oriented nature of AR, which requires preparation, are thought to contribute to the lower number of doctoral theses and the higher number of master's theses.

The Findings of the Studies Regarding the Publication Language

The distribution of the theses examined within the scope of the research was examined according to the language of publication. The distribution of studies on AR according to publication language is shown in Table 2.

Table 2. Distribution of studies according to publication language

Publication Language	Master's		Doctoral		Total	
	f	%	*f*	%	*f*	%
Turkish	99	94.29	25	75.00	124	91.85
English	6	5.71	5	25.00	11	8.35
Total	**105**	**100.00**	**30**	**100.00**	**135**	**100.00**

According to Table 2, it is observed that the publication language of thesis studies on augmented reality is distributed as Turkish (91.85%) and English (8.35%). Out of the 105 studies conducted at the master's level, 99 were in Turkish and only 6 were in English. When examined proportionally, while the percentage of English studies at the master's level is 5.71%, it increases to 20% at the doctoral level. Out of the 30 studies conducted at the doctoral level, 25 were in Turkish and 5 were in English.

The Findings Related to the Universities where the Studies were Conducted are as follows

The distribution of thesis studies conducted at universities examined within the scope of the research has been analyzed. The distribution of studies conducted at universities about AR is presented in Table 3.

Table 3. Distribution of studies according to the universities where they were conducted

University	*f*
Gazi University	16
Atatürk University	15
Eskişehir Osmangazi University, Necmettin Erbakan University, Orta Doğu Teknik University	5
Anadolu University, Çanakkale Onsekiz Mart University, Van Yüzüncü Yıl University	4
Afyon Kocatepe University, Burdur Mehmet Akif Ersoy University, Erciyes University, İstanbul University – Cerrahpaşa, Muğla Sıtkı Koçman University, Niğde Ömer Halisdemir University, Bartın University, Erzincan Binali Yıldırım University	3
Abant İzzet Baysal University, Akdeniz University, Aksaray University, Ankara University, Fırat University, Trakya University	2
Ankara Hacı Bayram Veli University, Aydın Adnan Menderes University, Balıkesir University, Bursa Uludağ University, Çukurova University, Düzce University, İnönü University, İstanbul Aydın University, Karamanoğlu Mehmetbey University, Kırşehir Ahi Evran University, Kilis 7 Aralık University, Pamukkale University, Zonguldak Bülent Ecevit University, Ankara Yıldırım Beyazıt University, Başkent University, Boğaziçi University	1

Upon examining Table 3, it can be observed that thesis studies on AR conducted in the field of education in Türkiye between 2010 and 2023 were carried out in 56 different universities. Considering that there were 208 universities in Türkiye as of 2023 (CHE, 2024), it can be concluded that AR studies were conducted in every four universities. The university with the highest number of studies on AR is Gazi University (f:16), followed by Atatürk University (f:15).

The Findings Regarding the Fields in which the Studies were Conducted

The distribution of thesis studies according to the fields in which they were conducted was examined within the scope of the research. The distribution of studies conducted on AR is shown in Table 4.

Table 4. Distribution of studies by field

Field	*f*	%
Natural Sciences	58	42.96
Mathematics	14	10.37
Computer Education and Technology	12	8.89
Foreign Language Teaching	9	6.67
Turkish Language Teaching	8	5.93
Preschool Education	7	5.19
Social Studies	7	5.19
Special Education	4	2.96
Geography Education	4	2.96
Music Education	4	2.96
Analysis of Academic Studies	3	2.22
Health Sciences	2	1.48
History Education	2	1.48
Tourism Education	1	0.74
Total	**135**	**100.00**

When Table 4 is examined, it is observed that the majority of thesis studies conducted in the field of education in Türkiye between 2010 and 2023 were in the field of Natural Sciences (f: 58, %42.96). This is followed by Mathematics (f: 14, %10.37) and Computer Education and Technology (f: 12, %8.89) fields.

Findings Regarding the Preferred Research Method in Studies

The distribution according to the preferred research method in thesis studies examined within the scope of the research has been analyzed. The distribution according to the preferred research method in studies conducted on AR is shown in Table 5.

Table 5. Distribution according to the preferred research method in studies

Method	*f*	%
Mixed	62	45.92
Quantitative	51	37.77
Qualitative	13	9.62
Not Specified	9	6.66
Total	**135**	**100.00**

When Table 5 is examined, it is seen that the mixed method (f: 62, %45.92) is the most preferred research method in the thesis studies conducted on the AR subject in the field of education in Türkiye between the years 2010-2023. This is followed by the quantitative method (f: 51, %37.77) and the qualitative method (f: 13, %9.62).

Findings Regarding Preferred Research Designs in Studies

The research designs used in the thesis studies examined in the research have been analyzed.The distribution of preferred research designs in studies on AR is shown in Table 6.

Table 6. Distribution of preferred research designs in studies

Design	*f*	%
Experimental	85	62.96
Descriptive	7	5.19
Design-based	7	5.19
Case Study	6	4.44
Convergent Parallel	3	2.22
Embedded	3	2.22
Action Research	3	2.22
Meta-analysis	2	1.48
Inter-subject Multiple Probe	2	1.48
Document Analysis	2	1.48
Phenomenology	1	0.74
Not Specified	14	10.47
Total	**135**	**100.00**

Upon examining Table 6, the most used research design in thesis studies conducted on AR in the field of education in Türkiye between 2010 and 2023 is the experimental design (f:85, %62.96). This is mainly because AR studies often involve examining the effects of a developed material on educational processes. Studies based on a developed product also tend to prefer experimental designs. In some studies, the design of the study was not specified, while in others, it was indicated that multiple designs were used.

Findings Regarding the Type and Size of Participants in the Studies

The distribution of the type and size of participants in the studies examined in the research was analyzed. The data obtained in this context are presented in Table 7.

Table 7. Distribution of the type and size of participants in the studies

Sample Type	Sample Size (*f*)			
	<30	**31-100**	**>101**	**Total**
Preschool	2	4	-	6
Primary School	2	8	2	12
Middle School	8	43	9	60
High School	1	10	4	15
Associate Degree	-	2	2	4
Undergraduate	4	11	5	20
Master	1	-	-	1
Special Education	1	-	-	1
Teacher	6	1	-	7
Total	**25**	**79**	**22**	**126**

When Table 7 is examined, it is observed that in the thesis studies conducted on AR in the field of education in Türkiye between 2010-2023, most participants were studied at the middle school level (f:60). This is followed by undergraduate level (f:20) and high school level (f:15). Considering the sample size, it is seen that sample sizes in the range of 31-100 (f:79) were mostly preferred. This is followed by studies with sample sizes smaller than 30 (f:25). In some studies, the sample and sample size of the study were not specified. Studies that conducted document review were not included in this analysis.

Findings Regarding the Data Collection Tools Used in the Studies

The distribution according to the data collection tools used in the thesis studies examined within the scope of the research has been analyzed. The distribution according to the data collection tools used in the studies on AR is shown in Table 8.

Table 8. Distribution according to the data collection tools used in the studies

Research Tool	***f***	**%**
Test	93	32.86
Scale	86	30.39
Interview	61	21.55
Survey	14	4.95
Assessment Form	8	2.83
Observation	5	1.77
Focus Group	4	1.41
Checklist, Dairy, Document Analysis	3	1.06
Rubric	2	0.71
Video	1	0.35
Total	**283**	**100.00**

When Table 8 is examined, it is observed that the most used data collection tool in the thesis studies conducted on AR in the field of education in Türkiye between 2010 and 2023 is the test (f:93). These tests were used under different names such as academic achievement test, retention test, and knowledge level test. The second most used data collection tool is the scale (f:86). Again, various scales were used to measure different criteria according to the purpose of the research. Among these, attitude and motivation scales stand out the most. Other prominent data collection tools include interviews (f:61) and surveys (f:14). Since multiple data collection tools were used in many studies, the total number of data collection tools exceeds the number of research studies. As a mixed method approach was predominantly used in the analyzed studies, both quantitative and qualitative data collection tools were mostly utilized.

Findings on the Keywords Used in the Studies

The keywords used in the thesis studies examined within the scope of the research were analyzed. Keywords used in studies on AR are shown in Table 9.

Table 9. Distribution according to keywords used in studies *

Keywords	*f*	Keywords	*f*
Augmented reality	145	Mobile Augmented reality	4
Academic achievement	28	Spatial ability	4
Attitude	23	Concept Misconception	3
Motivation	18	Collaborative learning	3
Success	16	Instructional technologies	3
Science teaching	12	Permanence	3
Mobile learning	10	Systems in our body	3
Mathematics education	10	Solar System	3
Science Education	8	Spatial intelligence	2
Science	7	Physics teaching	2
Virtual reality	6	Music Education	2
Multimedia	5	Scientific process skills	2
Social studies	5	Astronomy	2
Preschool education	5	Particle Structure of Matter	2
Cognitive load	5	Metaverse	2
Mixed Method	4	Anxiety	2
Elementary school	4	Geography teaching	2
Mobile application	4	Action research	2

** Due to the large number of keywords with a frequency value of one (f:1), they have not been transferred to the table.*

When Table 9 is examined, it is observed that the term "augmented reality" (f:145) is the most used keyword in thesis studies conducted in the field of AR in education in Türkiye between 2010 and 2023. This is followed by "academic achievement" (f:28) and "attitude" (f:23). Particularly noteworthy is the abundance of terms used in the field of science education.

Discussion and Conclusion

It is known that augmented reality and virtual reality applications have been used in the scientific world since the 1980s. When the literature is examined, studies in these areas have gained momentum in recent years. Especially since 2010, an increase in the number of studies in this field has been observed. This can be attributed to the rapid pace of technological development, increased accessibility to relatively expensive technologies, and the availability of content development tools. As technology advances, it becomes possible for the number and quality of studies in these areas to increase.

In recent years, there has been an increase in studies on augmented reality in the field of education. The scope of the study is to examine thesis studies conducted in the field of education in Türkiye between 2010 and 2023. The first result obtained is that there were no

thesis studies in the field of education between 2010 and 2013. Considering the time required for the preparation and presentation of thesis studies, a three-year gap between the first journal articles in the field and thesis studies is considered normal. Between 2013 and 2018, the number of theses published in the national thesis center was 33, while in 2019 alone, the number of published theses was 27. The number of theses prepared in almost one year is equivalent to the number of theses published in previous years. This is an indicator of how current the subject is. Despite a decrease between 2020 and 2021 due to the impact of Covid-19, there has been a resurgence in research numbers as of 2022, when the quarantine period ended. When the number of studies is examined by year, the highest number was reached in 2023. This indicates that the interest in the field of augmented reality continues to increase.

Another result obtained from the study is that the number of master's theses in academic theses is higher than the number of doctoral theses. This result is expected due to the shorter duration of master's theses and the significantly higher number of master's students compared to doctoral students. When the findings of the research are examined more carefully, it is observed that the proportion of doctoral studies has started to increase in recent years. In the literature, Sünger (2019) conducted a content analysis study on the concept of augmented reality and examined the theses in the national thesis center until 2018. According to Sünger's study, the proportion of master's theses was 80%, while doctoral studies constituted 20%. This finding supports the current study. Altınpulluk (2018) also reached a similar conclusion in his study. Between 2010 and 2023, the proportion was found to be 78% for master's theses and 22% for doctoral theses. The percentage of doctoral studies is increasing day by day.

When the publication language of the studies is considered, it is evident that the publication language is mostly Turkish. This is mainly due to the rule of the Council of Higher Education (CHE) requiring Turkish thesis writing in programs where the language of instruction is Turkish. Therefore, researchers who use English as the publication language are mostly from universities such as Middle East Technical University and Hacettepe University. It is known that these universities generally offer undergraduate programs in English. Therefore, the language of instruction at the undergraduate level affects the publication languages researchers use in their academic studies.

When the universities where the studies were conducted are considered, it is seen that the highest number of theses were prepared at Gazi University. Similar studies supporting

this result can be found in the literature (Sünger, 2019). Gazi University is one of the oldest educational institutions in Türkiye. Its long-standing master's and doctoral programs, especially in Educational Sciences and Computer Education and Technology departments, have had a significant impact on this result. Another university that stands out in terms of the number of theses compared to other institutions is Atatürk University. In total, thesis studies on augmented reality were conducted at 56 different universities. This number reveals the conclusion that augmented reality is studied in education at one out of every four universities.

When considering the disciplines in which the studies were conducted, it emerges that the theses were mostly prepared in the field of natural sciences (f:58), followed by Mathematics and Computer Education and Technology (BÖTE) fields. There are studies in the literature that support this result (Akçayır, 2018; Kara, 2018; Küçük-Avcı, 2018; Sünger, 2019). Particularly in recent years, there has been a concentration of studies in the field of natural sciences in technology-based education. The possibility of teaching both micro and macro topics in science education with a technology like augmented reality (Chiu et al., 2015) could be a concrete reason for this. When examining the studies conducted, it is noticeable that there is a concentration in similar subject areas within the field of natural sciences. This situation creates a disadvantage in understanding the impact of AR applications on educational processes. At this point, researchers working in the field of AR need to be more careful in selecting the subject area to conduct original and valuable research.

The most preferred research method in the studies is found to be the mixed method. Following that, quantitative studies and qualitative studies are preferred. Altınpulluk (2018) reached a similar conclusion supporting this finding. In the literature, Sünger (2019) conducted studies indicating that applied methods are more commonly used, while Kara (2018) and Akçayır (2018) conducted studies showing that quantitative methods are more commonly used. Some studies reach the conclusion that there are more quantitative studies in article studies (Altınpulluk, 2018). Since thesis studies are longer-term research compared to article studies, it is considered natural for researchers to prefer the mixed method, which includes both qualitative and quantitative processes.

When examining the research designs used in the studies, it is seen that experimental studies stand out by a large margin. Almost two out of every three thesis studies prefer the experimental method. There are studies in the literature supporting this situation (Kara,

2018; Sünger, 2019). Considering the applied nature of AR studies, it is natural for the studies to be experimental.

When the type of participants is examined, it is found that middle school students are the most common participants, and when the number of participants is examined, it is found that there are the most studies in the range of 31-100 participants. This result is consistent with past studies. In his study, Sünger (2019) found that most of the sample group consisted of K-12 students and ranged from 31-100. Another study by Kara (2018) stated that the sample group of research consisting of theses and articles was mostly at the undergraduate level, and the sample size ranged from 31-100. This result is consistent with the research design. However, the problem in the disciplines where the studies are conducted persists here as well. There is a significant clustering of middle school students in the type of participants. Concentrating on the same discipline and subject area in studies conducted with this group also creates problems regarding originality.

Another result obtained from the research is that the most used data collection tools in the studies are tests, scales, and interviews. Considering that the most preferred method used by researchers is mixed and quantitative methods, it is natural for this result to emerge. In the literature, Sünger (2019) found that interviews were the most used data collection tool, while Kara (2018) found that scales were the most commonly used quantitative data collection tool and interviews were the most commonly used qualitative data collection tool. The use of tests and scales is extremely common in experimental educational studies. These two data collection tools are widely used to analyze the effects of experimental processes. The research design of the examined studies, focusing on experimental studies and many of them collecting qualitative data with mixed methods, has highlighted interviews as the third data collection tool. It has been observed that the tests used are in different names such as academic achievement, retention, knowledge level, etc. Scales, on the other hand, especially stand out with attitude and motivation scales compared to other scales.

It has been concluded that the most prominent keywords in the theses examined in the study are augmented reality, academic achievement, attitude, and motivation. The emergence of this result is expected because of searching the national thesis center with the keyword "augmented reality". However, the other two keywords reveal which factors researchers focus on with AR applications. Accordingly, it is observed that the effort to investigate the possible positive effects of AR applications on academic achievement,

attitude, and motivation stands out. In a study conducted by Sünger (2019), it was found that the variables most used were academic achievement and attitude, and the most used keywords were augmented reality, science education, and academic achievement.

These studies are of great importance for the widespread use of AR applications in education. Like all other educational technology opportunities, AR harbors great opportunities as well as significant limitations. In this context, studies need to consider every stage of integration of AR applications into the educational process. Similar subject areas, similar types of participants, and similar keywords indicate that researchers are concentrating too much on a limited area of AR applications. In this context, our research will provide an important starting point for new studies in this field. Many components such as accessibility of AR applications in classroom activities, time usage, dimension of equal opportunity, time, cost, and availability of trained human resources for content development, teachers' attitudes and readiness levels towards AR applications, integration of AR applications into educational programs, national and international AR repositories, copyright issues, accessibility, cost, and procurement status of technical equipment on which AR applications depend, will affect AR applications.

AR applications are known to have positive effects on student achievement (AlNajdi et al., **2**020). Due to the opportunities it creates, studies in this field are increasing. Since it is a new educational practice, it is seen that the studies are mostly conducted in a theoretical framework due to the experimental and scientific basis. Although there are many studies in the field of medical education in the international literature (Menon et al., 2022), the limited number of studies (Djibril, 2022; Küçük, 2015) on this target group and scope in national thesis studies stands out. In addition, the fact that many studies are repetitive in terms of both subject area and content reveals that the results of the research will have an important contribution for future research.

Recommendations

The theses uploaded to the national thesis center in Türkiye between 2010-2023 were taken as reference within the scope of the research. Article studies conducted in this context should also be considered for the analysis of developments in the field of AR at the national level.

It is observed in the analyses that studies on AR often concentrate on similar subject areas in natural sciences. It is thought that researchers can make AR applications more original with studies conducted in different disciplines.

It is observed that AR applications consist mostly of experimental studies. It is recommended to develop studies in theoretical modeling of AR applications, what can be done for widespread use in educational processes, education planning and cost dimensions, creation of AR repositories, etc., in terms of education planning and management dimensions.

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Author Contribution Statement

Ulaş YABANOVA: *Conceptualization, literature review, data curation, methodology, implementation, data analysis, original draft, language editing, organization, and writing.*

İsmail SATMAZ: *Conceptualization, literature review, data curation, methodology, implementation, data analysis, original draft, language editing, organization, and writing.*

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