

# **Augmented Reality within the Past Five Years in Turkey: A Systematic Review**

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## **Abstract**

This study provides a systematic review of the literature on augmented reality (AR) focusing on the last five years in the Turkish context. Web of Science was used as the database. ‘Augmented reality’, ‘Turkey’ or ‘Turkish’, ‘Education Educational Research’ were applied as search parameters. The results were limited within the past five years (between 2018 and the first seven months of 2022). During the first run of the search 54 studies appeared, however, when analysed closely, it was found that five of those studies did not meet the search criteria. Hence, this study synthesises a set of 49 studies. Qualitative content analysis is adopted to investigate the general view of augmented reality research in Turkey. The studies were analysed based on the changes by years, fields that they were conducted in, methods that were used, and the aspects that they focused. The findings suggest that 2019 was the year with the most publications. Another finding of this systematic review was that almost %40 of the publications among the given parameters were in the Science field. When it comes to the methods, it seemed that the quantitative research method was the most popular among the analysed publications. It was interesting to see that most of the studies focused on investigating the effectiveness of AR in spite of the vastness of the studies claiming its benefits. This study encourages researchers to investigate more about different aspects of AR such as how to decrease if not fully overcome the barriers that AR users face or how to integrate AR better to the current teaching-learning process in order to enhance the learning experiences. This study also invites researchers to adopt different research methods than mere quantitative ones in order to have a deeper understanding of AR in educational use.

**Keywords:** Augmented reality, Education, systematic review, trends, content analysis

## **1. INTRODUCTION**

In the 21st century, the impact of technology on all facets of life cannot be denied. Like all other disciplines, technology has also permeated the field of education. The inclusion of technology in education “is not an issue anymore but it is like a dream coming true” (Mulyati, 2022, p. 73). One of those most innovative technologies used in education is Augmented Reality (AR). Augmented Reality has been discussed, investigated, and practiced for more than seven decades now. Yet, there is no consensus regarding its definition.

However, Azuma's (1997) definition is the mostly accepted and cited one. Azuma (1997) conceptualises AR as a variation of Virtual Reality (VR), which is a technology allowing the user to be fully immersed in a synthetic environment. Differently from VR, AR brings together the virtual world with the real one and allows those two to interact. Hence, instead of creating a barrier between the user and the real world, AR supplements reality. In this regard, AR can be defined as a technology that offers local virtuality by integrating virtual objects into the real world and allows the user to interact with them in real time.

The birth of AR dates back to second half of the 20<sup>th</sup> century. AR first appeared in the field of cinematography in the 1950's (Carmigniani and Furht, 2011). Since then, it has been used in numerous fields such as medicine (Eckert, Volmerg, and Friedrich, 2019; Ha and Hong, 2016), engineering (Menezes, Chouzal, Urbano, and Restivo, 2016; Pejić, Rizov, Krasić, and Stajić, 2014), military training (Urban, 1995), aircraft manufacture (Sims, 1997), and architecture (Tonn, Petzold, Bimber, Grundhöfer, and Donath, 2008; Wang, 2009). As AR technology has abundant benefits such as increasing students' motivation and attention (Khan, Johnston, and Ophoff, 2019; Estapa, and Nadolny, 2015), it has gained educational researchers' attention.

Currently, the education field seeks innovative teaching methods. This is because the interest is now on the methods that may help enhancing the learner experience as well as academic achievement. Martín-Gutiérrez et al. (2015) advocate that Information and Computer Technologies (ICT) have recently improved tremendously and contributed to educational tools. During the past few years, ICTs have been actively and effectively integrated into all levels of educational institutions from K12 to tertiary levels. Many higher education institutions have already adopted Virtual Learning Environments (VLEs) not only to help the teaching-learning process but also to increase learner motivation. Investigating that trend, several studies demonstrated that VLEs were accepted quickly and happily (Pan, Cheok, Yang, Zhu, and Shi, 2006; Barker and Gossman, 2013). Considering this fact, many educators and researchers eagerly focus on innovative methods to improve the current methods.

According to Martín-Gutiérrez et al. (2015, p. 752), AR is "one of the most promising technologies that currently exist". As the literature also suggests, integrating AR into the teaching-learning process has myriad benefits. Increasing motivation (Chang et al., 2014; Iwata, Yamabe, and Nakajima, 2011; Zhang et al., 2014), attention (Kamarainen, 2013; Vate-U-Lan, 2012), concentration (Ibáñez et al., 2014; Iwata et al. 2011; Yen et al., 2013), and satisfaction (Martín-Gutiérrez, 2013; Redondo et al., 2013) are some of the numerous benefits of using AR in the educational settings. Moreover, several studies suggest that AR helps visualising the micro worlds such as in the case of a teacher explaining about photosynthesis or acid rain (Kamarainen, 2013) and teaching about microstructures such as the composition of substances (Cai et al., 2014) or macro worlds such as teaching solar system (Sin and Zaman, 2010).

Although integrating AR into educational settings has numerous benefits and seems promising, it comes with some limitations which hinder its widespread use. Wu et al. (2013) categorise the limitations of AR into three: technical, pedagogical, and learning issues. In terms of technical issues, some AR technologies require heavy equipment such as a backpack with a laptop and a head-mounted display. However, current developments not only in mobile technology but also in AR are bridging the gap toward portable AR (Van Krevelen and Poelman, 2010). Regarding pedagogical issues, integrating AR in educational settings could face some hindrances both at the teacher and institutional levels. Innovative approaches integrating AR generally involves studio-based and student-centred pedagogy. The nature of these new approaches is different from the traditional delivery-based, teacher-centred pedagogy. Moreover, some teachers stated their concerns about the inflexibility of the content that is provided by AR technologies (Kerawalla et al. 2006). When it comes to the institutional level, it might be challenging to deliver the syllabus within a certain time frame due to the exploratory nature of using AR technology in educational settings. Therefore, AR learning environment designers and researchers are urged to bridge the gap by providing support to teachers (Wu et al. 2013). Learning issues, in turn, involve students and their learning process. Being cognitively overloaded with learning to use several technological devices and having to accomplish complex tasks are some of the issues related to the learner and learning process (Wu et al., 2013). Students' confusion and losing sight of where the AR ends and the real environment starts can be listed as another limitation of AR from the learning issues aspect (Klopfer, 2008). Besides those limitations, privacy, safety, and ethical aspects of AR usage are also raised as concerns in the literature (Berryman, 2012).

## **1.2. Purpose of the Study**

Over the last few decades, AR technologies and their applications to education have burgeoned throughout various fields in Turkey as in the world. Consequently, several systematic reviews have been conducted to investigate the picture of AR usage in a Turkish context (Kapucu & Yıldırım, 2019; Korucu, Ustan and Yavuzaslan, 2016; Turhan, Metin and Ezberci-Çevik, 2022). Among those studies, the parameters of Kapucu and Yıldırım's (2019) review were the years between 2010 and 2018. They included both virtual reality and augmented reality in their search. The databases that they used were DergiPark, Google Academic, TUBITAK, and ULAKBIM. The aim of their study was to examine the studies conducted on VR and AR in education in Turkey. They analysed the studies based on their subject field, application field, research methods, data collection instruments, analysis methods, participants, and the year of the study. They found that the majority of the studies on VR and AR were predominantly conducted in computer education field.

Another systematic review conducted by Korucu et al. (2019) analysed 33 studies that were published between 2007 and 2016. Korucu et al. investigated the publication year, research trends, methods, aims, contents, contexts of the study that were performed on AR. The

findings revealed that the number of the studies increased in recent years. As their study did not focus only on the educational usage of AR, they also investigated in which sectors AR was used predominately. Yet, the results yielded that the studies related to AR was mostly published on the education sector among the shopping, storing, finance, communication, construction, art, sports and administration sectors. As for the topics that the studies focused, it seemed that analysing applications and review studies were the most popular ones.

In a very recent review (Turhan et al., 2022), in turn, 87 academic studies that were published in Turkish national journals between the years of 2012 and 2020 were analysed. In their review study, Turhan et al. (2022) analysed the AR studies using the parameters of publication year, aim of the study, field, research methods used, participants and instruments for data collection. The analysis yielded a discernible outcome indicating that the number of the studies increased each year. Differently than Kapucu and Yıldırım's (2019) results, Turhan et al. (2022) found that majority of the studies were conducted on the field of science education.

In order to identify the current trends, such studies should be conducted periodically (Turhan et al., 2022). One of the many other reasons to conduct review studies is to reveal which aspects of the field have been explored and how, and which aspects of the field need more attention (Hart, 1998). Considering the abovementioned points, the aim of the current study is to investigate the general view of AR in educational use in the past five years in Turkey. Differently from Turhan et al.'s (2022) review, this study uses Web of Science as a database rather than mere Turkish national databases. Given the aim, the following research questions are addressed:

**RQ1.** What is the distribution of the publications that focus on the educational use of AR in Turkey within the past five years?

**RQ2.** In which fields have the studies about the educational use of AR been conducted in Turkey?

**RQ3.** Which methods have been used in order to investigate the educational use of AR in Turkey within the past five years?

**RQ4.** What aspects of AR have been investigated in Turkey within the past five years?

## **2. METHODOLOGY**

Web of Science (WoS) was used as the literature source for the current systematic review. In WoS, several advanced search functions were applied in order to narrow down the focus. Those functions were year (last five years, i.e. between 2018 and 2022), field (Education Educational Research), and context (Turkey or Turkish). All types of documents (i.e. article,

book review, book chapter) were included. The last search was conducted on 4th of August, 2022. In the first round of the search, 54 publications were identified. When examined closely, it was seen that five of those publications were not eligible for the current study as four of them were neither written by Turkish researchers nor conducted in a Turkish context. Although one of those five ineligible studies was written by Turkish researchers, it did not specifically target the educational field, yet it was a general meta-analysis of AR application in the whole world. As the scope of that review study was too general for the current study's aim, it was excluded from the analysis. Hence, the initial analyses left 49 publications to examine (See the PRISMA chart below). Content analysis was adopted to analyse those 49 publications. The studies were analysed based on their publication years, the field that they focus, the methods that they use, and the aspects of AR that they investigate.

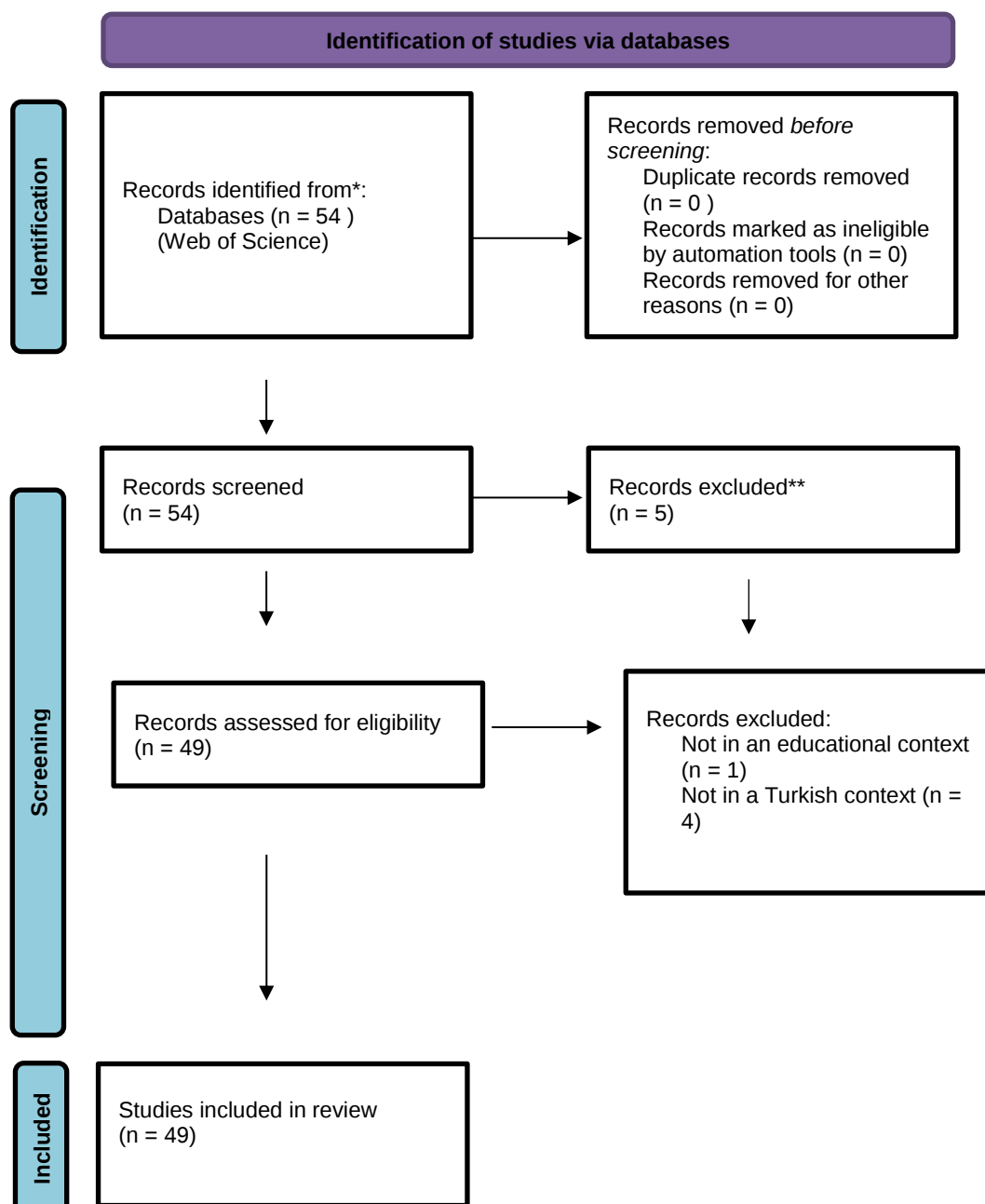


Chart 1: Identification of studies via databases

### 3. FINDINGS

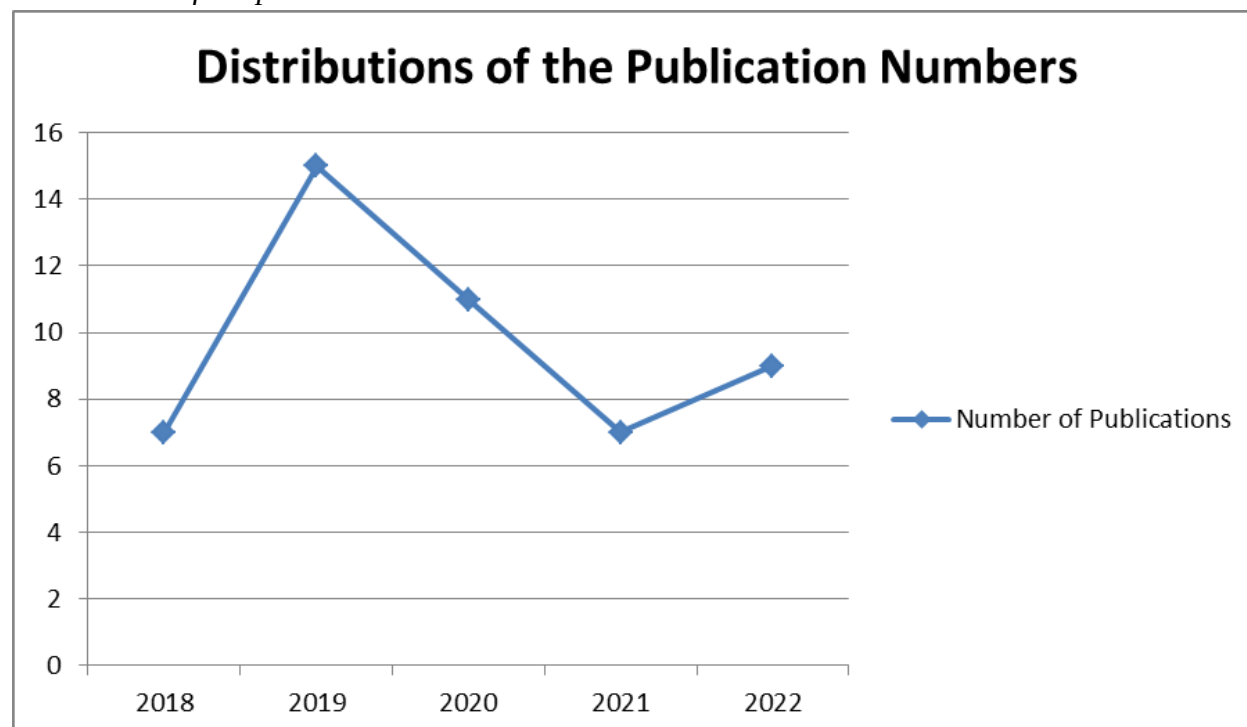
In order to have a general picture of the educational use of AR in Turkey, this systematic review has been conducted. In this regard, four research questions have been formulated. Those questions were set to investigate the change of the publications by year, the field that they were conducted, the methods that they used, and the aspects of AR that they focused. The research questions of this study have been analysed and answered below.

#### 4.1. Distribution of the studies according to the years

The first research question of this study is formulated as “What is the distribution of the publications that focus on educational use of AR in Turkey within the past five years?”. The distribution of the studies that are conducted in educational use of AR in Turkey between the years of 2018 and 2022 and listed in WoS is shown below:

Chart 2.

*Distribution of the publication numbers*



As shown in Chart 2, the number of the publications in 2018 and 2021 is equal ( $n=7$ ). The chart also shows that while the number of the publications hits a peak with 15 manuscripts in

2019, there are 11 publications in 2020. It is also identified that the number of the publications in 2022 shows a slight increase (n=9) compared to the previous year.

#### 4.2. Fields of the studies focusing on AR

The second research question was “In which fields have the studies about the educational use of AR been conducted in Turkey?”. The distribution of the field of the studies focusing on the educational use of AR for the past five years is shown below:

Table 1.

*Distribution of the field of the studies*

| Field of the study                              | 2018 | 2019                                  | 2020                           | 2021                 | 2022 | Total |
|-------------------------------------------------|------|---------------------------------------|--------------------------------|----------------------|------|-------|
| Archeology                                      |      |                                       | 1                              |                      |      | 1     |
| Architecture                                    |      |                                       |                                | 1                    |      | 1     |
| Business                                        |      | 1                                     |                                |                      |      | 1     |
| Computer Education and Instructional Technology | 1    | 2                                     |                                |                      |      | 3     |
| Education                                       | 2    | 5                                     | 1 (open and distance learning) |                      | 1    | 9     |
| English Language and Teaching                   |      |                                       |                                |                      | 2    | 2     |
| Geography                                       | 1    |                                       |                                |                      |      | 1     |
| Special Educational Needs                       | 1    |                                       |                                | 2                    |      | 3     |
| Science                                         | 2    | 4 (one in physics and one in biology) | 5 (one in physics)             | 4 (one in astronomy) | 5    | 20    |
| STEM                                            |      |                                       | 1                              |                      |      | 1     |
| Mathematics                                     |      | 3 (two in geometry)                   | 3 (geometry)                   |                      | 1    | 7     |

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The analysis of this systematic review shows that most of the studies are conducted in the Science field (n=20) which consist approximately 40% of all. Among those 20 studies, it was identified that two of them were in Physics, one of them was in Biology and another one was in Astronomy. When the studies focusing on the educational use of AR in the past five years are examined, it was seen that nine of them did not specify which branch of education that they conducted the studies on. With a number of seven publications, Mathematics followed Science (n=20) and Education (n=9) in general, when the number of the studies were ranked according to the fields. It was also seen that the number of the studies that are conducted in the Special Educational Needs and Computer Education and Instructional Technology between the years of 2018 and 2022 were the same, that is three. The table above shows that during the past five years, only two studies were conducted in English Language and

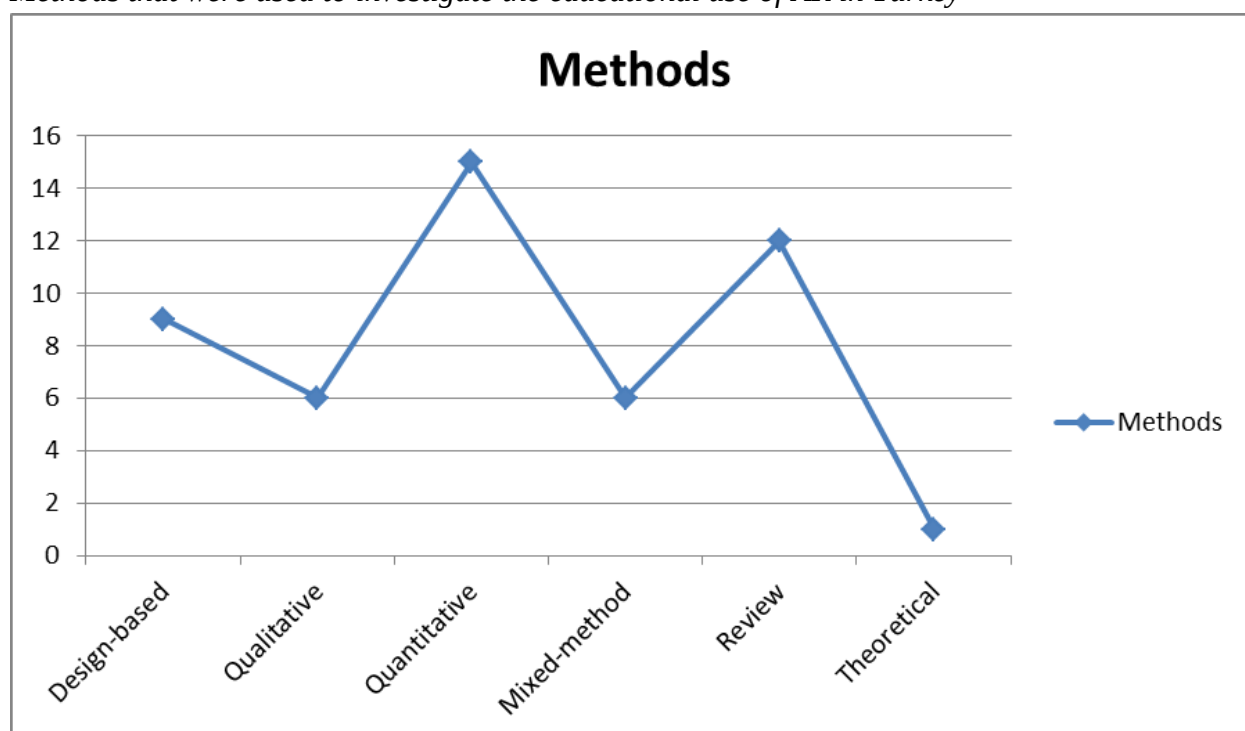
Teaching focusing on the educational use of AR. The table also shows that only one study each was conducted on the following branches: Archeology, Architecture, Business, Geography and Science, Technology, Engineering, and Mathematics (STEM). The study that was conducted on the STEM field did not specify which branch of STEM focused on (i.e. Science or Mathematics). Therefore, it was categorised separately.

#### 4.3. Methods used to investigate the educational use of AR in Turkey

The third research question of this study aimed to investigate the method trends in educational use of AR in Turkey. Answering the third research question, the chart above shows the distribution of the preferred methods to investigate the educational use of AR in Turkey in the past five years.

Chart 3.

*Methods that were used to investigate the educational use of AR in Turkey*



The chart above shows that most of the studies that have been conducted since 2008 in Turkey and indexed in WoS adopted a quantitative research method ( $n=15$ ). This number is followed by review studies ( $n=12$ ). The review studies included literature review ( $n=2$ ), meta-analysis ( $n=4$ ), systematic review ( $n=4$ ), bibliometric mapping analysis ( $n=1$ ), and book review ( $n=1$ ) studies. It is seen that nine of the studies that are conducted within the given criteria were design-based. The results also show that the number of the studies that adopted a qualitative method are equal to that of the studies that adopted a mixed-method research

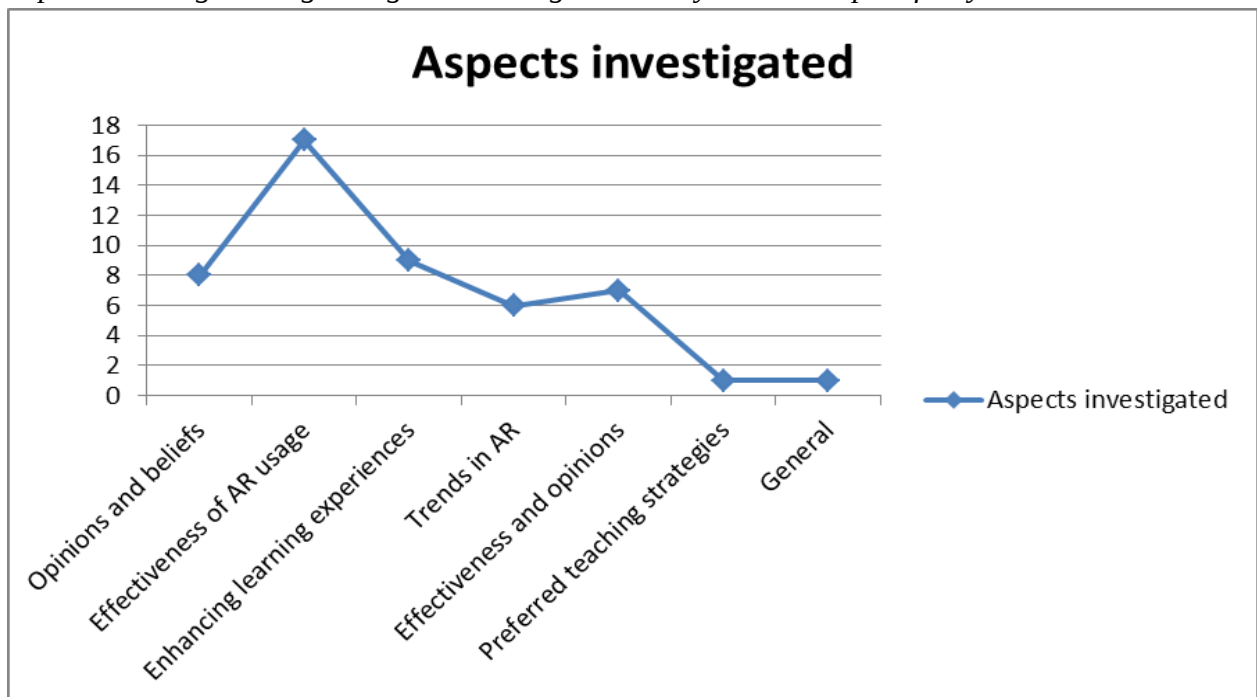
design (n=6). The chart above shows that only one theoretical publication, a book chapter, was identified when the given criteria were taken into consideration.

#### 4.4. Aspects of AR usage in Turkey within the past five years

The last research question of this study aimed to find out which aspects of AR were investigated in the past five years in Turkey. In this regard, the findings are presented below.

Chart 4.

*Aspects investigated regarding the AR usage in Turkey within the past five years*



The chart above demonstrates that most of the studies (n=17) that were conducted within the past five years and focused on AR in Turkey investigated the effectiveness of AR usage. When the chart is examined, it is seen that the theme of enhancing learning experiences was the second most focused theme (n=9) among the analysed publications. Next, it is followed by the studies focusing on investigating the participants' opinions, beliefs, and level of acceptance with a number of eight publications. Seven studies investigated both the effectiveness of AR usage and the participants' attitudes and opinions. It appeared that six of the studies that were conducted within the past five years investigated the trends in the educational usage of AR. There was only one study exploring the pre-service teachers' teaching strategies preferences. Similarly, only one of the studies' themes was general, which was in the form of a book review.

#### **4. DISCUSSION, CONCLUSION, AND RECOMMENDATIONS**

The aim of this systematic review was to analyse the existing literature exploring the educational use of AR in Turkey between the years of 2018 and 2022. In this regard, the distribution of the publication numbers according to the years, fields of the studies, methods that were used, and the aspects that were focused on were examined.

The findings suggest that although the numbers of the studies reached the peak in 2019 with a number of 15 publications, a decrease was observed for the following two years. The decline in the years following 2019 could potentially be attributed to the disruptive impact of the pandemic on academic research and scholarly pursuits across various fields, including educational technology, as Fernández-Batanero, Montenegro-Rueda, & Fernández-Cerero (2022) also rightfully suggest. The pandemic, characterised by widespread lockdowns, social distancing measures, and an abrupt shift to remote learning, has likely led to a reconfiguration of research priorities and methodologies in educational settings. Obstacles caused by the pandemic may have affected researchers' ability to conduct empirical studies, access resources, and engage with traditional data collection methods, thereby hindering the progress of AR-related research. However, it is important to note that there is an upward trend in the first few months of 2022. The resurgence of research activity during this period suggests the possibility of a resurgence or resurgence of interest and scholarly efforts regarding AR in education. It is reasonable to assume that AR-focused research may gradually increase in the foreseeable future as academic institutions and researchers adapt to the ongoing challenges of the pandemic. The increased momentum observed in the first seven months of 2022 may indicate an adaptive response within the academic community. This likely indicates a shift towards innovative methodologies, robust research frameworks, and a growing recognition of the importance of AR in educational settings despite ongoing challenges. Although the pandemic initially caused a setback and disruption of academic activity in AR-related educational research, a recent surge in academic contributions has revitalised interest in exploring the applications and contextual implications of AR in education. This resurgence provides an optimistic outlook and suggests that the trajectory of AR-related research in education will continue to increase in the near future.

The analysis results showed that AR is most commonly investigated and used in the Science field. That was not a surprising finding as it is in line with the existing literature (Altinpulluk, 2018; Amanatidis, 2022; Ekanayake and Gayanika, 2022; Saputri and Susilowati, 2022; and Tolba, Elarif, and Taha, 2022). These findings support the widespread perception that AR technology has attracted particular attention in the sciences. As Arici et al. (2019) claim that the field of science is a field of education where AR technology is primarily examined. This finding is consistent with the results of the current study. However, this claim and the results of the current study suggest that social sciences and other disciplines are underrepresented despite having potential growth opportunities. In particular, the social sciences are considered to have great potential for growth in the application of AR technology (Azi & Gunduz, 2020;

Toledo-Morales, & Sanchez-Garcia, 2018). This points to opportunities where the social sciences, as well as the humanities, arts, linguistics, and other fields of education, could benefit more from the potential of AR technology. At this point, there is a need for diversity and broadening the scope of educational research. It is important that various disciplines and fields are further explored and represented in order to understand the impact of AR technology in education and to improve its applications. This requires adopting a comprehensive and multifaceted approach to understanding the potential impact of AR in education and exploring how this technology can be used more effectively in various fields.

Another finding of this study suggests that quantitative research methods were predominantly used in order to investigate the educational use of AR in Turkey. This finding is consistent with that of Arici et al. (2019) who found that 81% of the articles published between the years 2013 and 2018 and were indexed in WoS adopted a quantitative method. The use of these statistical methods may be a result of the emphasis on research in the field of augmented reality. Although this rate decreases to % 52 according to Ozsari and Saykili (2020)'s results and to %50 according to Sirakaya and Alsancak-Sirakaya's (2020) results, this study encourages researchers to conduct studies adopting research methods other than quantitative ones in order to explore the AR usage in-depth from various perspectives. Qualitative research methods can be useful to gain a more detailed understanding of individual experiences, perceptions and participants' perspectives. Such approaches allow for a more comprehensive and in-depth assessment of the impacts and applications of AR technology in education. In this regard, future studies investigating the use of AR in educational contexts are expected to encourage methodological diversity and provide a more comprehensive and richer analysis using both quantitative and qualitative research methods. This could be an important step towards a deeper understanding of the role of AR technology in education and a more comprehensive assessment of its impact on learning processes.

Despite the increasing popularity of augmented reality (AR) technology in the context of education, it is noteworthy that there are still some hesitations in academic circles about the effectiveness of the technology. These hesitations give the impression of skepticism that is reflected in the studies. When the number of studies examining the effectiveness of AR and the number of studies evaluating participant views are analysed, it is observed that the studies focusing on participant views (%7) constitute almost half (%49) of the total studies, in addition to those focusing on evaluating the effectiveness of AR (%17). While this situation reflects the difficulty of making a clear evaluation on the effects of AR, it also emphasises the diversity of research in this field. Objectively assessing the effects of AR technology on learning processes shows that uncertainties still exist among researchers. However, there are many studies focusing on the various benefits of AR, which shows the potential of the technology. Research on increasing student motivation, improving academic achievement, and promoting self-directed learning in the learning process point to the positive effects of AR in education (Aydogdu, 2022; Çakıroğlu, Atabas, Aydın, & Ozyilmaz, 2022; Chiang, Yang, & Hwang, 2014; Cetin & Turkan, 2022; Contero & Lopez, 2013; Petrov & Atanasova,

2020; Ferrer-Torregrosa, Torralba, Jimenez, Garcia, & Barcia, 2015). These studies reveal the potential advantages of AR technology in education and its capacity to enrich learning experiences. However, current uncertainties about the effectiveness of the technology require further research and in-depth analysis. Further work in this area can contribute to understanding the role of AR in education and developing a clearer understanding of how the technology can be integrated most effectively and efficiently.

The integration of augmented reality (AR) technology into educational environments brings with it various advantages as well as some challenges. These challenges appear as factors that limit the use of the technology and cannot be ignored. Firstly, logistical limitations, such as hardware and software issues, can hinder the effective use of AR. Such technology-related infrastructural challenges are among the major obstacles that educational institutions and users may face. However, the lack of adequate qualified personnel or technical support can also hinder the diffusion of AR. The use of AR may depend on the availability of specialised people in educational institutions who can effectively integrate this technology. In addition, students' cognitive overload is an important problem encountered in the integration of AR technology into educational processes (Dunleavy, Dede, & Mitchell, 2009). The complexity of the technology and its intensity in the learning process may distract students or cause them to experience excessive fatigue. Difficulties in social acceptance are also among the factors affecting the use of AR in education (Van Krevelen & Poelman, 2010). In some cases, societal norms or perceptions about the integration of technology in classrooms may prevent teachers or students from accepting or using the technology. In addition, privacy and ethical issues are also among the limitations of AR (Berryman, 2012). In particular, issues such as privacy and security of student data stand out as important ethical concerns that limit the use of technology in education. These challenges may prevent AR from realising its full potential in education. However, given that technology is increasingly becoming an integral part of daily life and has a wide range of uses, researchers are urged to explore ways to overcome these limitations. In particular, making pre-service and in-service teacher trainings more appropriate for teachers to utilise AR can be an important step towards more effective use of this technology in education. Such trainings can increase teachers' ability to integrate technology effectively and make the use of AR in education more efficient.

## **5. CONCLUSION**

This study aimed to present the general view of AR usage in the education field in Turkey. Therefore, the current study analysed 49 studies that were published between the years of 2018 and 2022 and indexed in WoS. The applied search criteria were the studies including augmented reality, been published within the past five years in the context of Turkey and in the educational field. The studies were analysed based on the publication years, the fields that they were conducted in, the methods that they adopted, and the aspects of AR that they focused on. The results showed that most of the studies were published in 2019. It was predicted that the number of the publications will

increase in the upcoming years. When it comes to the fields that the studies were conducted, it was seen that Science was the most popular field with a number of 20 publications. That was followed by Education in general (n=9) which consists of less than half of the studies that were conducted in the Science field. Hence, researchers interested in Social Sciences were strongly recommended to conduct research investigating the effects of AR and how to integrate it into the educational settings better. Next, the studies were categorised based on the methods that they adopted. The results revealed that most of the studies applied quantitative research methods. As useful as they might be, it was recommended that more studies need to be conducted using qualitative research methods in order to give voice to the users and investigate the effects of AR in educational settings in-depth. Finally, the aspects of AR usage were also investigated. The data showed that most of the researchers investigated the effectiveness of AR usage. Researchers and AR designers were invited to seek ways to diminish the limitations of AR usage in educational settings.

#### **Research and Publication Ethics Statement**

No data were collected from human participants during the study. This research article is a document review. The author followed ethical standards and rules during the research process.

#### **Contribution Rates of Authors to the Article**

The research was prepared by a single author.

#### **Data availability**

The datasets generated during and analysed during the current study are available in the Web of Science repository, [<https://www.webofscience.com/wos/woscc/summary/bb0f7373-be69-402a-ab5a-ea0f5df55068-41fe2b26/relevance/2> Last access on 08.08.2022].

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

#### **Statement of Interest**

There is no conflict of interest.

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