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A Systematic Review of the Use of Augmented Reality Technology for Individuals with Special Needs

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Abstract

In this study, studies on the use of augmented reality technology for individuals with special needs were examined. In this context, studies published between 2018-2022 were scanned. As a result of the screening, 20 studies that met the criteria were included in the study. Examined studies; publication year, subject, purpose, variable, special needs of individuals, hardware and software used for augmented reality, method, data collection tools, data analysis methods, limitations, results and suggestions were examined. When the studies are examined by years, they show an increasing trend and focus mostly on 'social interaction' as a variable. It has been seen that the studies are mostly carried out for individuals with autism and applications are made with small sample groups. In the results of the studies, it is revealed that the use of augmented reality technology in individuals with special needs is effective and motivating in general. In this study, the trend of the use of augmented reality technology for individuals with special needs in recent years has been described.

Keywords: Augmented reality, individuals with special needs, systematic review

1. Introduction

Augmented reality is defined as a three-dimensional technology that surrounds the real world with objects created in virtual environments, supporting individuals' understanding and perception of it (Leung & Blauw, 2020). In other words, augmented reality technology, which appears as a technological tool that brings together the real world and virtual objects (Azuma, 1997), is increasingly being used in educational environments as the costs of these technologies decrease and they become more usable and accessible (Somyürek, 2014). Although augmented reality technology is sometimes confused with virtual reality technology, unlike virtual reality, augmented reality provides users with an appropriate interface that combines virtual objects with the real world (Tekedere & Hoker, 2016). Virtual reality, on the other hand, is the simulation of a real or imaginary environment created from three-dimensional virtual objects presented by the computer (Fridhi et al., 2018).

Augmented reality, together with its ability to combine real objects with virtual objects, has the potential to be a useful tool for generalizing the skills learned in the virtual world to the real world (Kientz et al., 2020). In addition, augmented reality is accepted as a technology that increases students' success (Kellems et al., 2019; Carreon et al., 2019) and affects student motivation and participation (Bacca et al., 2018).

Augmented reality also enables students to improve their knowledge and skills through the combination of real world and digital information (Wojciechowski & Cellary, 2013). In addition, this technology makes it possible to safely present events that can be rarely observed in the real world and potentially dangerous experiments to the educational environment, and provides practical experiences to students by embodying abstract concepts (Shelton 2003). With all these advantages, augmented reality has found its place in the field of education with various applications. The real environment is supported by digital elements such as 3D objects, sound and multimedia, and the gap between virtual and physical elements is reduced (Yuen et al., 2011). As a matter of fact, many studies show that augmented reality-based applications increase academic achievement (Tosik & Atasoy, 2017; Petrov & Atanasova, 2020) and keep interest and motivation high (Chen et al., 2017; Bistaman et al., 2018). In addition to all these advantages, augmented reality also provides time and cost savings in educational environments (Gavish et al., 2015).

1.1 Augmented Reality for Individuals with Special Needs

When the literature is examined, many studies show that augmented reality contributes to the learning process, facilitating the integration of individuals with special needs into society and improving their social skills (Lorenzo et al., 2019; Çakır and Korkmaz, 2019; Cate et al., 2017).

Bridges et al. (2019) revealed the positive effect of augmented reality applications carried out for individuals with intellectual disabilities on their daily living skills and concluded that the augmented reality teaching

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material was deemed appropriate to contribute to the learning development of individuals with cognitive impairment. The use of interactive and multimedia elements appealing to different senses in practices conducted for individuals with special needs can positively affect the learning experience of these individuals (Kumar and Wilson 1997). In this context, augmented reality can enrich text-based materials cost-effectively (Martín-Gutiérrez et al., 2015). The benefits of augmented reality technology for individuals with special needs can be briefly summarized as follows:

- Augmented reality technology supports the creation of a student-centered learning environment (Kamarainen et al. 2013). In this way, students with learning difficulties can be supported to learn outside of school and their understanding of the subjects can be improved.
- Augmented reality technology can help students who have attention deficit and learning difficulties in their learning processes to understand the subjects by increasing their motivation (Çakır and Korkmaz 2019).
- Augmented reality technology allows individuals with special needs to repeat what they want to learn whenever they want. Thus, it can help them solve the problem of insufficient time to practice in the classroom (Lin et al. 2016).
- Augmented reality technology makes it easier for students to learn abstract concepts by using both real and virtual objects (Bujak et al. 2013). Thus, it can facilitate the learning of individuals with special needs who have learning difficulties (Kellems et al., 2020).

1.2 Justification and Purpose of the Study

When the literature is examined, it is seen that augmented reality studies for individuals with special needs are limited. It is important for future studies to have a general idea about these studies and to know the characteristics of the studies. In addition, studies that analyze these processes in general are needed in order to make the processes for augmented reality studies being implemented more efficient. For these reasons, it is important to reveal the current situation in order to reveal the features of augmented reality applications for individuals with special needs and to offer suggestions for applications and researches planned to be implemented in the future. In this context, the problem statement of the research is “What is the scope and nature of research on augmented reality applications for individuals with special needs?” is in the form. Within the framework of the main problem, answers to the following questions are sought:

1. What are the general characteristics of augmented reality studies for individuals with special needs?
2. Which research methods were adopted in these studies?
3. What are the data collection tools used in the studies?
4. What are the limitations of the studies?
5. What are the suggestions presented in the studies?
6. What are the results of the studies?

2. Method

The main purpose of this study is to examine the augmented reality studies for individuals with special needs and to reveal the trends in the studies in the context of the basic features of a scientific research process. In order to achieve this goal, content analysis method was used in the study. This method, which is used in qualitative studies, appears as a systematic technique in which a text can be summarized with coding (Büyüköztürk et al. 2014). Çalık and Sözbilir (2014) divide content analysis into three as 'meta-analysis', 'meta-synthesis' and 'descriptive content analysis'. In this study, descriptive content analysis was used. Descriptive content analysis is a method that covers the evaluation of trends and research results by examining studies on a subject (Çalık & Sözbilir, 2014).

2.1 Data Collection and Analysis

In the study, augmented reality studies conducted for individuals with special needs in the last 5 years were examined. As a keyword while scanning the studies; In addition to the word pair 'augmented reality', searches were made where the words 'special need' and 'special disability' were used together. While scanning Turkish resources, in addition to the word group 'augmented reality', 'special education' 'individuals with special needs', detailed information on different types of special needs such as 'mental disability', 'learning difficulties', 'attention deficit', 'autism', 'hyperactivity' scans were also made.

While analyzing the studies; The publication year, subject, method, sample group, variables, special needs type, software used, hardware used, data collection tools, data analysis methods, limitations, results and suggestions were examined. In order to carry out these analyzes; a study review form was created and these criteria were added to the form categories.

The term validity emerges as the degree of reflecting the subject by using measurement tools that can fully express the researched problem (Çepni, 2009). In this study, while the study review form was being created, the forms used in content analysis studies were examined in detail in order to ensure content validity, and themes specific to the study were added. Reliability, on the other hand, is a situation that expresses the accuracy, reproducibility of the findings and the availability of the same results if the research is repeated (Çepni, 2009). In order to ensure reliability in the study, the coding made during the analysis process was re-examined by the same researcher at different times. As a result of the examinations made at different times, the necessary arrangements were made in the form, and the themes that were found to be missing during the examination of the studies were added to the form and the examinations were made again.

3. Results

Considering the inclusion criteria of the research in the screening results, 20 studies shown in Table 1 were included in the scope.

Table 1. Imprint information of the studies that make up the research sample

Code	Study Name	Authors	Year
S1	Intelligent Tutoring System in Education for Disabled Learners Using Human–Computer Interaction and Augmented Reality	Ahuja, N.J., et al.	2022
S2	'AReal-Vocab': An Augmented Reality English Vocabulary Mobile Application to Cater to Mild Autism Children in Response towards Sustainable Education for Children with Disabilities	Hashim, H. U., et al.	2022
S3	Effects of Augmented Reality-Based Dual-Task Program on Physical Ability by Cognitive Stage with Developmental Disabilities	Kang, H.Y., et al.	2022
S4	Using video modeling, explicit instruction, and augmented reality to teach mathematics to students with disabilities.	Morris, J.R., et al.	2022
S5	Enhancing joint attention skills in children on the autism spectrum through an augmented reality technology-mediated intervention	Pérez-Fuster, P., et al.	2022
S6	The effectiveness of augmented reality for English vocabulary instruction of Greek students with intellectual disability	Rapti, D., et al.	2022
S7	Comparıson Of Augmented Reality And Conventional Teaching On Special Needs Students'attitudes Towards Science And Their Learning Outcomes	Alqarni, T	2021
S8	Effectiveness of video prompting delivered via augmented reality for teaching transition-related math skills to adults with intellectual disabilities.	Kellems, R.O., et al.	2021
S9	Exploring the effect of an augmented reality literacy programme for reading and spelling difficulties for children diagnosed with ADHD.	Tosto, C., et al.	2021
S10	Augmented reality technology in science education for students with specific learning difficulties: its effect on students' learning and views	Turan, Z., & Atila, G.	2021
S11	Augmented reality for autistic children to enhance their understanding of facial expressions.	Wedyan, M., et al.	2021
S12	Use of augmented reality with a motion-controlled game utilizing alphabet letters and numbers to improve performance and reaction time skills for people with autism spectrum disorder	Antão, J. Y. F. D. L., et al.	2020
S13	Augmented reality: Teaching daily living skills to adults with intellectual disabilities	Bridges, S. A., et al.	2020
S14	Exploring the use of virtual characters (avatars), live animation, and augmented reality to teach social skills to individuals with autism	Kellems, R. O., et al.	2020
S15	Kinect-for-windows with augmented reality in an interactive roleplay system for children with an autism spectrum disorder	Lee, I. J.	2020
S16	The effectiveness of augmented reality environments on individuals with special education needs	Cakir, R., & Korkmaz, O.	2019
S17	Using an augmented reality game to teach three junior high school students with intellectual disabilities to improve ATM use	Kang, Y. S., & Chang, Y. J.	2019
S18	Preliminary study of augmented reality as an instrument for improvement of social skills in children with autism spectrum disorder	Lorenzo, G., et al.	2019

S19	Augmented reality plus concept map technique to teach children with ASD to use social cues when meeting and greeting	Lee, I. J., et al.	2018
S20	Safety and lack of negative effects of wearable augmented-reality social communication aid for children and adults with autism	Sahin, N. T., et al.	2018

3.1 General characteristics of augmented reality studies for individuals with special needs

3.1.1. Number of Studies by Years

When the studies are examined in this context, it is seen that the studies show an increasing trend over the years. Figure 1 shows the number of studies by years.

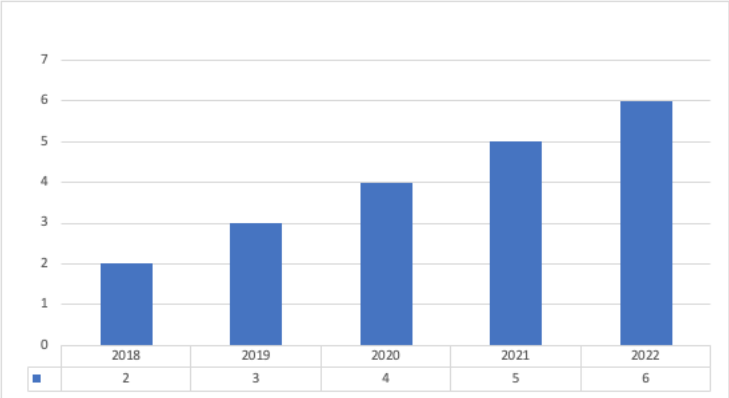

Figure 1. Number of studies by years

3.1.2. Databases of Studies

The studies were found by scanning the university online library resources. The databases of the studies found are as shown in Table 2, and there are mostly studies from the ERIC database with a rate of 30%. This is followed by Web of Science, Springer Nature Journals and Scopus with 15%, Directory of Open Access Journals with 10%, Academic Search Ultimate, Google Scholar and EBSCO with 5%.

Table 2. Databases of studies

Database	Studies	f	%
ERIC	S4, S7, S13, S15, S16, S17	6	30
Web of Science	S2, S5, S10	3	15
Springer Nature Journals	S18, S19, S9	3	15
Scopus	S3, S8, S11	3	15
Directory of Open Access Journals	S14, S20	2	10
Academic Search Ultimate	S6	1	5
Google Scholar	S12	1	5
EBSCO	S1	1	5

3.1.3. Variables Examined in Studies

The skill areas in which the studies examined are concentrated; social interaction skills, academic performance, language skills, active participation skills, daily life skills, kinesthetic skills. In general, it is seen that the studies focus on social interaction skills with a rate of 26.09%. This is followed by academic performance with a rate of 21.74%. It is seen that skills such as language learning, reading and spelling are examined with a rate of 17.39%. While it is seen that active participation and daily life skills are encountered with a rate of 13.04%, the rate of Kinesthetic skills is 8.7%. Table 3 shows the findings regarding the variables of the studies.

Table 3. Findings for the variables

Variable	Studies	f	%
Social Interaction Skills	S11, S14, S15, S18, S19, S20	6	26,09
Academic Performance	S1, S4, S7, S8, S10	5	21,74
Language skills (eg. language learning, reading-spelling)	S2, S6, S9,S12	4	17,39

Active Participation Skills (Awareness, Attention, Curiosity, Patience)	S2, S5, S7	3	13,04
Daily Living Skills	S13, S16, S17	3	13,04
Kinesthetic Skills	S3, S15	2	8,7

3.1.4. Participant's special need type

It was seen that the studies examined within the scope of the research were mostly directed to individuals with autism with a rate of 47.62%. It is seen that studies are conducted on individuals with intellectual disability and learning difficulties with a rate of 19.05%, and in addition to this, some studies (S16) also include participants with more than one type of special needs. The rate of studies on individuals with special needs such as learning disabilities, attention deficit and hyperactivity is 4.76%. The special needs types of the participants are shown in Table 4.

Table 4. Findings regarding the special needs type of the participants

Special Need Type	Studies	f	%
Autism	S2, S4, S5, S11, S12, S19, S15, S18, S19,S20	10	47,62
Mental Disability	S6, S8, S13, S17	4	19,05
Learning Disability	S1, S4, S7, S10	4	19,05
Attention Deficit and Hyperactivity	S9	1	4,76
Physical Disability	S3	1	4,76
Mixed	S16	1	4,76

3.1.5. Used Hardware

When the studies were examined, it was seen that systems were designed to use more than one hardware together in line with the application needs used in some studies. Due to the technical nature of augmented reality, although it is seen that mobile devices are mostly used, kinect etc. It is seen that the hardware devices used in terms of integration with other technologies have diversified. When smartphones and tablet computers are evaluated together in the mobile device category, their usage rate is 43.48% in total, and it is the most used type of hardware. This is followed by kinect device with 17.39%, computer with 13.04%, projector, interactive board, laptop and google glass with 4.35%. Findings regarding hardware usage are shown in Table 5.

Table 5. Findings for the used hardware

Used Hardware	Studies	f	%
İpad, Tablet Pc	S4, S6, S8, S13, S16, S19	6	26,09
Smart phone	S2, S10, S17, S18	4	17,39
Kinect device	S3, S5, S11, S15	4	17,39
Computer	S5, S9, S12	3	13,04
Projector	S5	1	4,35
Interactive board	S5	1	4,35
Laptop	S14	1	4,35
Google Glass	S20	1	4,35
Unspecified	S1, S7	2	8,7

3.2 Methods and models of studies

When the methods and models of the studies are examined, it is seen that there are studies that have adopted the quantitative method the most with a rate of 50%. In general, we see that the total rates of qualitative and mixed methods are equally distributed as 25%.

Table 6. Findings regarding the methods and models of the studies

	Studies		f	%
Qualitative	Case Study	S2, S6, S13	3	15
	Single subject multiple probe model	S8	1	5
	single subject model	S19	1	5

Quantitative	Experimental	S3, S4, S5, S12, S14	5	25
	Quasi-experimental	S1, S7, S9, S11, S18	5	25
Mixed		S10, S15, S16, S17, S20	5	25

3.3 Data Collection Tools

When the data collection tools of the studies are examined, it is seen that the scales are used the most with a rate of 29.27%. Many scales such as social communication scales for individuals with special needs, social skills scales, and attitude scales towards practices have been used in studies. Observation forms and achievement tests are the other most used data collection tools with a rate of 21.95%. Interview forms were used with a rate of 12.2%. This is followed by video recording with 9.76%, field notes and application evaluation test with 2.44%. Table 7 shows the data collection tools used in the studies.

Table 7. Data collection tools used in the studies

Data collection tool	Studies	f	%
Scale	S1, S4, S5, S7, S10, S13, S14, S15,S17,S18,S19,S20	12	29,27
Observation Form	S4, S6, S8, S9, S11, S13, S14, S15, S16	9	21,95
Achievement test	S1, S3, S4, S7, S8, S9, S12, S15, S19	9	21,95
Interview form	S1, S2, S6, S10, S20	5	12,2
Video recording	S5, S10, S14, S20	4	9,76
Field Notes	S2	1	2,44
Application Evaluation Test	S1	1	2,44

3.4 Limitations of studies

The limitations stated in the studies were examined in general and themes were formed. When examining within the framework of the themes created, we encounter the situation of 'working with a small sample group' with a rate of 31.25%. With a rate of 15.63%, it is seen that 'the extent to which the skills observed during the application are applied in real life (school, classroom, social environments)' and 'limitations about the data collection tool (low sensitivity, inconvenience, etc.)' are observed. These are followed by 'limited practice time', 'inhomogeneity of the sample group' and 'limited content (work on limited skill)' with a rate of 6.25%. Other limitations include 'studying without a control group' with a rate of 3.13% and 'inability to fully verify the data observed and transmitted by others'. The rate of studies in which limitations are not specified is 12.5%. The limitations of the studies are shown in Table 8.

Table 8. Limitations in the studies

Limitations	Studies	f	%
Small sample group	S5, S6, S7, S8, S11, S13, S15, S16, S18, S19	10	31,25
Inability to generalize to real life	S6, S15, S16, S17, S19	5	15,63
Limitations of the data collection tool (low sensitivity, inappropriateness, etc.)	S4, S5, S8, S9, S18	5	15,63
Limited application time	S7, S13	2	6,25
Sample group is not homogeneous	S12, S18	2	6,25
Limited content (work on limited skill)	S3, S19	2	6,25
Data observed and transmitted by others not fully verified	S14	1	3,13
Studying without a control group	S3	1	3,13
Unspecified	S2, S10, S16, S20	4	12,5

3.5 Recommendations presented in studies

The themes were formed by examining the recommendations presented in the studies. Examinations were made again around the themes created, and the most suggested recommendations with a rate of 25% was 'examination of the development of other skills'. This is followed by the recommendation of 'doing more detailed research' with a rate of 18.75%. The case of sample smallness, which is also highly indicated in the limitations, was stated with a rate of 15,63% in the recommendations of the studies as 'working with a larger sample' in order to eliminate this limitation. With a rate of 12.5%, we come across the recommendation of 'working for different special needs groups'. Recommendations of 'doing research on other age groups' and 'longer-term practice' were presented with a rate of 6.25%. The least suggested recommendations were 'Using different research methods' and 'doing more research' with 3.13%. In 9.38% of the studies, no recommendations were presented.

Table 9. Distribution of studies according to the recommendations presented

Recommendations	Studies	f	%
Examining the development of other skills	S4, S6, S8, S9, S10, S12,S17,S19	8	25
Making more detailed research	S1, S8, S11, S13, S19, S20	6	18,75
Working with a larger sample	S4, S13, S15, S18, S19	5	15,63
Working on different special needs groups	S3, S4, S8, S10	4	12,5
Conducting research on other age groups	S7, S10	2	6,25
Longer application time	S12, S18	2	6,25
Using different research methods	S7	1	3,13
Doing more research	S1	1	3,13
Unspecified	S2, S5, S14	3	9,38

3.6 Results from studies

The results of the studies were examined and themes were formed. When the results presented in the studies within the framework of these themes are re-examined, the result of "being effective in the targeted skill development" is the most mentioned result with a rate of 42.86% among the themes. In fact, this result was obtained in all but 2 of the studies, and this result was obtained when the other themes and frequency of use were looked at proportionally. Results such as 'ensuring willingness' and 'being effective in attracting attention' were obtained with a rate of 9.52%, followed by 'increasing motivation' with a rate of 7.14%. Other themes and their acquisition rates are shown in Table 10.

Table 8. Results from the studies

Results	Studies	f	%
Being effective in targeted skill development	S1,S2,S3,S4,S5,S6,S7,S8,S10,S11, S12, 13,S14,S15,S16,S17,S19,S20	18	42,86
Ensuring willingness	S7,S10,S14,S16	4	9,52
Being effective at attracting attention	S2,S11,S14,S15	4	9,52
Increasing motivation	S3,S7,S15	3	7,14
Increasing readiness levels	S7,S16	2	4,76
Overall satisfaction	S1,S4	2	4,76
Generalization of skills to real life	S5	1	2,38
Maintaining skills	S8	1	2,38
To be Funny	S6	1	2,38
Developing positive thoughts about learning environments	S7	1	2,38
Ensuring independent work	S6	1	2,38
Not encountering any problems	S10	1	2,38
Providing practical use	S13	1	2,38
No difference in skill development (between experimental and control groups)	S9, S18	2	4,76

4. Discussion

In this section, the general characteristics of the studies examined within the scope of the research and the research problems are summarized within the framework of the findings and discussed with their similar and different aspects in the literature.

When we look at the skill areas in which the studies examined within the scope of the research are concentrated, we come across predominantly social interaction skills with a rate of 26.09%. Similarly to this situation, it was concluded that the subjects examined in the review of studies conducted on individuals with autism by Khowaja et al. (2020) were "social skills" with the highest rate.

When we look at the participant characteristics of the studies, we see that individuals with autism constitute the largest participant group with a rate of 47.62%. In general, when the screening studies for individuals with special needs are examined, it is seen that augmented reality applications are mostly made for individuals with autism (Yenioğlu et al., 2021; Köse, H., and Güner-Yildiz, 2021). In addition, when the screening studies are specialized in terms of special needs, it is seen that more screening studies are conducted for individuals with autism (Khowaja et al., 2020). The features of augmented reality environments such as being away from the difficulties of face-to-face learning environments that require face-to-face interaction and helping these individuals overcome the difficulties they encounter in real environments (Fridhi et al., 2018) can be counted as one of the most common reasons for using this technology for individuals with autism.

When the studies are examined in terms of the hardware used, it is seen that mobile devices such as smart phones and tablet computers are mostly used as content display tools. When these devices are evaluated in a common category as mobile devices, their usage rate reaches 43.48%. These findings are actually technical features of augmented reality, transportation costs to devices, etc. It is related to situations and is valid not only for individuals with special needs, but also for most studies using augmented reality in education (Akçayır & Akçayır, 2017). Although the use of mobile devices is common due to the structure of augmented reality, some studies have also used equipment such as projectors, interactive boards, google glass and kinect devices. Researchers have also designed systems in which more than one hardware device is used together by diversifying the hardware used according to the content of the application and the targeted behavioral skills.

When the methods and models of the studies are examined, it is seen that the qualitative and quantitative methods are generally distributed equally. When the literature is examined, it is seen that the studies generally intensify qualitatively when considering the difficulties of conducting quantitative research on individuals with special needs. This situation is supported by the findings that mostly single-subject studies are carried out, as determined in the review study conducted by Berenguer et al. (2020).

When the data collection tools of the studies are examined, it is seen that the scales are used the most. It is seen that scales such as social communication scales, social skill scales, performance scale, learning outcomes test, attitude scales are used to monitor the skill development of individuals with special needs. In fact, the rate of studies stating that observation forms are used as data collection tools is 21.95%, although observation-based data is collected in most of the studies. In the literature, it is seen that data based on observation are generally collected. In the compilation study conducted by Khowaja et al. (2020), it is seen that observation-based data is the most used data collection method.

When the limitations of the studies are examined; It is seen that the cases of applying with a small sample group and not being able to observe the generalization of skills to real life are clearly mentioned in the studies. As Lee (2020) stated in his study; It is seen that the studies were conducted with a small sample group due to situations such as the necessity of spending more manpower and time in order to direct the research in the studies conducted for individuals with special needs, and the difficulty of working with these individuals.

In the suggestions of the studies, it was seen that suggestions were made to eliminate the situations stated in the limitations in general. When the findings are examined, it is seen that most suggestions are made for 'examination of other skill developments', 'working with a larger sample' and more detailed research. As mentioned before, the situations that could not be carried out in studies on this subject due to the difficulties, cost and time disadvantages of working for individuals with special needs were presented as suggestions.

When the results of the studies are examined, it is seen that the themes created are for positive situations. It has been concluded that in augmented reality supported learning environments for individuals with special needs, there is a general improvement in the targeted skills, individuals are willing to practice, the application draws their attention and interest, and increases their motivation. In 2 studies (S9 and S18), it was observed that there was no significant difference between the experimental and control groups in the skill development of individuals. Although there was no significant difference between the groups in this study, improvement was observed in the skills of the individuals in both groups. In all of the other studies, it is seen that there is an improvement in the skills of the individuals and that there are significant differences in favor of the augmented reality supported environments in the studies with experimental control groups.

5. Conclusion

Within the scope of the research, current augmented reality studies for individuals with special needs were examined. Along with the examinations, an overview of the studies carried out in this field was provided and information on the current situation was presented.

It has been observed that individuals with special needs are willing to practice, have fun while using the application, and their motivation and readiness levels increase with learning environments supported by augmented reality technology applications. It has also been observed that augmented reality is effective in the development of targeted skills and that these skills can be generalized to real life in some studies. As a result of all these examinations, it can be said that augmented reality technology can be an effective learning tool for individuals with special needs.

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