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A Systematic Review of Studies on Augmented Reality Based Applications in Primary Education

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ABSTRACT

This research aims to examine the researches based on augmented reality-based applications conducted for primary school students between 2015-2021 and to determine the positive and negative effects of this applications on students. The document analysis method was used in the research. In this context, articles containing AR-based applications prepared for primary school students using the keywords "augmented reality", "primary education", "elementary education", "teachers 'and parents' perceptions" were examined in ScienceDirect, ERIC, Sagepub and SpringerLink databases. As a result of the research, 48 articles were determined in accordance with the criteria. As a result of the content analysis, these studies were divided into seven different categories under the augmented reality theme: teacher and parent perceptions, reading and literacy skills, science education, special education, language education, mathematics education, and history/social sciences education. It has been observed that these practices improve students' motivation, academic achievement and remembering skills, increase their vocabulary, help them develop a positive attitude towards lessons, and improve their spatial thinking and creativity skills. In addition, there are also studies that have negative results stating that it limits the imagination, requires a lot of time for the application, it prevents reading because it is distracting, there is no available amount of free AR-based applications, and there are inadequate professional support to teachers for the use of these applications.

Key words: Augmented reality, primary education, educational technology, reading, science education, special education

INTRODUCTION

Technology, which is defined as the process of developing people's existing potentials by using the resources they have and changing the environment in which they live (Hansen & Froelich, 1994). It emerges as a concept that directly affects almost everything from politics to economy, from culture to daily life (Sasvari, 2012). One of the areas affected by technology is undoubtedly education. In the digital age, developing technology is rapidly integrated into educational environments, and different educational technologies are included in learning environments in order to maximize the efficiency of education. With these new technologies, individuals' communication skills, creativity, critical and systematic thinking skills are developed and they are enabled to discover faster and more effective ways of solving problems (Radu et al., 2011). Individuals living in the 21st century are described as individuals who use all virtual and digital ways to access and use the information obtained. Today, new discoveries for learning require the planning of new physical and virtual teaching spaces and the introduction of new digital resources to encourage a more dynamic teaching-learning process (Dufva & Dufva, 2019; Rensink, 2020). One of these resources is augmented reality based applications. Augmented reality is defined as a technology that enables the enrichment of the real world by transferring three-dimensional objects created in computer environments to real life environments, and supports individuals to perceive and make sense of their environment (Altınpulluk, 2015; Leung & Blauw, 2020). According to Azuma (1997), augmented reality-based environments have three basic features. These features; the coexistence of real and virtual environments in these environments, the presence of real-time interaction and the presence of three-dimensional objects.

When we look at the short history of augmented reality, it is seen that the first augmented reality-based system was created by Ivan Sutherland in 1968 (Sutherland, 1968 as cited in Arth et al., 2015). It is seen that Thomas Caudell and David Mizell expressed the placement of materials created in computer environment in the real environment in 1992 with the name of augmented reality. This expression was the first place the augmented reality technology was called by this name. AR-based applications, which first emerged to perform imaging operations of some companies, have started to be used in different fields from medicine to tourism, entertainment industry to scientific research and art activities with the advancement of technology over time (Johnson

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et al., 2010; Garzon et al., 2017; Kapur, 2019). Figure 1 shows how the augmented reality applications started and a short timeline of some of the researches that are considered to be important in this field.

With the realization of the potential of its use in educational settings and the discovery of the innovations it provides in learning and teaching activities, augmented reality-based applications have also started to be used in educational environments (Wu et al., 2020).

Yuen et al. (2011) mention five different classifications in which augmented reality-based applications can be used in educational environments. These; It is defined as contribution to exploratory-based learning, contribution to modeling objects, augmented reality-based books, contribution to exercises for skills, and augmented reality-based games. It is stated that the exploratory contribution of these applications can be used in virtual museum tours, astronomy education and teaching historical places. It is stated that its contribution to the modeling of objects can be used to ensure that students receive instant visual feedback about any object and can be used mostly in architectural education, and that augmented reality-based books can attract individuals who are described as digital natives and thus can be used in initiatives to increase their reading motivation. Visual demonstration of what needs to be done at each step during the repair in the training of aircraft maintenance in the studies to be carried out for the development of skills can support individuals to be more successful. Today, many technology companies bring augmented reality and virtual reality applications in different fields, especially science, engineering, mathematics and technology education, to classroom environments and help students to experience situations that they cannot encounter in daily life. These environments increase students' curiosity towards learning, make them more interested in lessons and increase their motivation to learn (Bursalı & Yılmaz, 2019; Danaei-Moghadam et al., 2019; Nersesian et al., 2019; Çetin, 2020). When the relevant literature is examined, there are also studies that indicate that augmented reality-based applications do not have a positive or significant effect on students. Billinghurst and Duenser (2012) state that many problems can be encountered during the implementation of augmented reality-based applications in the classroom. They state that especially teachers do not have enough knowledge about these technologies and therefore applications cannot be fully efficient. In another similar study, Lin et al. (2011) stated that students find augmented reality-based applications complicated and they constantly encounter technical problems during applications. Muñoz-Cristóbal et al. (2015) state that a lot of extra time should be given in lessons for augmented reality-based applications to be effective.

The Purpose of the Study

This study aims to examine the studies conducted for primary school students regarding applications made for them with augmented reality-based applications between 2015 and 2021. Within the scope of the research, the results of the augmented reality-based research in the relevant literature and what kind of effects these applications have on students were investigated.

METHOD

Research Model

Document analysis, one of the qualitative research methods, was used in this study. Document analysis is defined as the analysis of printed materials that provide information about the subjects to be researched. Documents obtained in this design should be examined in detail and systematically in terms of content (Wach & Ward 2013; Yıldırım & Şimşek, 2013). In document analysis, researchers examine previous researches in the relevant field and include information about these researches in their own research. In document analysis, which is an analytical method, researchers aim to synthesize the data obtained. Then, the data obtained using content analysis are classified. In this study, the documents related to the augmented reality-based researches made for primary school students were examined and the data obtained were presented by creating a certain classification using content analysis (Labuschagne, 2003 as cited in Kıral, 2020).

Data Collection and Inclusion Criteria

During the data collection process, firstly the keywords related to the fields to be included in the research were

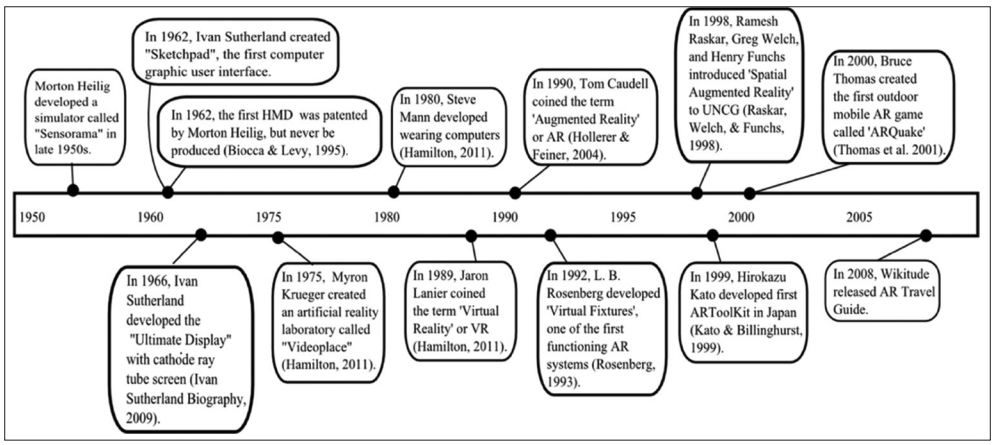

Figure 1. Augmented reality history in a short timeline. Adapted from Yuen et al. (2011)

determined and then it was decided in which databases to be searched for these keywords. Articles published between 2015-2021 in the databases of "ScienceDirect", "ERIC", "SpringerLink" and "Sagepub" were determined as the inclusion criteria. The main reason for choosing the articles in these databases is that these are databases with high validity and reliability. In the examination, it was determined that there were 1732 articles related to the keyword "augmented reality" in the field of education in these databases. When the keywords "augmented reality", "primary education", "elementary education", "teachers' and parents" perceptions "are used in these databases, it has been determined that there are 62 publications that comply with the general search criteria. During the detailed analysis, it was determined that some of the studies in pre-school education and the studies in which 6th and 7th grade students were used as the sample group were listed on the search page with these keywords and were excluded from the study. With this regulation, 14 more studies that did not comply with the criteria were eliminated, and finally, 48 articles complying with the research criteria were included in the study. The data of the flow chart of this systematic review are presented in Figure 2.

Data Analysis

Content analysis was used as a data analysis method in the research. Content analysis is a data analysis method that requires an in-depth analysis of the data obtained from the research and allows to reveal previously unknown themes, categories and codes after the examination. As a result of the research, the articles about the keywords were brought together and divided into specific categories and codes under the augmented reality theme. Then, these data are arranged and interpreted in a way that the readers can understand (Yıldırım & Şimşek, 2013).

Validity and Reliability

The concept of validity is the level of solving the event or problem examined by an individual actively involved in a research process as objectively as possible (Yıldırım & Şimşek, 2013). In this way, the data obtained will reflect the existing situation correctly (Baltacı, 2019). As in other types of qualitative research, data diversity in document analysis is a very effective method in ensuring validity and reliability. The use of data obtained by using more than one method to confirm the results achieved is called data diversity. The use of different methods together is very important in determining the accuracy and validity of the collected data and explanations. Validity in qualitative research means observing the researched phenomenon as impartially as possible. In order to obtain a holistic observation of events, the researcher can use expert confirmation. In order to increase the credibility of the research, the reasons for each explanation and conclusions should be stated and the supporting findings should be presented to the reader. One of the most effective things that can be done in this process is to include direct quotations (Yıldırım & Şimşek, 2013). In order to increase the validity of this study, researcher confirmation was used. In order to be a highly valid research, the categories and codes obtained in this study were confirmed by a different researcher who is an expert in the relevant field. The concept of reliability is a concept related to the repeatability of research results. If a research that has been conducted can yield the same results when it is desired to be carried out again, it can be expressed as a research with high reliability. In this study, direct quotations from the researches examined are included in order to ensure reliability (Karataş, 2015).

FINDINGS

In this section, articles obtained as a result of researches and categories and codes determined after content analysis are presented. After entering the keywords determined in the search field of the journals selected in the study, the articles obtained in the relevant databases are presented in Table 1.

When Table 1 is examined, it is seen that there are a total of 48 articles in accordance with the criteria determined in the study. Content analysis was carried out to systematically classify the articles obtained from the research. As a result of this analysis, under the theme of augmented reality, "teacher and parent perceptions", "reading and literacy skills," science education "," mathematics education "," social sciences and history education "," language education" and " special education " seven different categories have been determined.

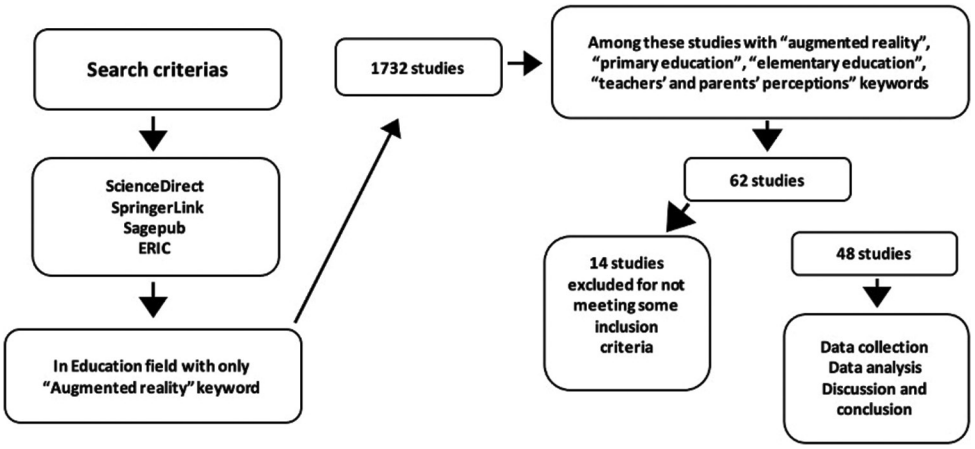

Figure 2. Flowchart of the systematic review

Table 1. Investigated articles

Studies	Authors	Databases
S1	Cheng & Tsai (2016)	ScienceDirect SpringerLink ERIC Sagepub
S2	Cheng (2017a)	
S3	Cheng (2019)	
S4	Mundy, Hernandez & Green (2019)	
S5	Alalwan, Cheng, Samarraie, Yousef, Alzahrani & Sarsam (2020)	
S6	Trust, Woodruff, Checrallah & Whalen (2021)	
S7	Alhumaidan, Lo & Selby (2017)	
S8	Cheng (2017b)	
S9	Tobar-Munoz, Baldiris & Fabregat (2017)	
S10	Hsu, Wenting, Hughes (2018)	
S11	Lubis & Wangid (2019)	
S12	Danaei, Jamali, Mansourian & Rastegarpour (2020)	
S13	Kumpulainen, Byman, Renlund & Wong (2020)	
S14	Mavrotheris, Carrilho, Charalambous, Mavrou & Christou (2020)	
S15	Hwang, Wu, Chen & Tu (2016)	
S16	Laine, Nygren, Dirin & Suk (2016)	
S17	Hung, Chen & Huang (2017)	
S18	Liou, Yang, Chen & Tarng (2017)	
S19	Chang & Hwang (2018)	
S20	Wu, Hwang, Yang & Chen (2018)	
S21	Bhagat, Liou, Spector & Chang (2019)	
S22	Lai, Chen & Lee (2019)	
S23	Ponners & Piller (2019)	
S24	Winarni & Purwandari (2019)	
S25	Beyoğlu, Hursen & Nasiboğlu (2020)	
S26	Chen (2020)	
S27	Chen, Wang, Chen, Chen & Lin (2020)	
S28	Pombo & Marques (2020)	
S29	Wahyu, Suastra, Sadia & Suarni (2020)	
S30	Wang (2020)	
S31	Chen, Lee & Lin (2016)	
S32	Cihak, Moore, Wright, McMahon, Gibbons & Smith (2016)	
S33	Çakır & Korkmaz (2019)	
S34	Howorth, Rooks-Ellis, Flanagan & Ok (2019)	
S35	Baragash, Al-Samarraie, Alzahrani & Alfarraj (2020)	
S36	Carreon, Smith & Rowland (2020)	
S37	Solak & Çakır (2016)	
S38	Hsu (2017)	
S39	Chen & Chan (2019)	
S40	Wen (2019)	
S41	Wen (2020)	
S42	Hossain & Ahmed (2021)	
S43	Ibili, Resnyansky & Billinghurst (2019)	
S44	Amir, Fediyanto, Rudyanto, Afifah & Tortop (2020)	
S45	Arvanitaki & Zaranis (2020)	
S46	Demitriadou, Stavroulia & Lanitis (2020)	
S47	Efstathiou, Kyza & Georgiou (2017)	
S48	Morales & Garcia (2018)	

Detailed data of the determined themes and categories are presented in Figure 3.

Teachers' and Parents' Perception Findings

When the databases determined between 2015-2021 are examined in the study, it is seen that there are six publications based on augmented reality for the perceptions of teachers and parents. Themes, categories and codes for these studies are presented in Table 2.

It is seen that 16 different codes were created in line with the data obtained in Table 2. These codes include high sense of reality, being innovative, distracting effect, antipathicism, fun, increasing attention, motivating, developing deep understanding skills, increasing interaction, preventing reading, limiting imagination, not being familiar, facilitating learning, being inadequate, resources and not enough time for such applications. These findings show that teachers and parents have positive and negative perceptions about augmented reality technologies. Findings about some of the studies included in the study about teacher and parent perceptions are given below.

Cheng and Tsai (2016) stated that parents stated that the augmented reality-based applications for students were beneficial, increased motivation level and gained the ability to understand books more deeply. Alalwan et al. (2020) stated that these applications are limited in instructional design, environmental resources related to this technology are scarce, and more time should be allocated for implementation in their study. If these problems are solved, teachers stated that these applications are useful and they can adopt a positive attitude. Cheng (2017) obtained opinions that augmented reality-based applications prevent reading, limit imagination, and increase interaction and deep understanding.

In the studies examining the views of teachers and parents on augmented reality-based applications in primary school, some parents and teachers stated that these applications

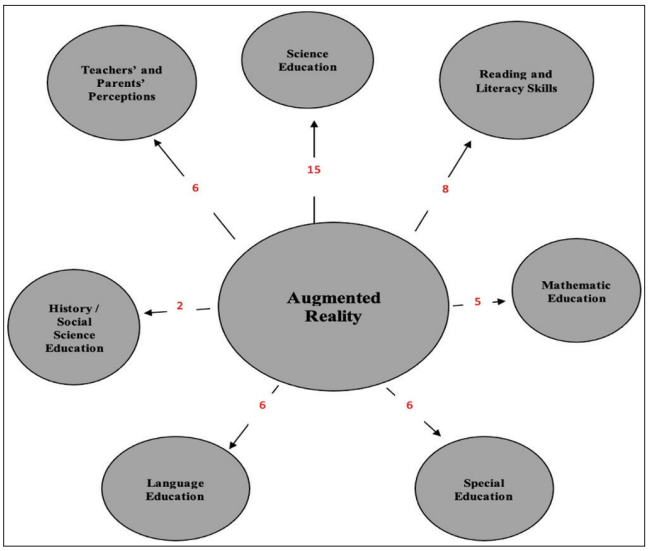

Figure 3. Themes and categories of the study

Table 2. Teachers and parents perceptions theme, category and codes

Theme	Category	Codes	
Augmented Reality	Teachers' and parents' perception	Sense of reality Novelty Distracting Antipathic Playful Distracting Motivation Deep understanding skills Increasing interaction	Obstruct reading Limited imagination Not being familiar Facilitating learning Lack of competency Limited learning resources Lack of time

increase motivation and interaction, and that they are innovative and realistic applications. On the other hand, in some studies, it was observed that parents and teachers stated that these practices were distracting practices that limited the imagination.

Reading and Literacy Skills Findings

In the research, it is seen that there are 8 publications based on augmented reality on reading and literacy skills in the databases determined between 2015-2021. Themes, categories and codes for these studies are presented in Table 3.

It is seen that 24 different codes were created in line with the data obtained in Table 3. These codes include supporting active participation in the education process, encouraging exploration, increasing social interaction, providing collaborative learning, increasing motivation and positive attitude, reducing cognitive load, neutral effect on reading comprehension, arousing curiosity towards learning, being fun, information management, improving communication and sharing skills, enhancing creativity, improving assessment and problem solving skills, teaching values, ensuring that students are willing to finish a book being read, appealing to the senses, being an expensive tool, having technical and pedagogical limitations, disappointing students when the content is difficult to understand or when a technical error occurs, causes distraction in students, the limitation of AR-based applications that can be reached, and the lack of professional support for teachers to develop in the field. These findings show that augmented reality-based technologies have positive and negative effects on improving reading and literacy skills. Some of the findings of the studies examined on reading and literacy skills are presented below.

Tobar-Munoz et al. (2017) stated that augmented reality-based applications do not make a significant difference on students' reading comprehension skills. However, they stated that these practices revealed a significant difference in terms of interest, enjoyment, increasing motivation and developing problem solving skills. Danaei-Moghadam et al. (2020) stated that augmented reality-based applications improve literacy skills such as reading comprehension, verbal expression and recall. Cheng (2017) states that augmented reality-based books reduce cognitive load, increase motivation level, and students adopt a more positive attitude when they perform their reading experiences with AR-based books.

When we look at the studies examining the effects of augmented reality-based applications in primary school on reading and literacy skills, some researchers have found that these applications increase motivation in reading environments, support collaborative learning, reduce cognitive load in students, and create enjoyable reading environments. On the other hand, in some studies, research results have been found that these applications are expensive and therefore not very accessible and cause students to be distracted while reading.

Science Education Findings

In the research, it is seen that there are 15 publications based on augmented reality for science education in the databases determined between 2015-2021. Themes, categories and codes for these studies are presented in Table 4.

It is seen that 30 different codes were created in line with the data obtained in Table 4. These codes include making the lesson fun, increasing the learning success in the science lesson, keeping the information in the memory for a longer time, increasing the level of satisfaction in the lesson, helping students in the science lesson, increasing the students' attitudes towards learning, decreasing the cognitive load, increasing learning motivation, increase fulfilling the given tasks, providing realistic experiences, increasing learning performance, facilitating students to construct knowledge, enable them to develop critical thinking skills, increasing the levels of self-efficacy, increasing interest and excitement towards the lesson, increasing attention span, increasing science learning levels, enabling them to understand the lessons more easily, providing motivation to work as a group in science, the ability to collaborate with peers, excite students, enjoying learning, increasing the desire for independent learning skills, creating a sense of reality, developing scientific literacy skills, creating a positive effect on learning science, hindering thinking ability, restrict creativity and

Table 3. Reading and literacy skills theme, category and codes

Theme	Category	Codes	
Augmented Reality	Reading and Literacy Skills	Support for active participation in the education process	Communication and sharing
		Encourage exploring	Creation
		Social interaction	Evaluation and problem-solving
		Collaborative learning	Teaching values
		Increase motivation	Eager to finish reading the book
		Positive attitude	Sensuous
		Less cognitive load	Expensive
		Neutral effect on reading comprehension	Technical and pedagogical constraints
		Interested in learning	Students' frustrations
		Enjoyable	Students' distraction
		Information management	Limited number of freely available AR apps
			Lack of professional development opportunities and support for teachers.

Table 4. Science education theme, category and codes

Theme	Category	Codes	
Augmented Reality	Science Education	Enjoyable	Promote science learning
		Learning achievement	Improve science reading
		Retain information in memory	Understand lesson easily
		Satisfaction	Motivation for collaborative work in science
		Helpful	Collaboration with peers
		Attitude towards learning	Make students excited
		Decrease cognitive load	Negative effect on learning success
		Learning motivation	Have fun while learning
		Keep conducting task	Increase their willingness to learn independently
		Promote realistic experience	Sense of reality
		Learning performance	Increase scientific literacy
		Facilitate students 'construction of knowledge	Positive impact on students' science learning
		Improve critical thinking tendency	Hinder thinking ability
		Improve self-efficacy	Restrict creativity
		Interest and excitement	
		Extend attention span	

negative effect on learning success. Some of the researches that provide these codes related to science education are presented below.

Liou et al. (2017) stated that the augmented reality application they used on the phases of the moon in the science course played an important role in the learning process. They state that these practices not only increase learning motivation but also encourage students to fulfill the given tasks. In addition, they stated that since these applications increase the sense of reality, they enable students to concentrate more on the lesson. Beyoğlu et al. (2020) state that the use of augmented reality-based applications in science teaching increases motivation in collaborative work. They also stated that these practices have no effect on performance, communication and participation in the process. Wahyu et al. (2020) state that mobile augmented reality applications based on STEM-based learning improve academic achievement and scientific literacy skills in the science course.

Considering the studies examining the effects of the use of augmented reality-based applications in the science lesson in primary school, it has been observed that some researchers have reached conclusions stating that these applications facilitate the acquisition of real experiences in the science lesson, increase learning success, interest and motivation, and extend attention spans. On the other hand, in some studies, research results have been found that these practices have a negative effect on learning achievement in science lessons and limit students' thinking skills.

Special Education Findings

In the research, it is seen that there are 6 publications based on augmented reality for special education in the databases determined between 2015-2021. Themes, categories and codes for these studies are presented in Table 5.

It is seen that 17 different codes were created in line with the data obtained in Table 5. These codes include attracting the students attention, eliminating focus problems, improving social and emotional awareness, increasing independent performance, being an acceptable way to acquire new skills, the ability to perform chain tasks, developing individual learning skills, developing social, physical, vital and academic skills, increasing the level of readiness for the lesson, making students more active and enthusiastic, contributing to development with real life experiences, increase motivation, communication and interaction levels and make learning more fun. Some of the researches that led to the creation of codes related to special education are presented below.

Table 5. Special education theme, category and codes

Theme	Category	Codes	
Augmented Reality	Special Education	Attract the childrens' attention	Living skills
		Allow them to remain focused	Academic skills
		Improve social and emotional awareness	Increase the level of readiness to the lesson
		Increase independent performance	More active students
		Acceptable way to learn new skills	More eager and enthusiastic students
		The ability to perform chain tasks	Contribute to the development with real life experiences
		Promoting individual's learning skills	
		Social skills	Promote motivation, interaction and communication
		Physical skills	
			Make learning fun

Cihak et al. (2016) state that augmented reality-based applications in special education directly increase the ability to perform independently. They also stated that these practices were perceived by students as an acceptable method for gaining new skills. For Çakır and Korkmaz (2019) augmented reality-based applications are suitable for students who need special education because they gain real-life experiences and these applications are very helpful in terms of contributing to students› development. Howorth et al. (2019) state that augmented reality-based applications increase motivation and communication skills, make learning more enjoyable, and increase recall levels in individuals who need special education.

Considering the studies examining the effects of the use of augmented reality-based applications in special education in primary school, it was observed that some researchers reached results indicating that these applications partially eliminated the problem of focusing in special education, increased individual learning skills and improved social skills. Among the studies examined, no evidence was found that augmented reality-based applications cause any negative results in special education.

Language Education Findings

In the research, it is seen that there are 6 augmented reality-based publications on language education in the databases determined between 2015-2021. Themes, categories and codes for these studies are presented in Table 6.

It is seen that 10 different codes were created in line with the data obtained in Table 6. These codes include increasing learning performance, creating more effective vocabulary learning environments, gaining the ability to store more words in memory, increasing motivation and satisfaction level, creating a fun environment, increasing students' vocabulary knowledge, improving orthographic knowledge, increasing interest, enabling them to continue active participation and providing effectiveness on learning. Some of the researches that lead to the creation of codes related to language education are presented below.

Solak and Çakır (2015) states that the use of augmented reality-based applications in language teaching at primary school level is a more effective method in increasing learning performance and improving vocabulary compared to traditional methods.

Table 6. Language education theme, category and codes

Theme	Category	Codes
Augmented Reality	Language Education	Increase learning performance
		More effective vocabulary learning
		Longer storage in the memory
		Increase motivation and satisfaction
		High learning effectiveness
		Enjoyable
		Enhance students' vocabulary expansion
		Improve orthographic knowledge
		Promote interest
		Sustain learners' active engagement

Wen (2020) states that the use of augmented reality-based application in language teaching enables students to adopt a more relevant attitude in learning activities and to maintain this attitude throughout the learning process.

When we look at the studies examining the effects of the use of augmented reality-based applications in language education, it has been seen that some researchers have found that these applications are very effective in the vocabulary learning process, increase the interest in language learning and help students participate actively in the lesson. Among the studies reviewed, no evidence was found that augmented reality-based applications lead to any negative outcomes in language education.

Mathematic Education Findings

In the study, it is seen that there are 5 augmented reality-based publications on mathematics education in the databases determined between 2015-2021. The themes, categories and codes for these studies are presented in Table 7.

It is seen that 8 different codes were created in line with the data obtained in Table 7. These codes include increasing interaction levels, increasing interest in mathematics education, contributing to learning and understanding mathematical concepts more effectively, creating a positive opinion in students, increasing motivation, increasing academic success and creating a positive effect on the lesson. Some of the researches that lead to the creation of codes related to mathematic education are presented below.

Demitriadou et al. (2019) state that using augmented reality-based applications in mathematics teaching contributes

Table 7. Mathematic education theme, category and codes

Theme	Category	Codes
Augmented Reality	Mathematic Education	Improve interactivity Improve interest in math education Contribute to more efficient learning and understanding of math concepts Positive perception Increase motivation Powerful motivator Positive effect Improve academic achievement

more to students' interests in mathematics and their understanding and learning levels of mathematical concepts compared to traditional methods. Arvanitaki and Zaranis (2020) state that using augmented reality-based applications in mathematics education creates a more interactive process for students and these applications have positive effects on geometry teaching compared to traditional methods.

When we look at the studies examining the effects of using augmented reality in mathematics education, it has been seen that some researchers have reached conclusions that these applications increase academic success, contribute to learning and understanding mathematical concepts more effectively, and increase the interest in mathematics lessons. Among the studies reviewed, no evidence was found that augmented reality-based applications lead to any negative outcomes in mathematics education.

History and Social Science Education Findings

In the study, it is seen that there are 2 publications based on augmented reality for history and social studies education in the databases determined between 2015-2021. Themes, categories and codes for these studies are presented in Table 8.

It is seen that 5 different codes were created in line with the data obtained in Table 8. These codes include increasing historical empaty level, developing conceptual understanding, playing an encouraging and helpful role in the acquisition of knowledge, increasing the level of academic achievement and motivation. Some of the researches that lead to the creation of codes related to history and sociel studies education are presented below.

Efstathiou et al. (2017) state that augmented reality-based applications increase historical empathy and conceptual understanding skills. Morales and Garcia (2018) states that the augmented reality-based applications play an encouraging and supportive role in the knowledge acquisition of students in social studies course. During these applications, it was observed that the knowledge level of the students increased significantly.

When the studies examining the effects of augmented reality use in history and social studies education are examined, it has been seen that some researchers have reached conclusions that these applications increase the ability of historical empathy, academic success and motivation. Among the studies examined, no evidence was found that augmented reality-based applications lead to any negative results in history and social studies education.

Table 8. History and social science theme, category and codes

Theme	Category	Codes
Augmented Reality	History and Social Studies Education	Increase historical empathy Increase conceptual understanding Incentive and facilitator in the acquisition of knowledge Academic achievement Motivating

DISCUSSION

This research examines studies involving augmented reality-based applications for primary school students between 2015-2021. According to the results of the research, it was observed that there are 48 studies that comply with the criteria determined in the relevant databases. After the content analysis, these studies were divided into seven different categories: teachers and parents perceptions, reading and literacy skills, science education, special education, language education, mathematics education, and history/social studies education. The studies in each category were examined separately and a total of 110 different codes were obtained. Within the scope of the study, it was observed that augmented reality-based applications in almost all categories determined to improve academic achievement, increase students' motivation levels, attitude and interest towards the relevant lesson, increase the level of recall, make them more active, more participatory, entertaining and enjoying the lesson. In addition, there are studies that show negative results such as these practices limit the imagination of students and negatively affect their creativity skills, accessibility is difficult due to the fact that even if the applications are effective, the professional support required for the use of such applications is not provided to teachers.

When the research findings are examined, it is seen that the augmented reality-based research for primary school between 2015-2021 has increased significantly in 2019 and 2020 compared to other years. The reason for this is thought to be due to the rapid development of technology. In information and communication technologies, especially with the developments in the industry, the increased production capacity has accelerated the spread of technology to the society and the globalization process (Çelik, 2012). Although these applications, which had a very complex structure and were expensive to use in the early days, could not be used in different areas, with the developing technology, they started to be displayed easily even on phone and tablet screens (Sunger & Cankaya, 2019).

It is thought that this development facilitates researchers who aim to measure the effect of augmented reality technology on different skills or who want to gain new skills through these applications, and therefore increase research in the relevant field. In addition, Prensky (2001) states that digital natives have started to use technology as an indispensable part of their daily lives. It is thought that what kind of results

these applications can produce has attracted the attention of the researchers. In the study, it is seen that between the years of 2015-2021, augmented reality-based applications were mostly performed in the field of science education. Science education is followed by researches on reading and literacy skills, research involving teachers and parents' perceptions, research in language education and special education, mathematics education research, and history/social studies research, respectively. It is thought that the reason why the researches were mostly conducted in the field of science is that it is a course that includes abstract concepts and situations where it is dangerous and very difficult to examine in real environments.

Ucelli et al. (2005) state that AR-based applications are technologies that create a sense of touch in the individual, are very close to the real world and allow the individual to interact with his environment more comfortably by controlling these objects through various assistive applications. This view supports the view stated by the researcher about why the applications based on augmented reality are mostly applied in the field of science education. From this point of view, it is thought that since the mathematics lesson is a lesson containing abundant abstract concepts, it is necessary to develop and apply appropriate applications in mathematics education. In the research, it is seen that the studies in which augmented reality-based applications take place the most after the science course are the studies that are made to improve reading and literacy skills. Reading is a dynamic meaning-making process that requires active and effective communication between author and reader. Improving reading skills is stated as one of the biggest contributions made to make human life meaningful (Akyol, 2016). The inability of students to read is a cause for concern among educators. A more serious problem is that students have low motivation to read (Muliati, 2017). Studies show that at least seven different components should come together in order to increase the student's reading motivation. Some of these components are expressed as a sense of curiosity, engagement, self-efficacy, social interaction and interest (Baker & Wigfield, 1999; Wigfield & Guthrie, 1997).

Considering the results of augmented reality-based research on reading and literacy skills, it is observed that these applications increase student motivation (Tobar-Munoz et al., 2017), increase social interaction (Hsu et al., 2018) and improve self-efficacy skills (Chang & Hwang, 2018). These findings show that augmented reality-based applications positively affect some of the concepts stated as basic components of reading motivation. For this reason, it is thought that research using augmented reality-based applications to improve reading and literacy skills should be focused on.

CONCLUSION

Within the scope of the research, only the articles published in some databases on augmented reality in primary school were included. This situation can be considered as the main limitation of the research. Considering that primary school is a level where students adapt to the school, it is thought that these applications should be used more in the process as augmented reality-based research contributes such as increasing students' motivation, improving their academic success, being interested in the lesson, and having fun during the lesson. In addition to the science course, it is necessary to increase the number of researches on mathematics, arts education and social studies courses. Teachers should be given professional support about these applications as soon as possible and they should be given the opportunity to make simple augmented reality based applications. In this study, researches in some databases were examined. More comprehensive data can be obtained by examining studies in different databases that include research on the use of augmented reality in primary school.

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