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The effectiveness of augmented reality environments on individuals with special education needs

Recep Cakir [1] · Ozgen Korkmaz [2]

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Abstract

The purpose of this study is determined as the design, development and effectiveness of the Augmented Reality (AR) environments aimed at providing individuals with special education needs. The developed AR teaching materials are thought to be useful in terms of allowing children with special education needs to meet their basic needs with their own efforts without being dependent on others. The design-based research design was used to conduct this study. Four teachers and 6 students constituted the group of the study. Design Observation Forms, Student Attention Observation Form and Criterion-Referenced Assessment Tools were used to collect data. According to the results, AR teaching material is appropriate and helpful in terms of contributing to the development of children with special education needs by bringing them real-life experiences. Moreover, it was observed that students were more eager and enthusiastic about the lesson during the course of application. Indeed, their level of readiness to the lesson increased, their interest in the subjects increased, and they were relatively more active and more likely to respond correctly to questions. In the light of results, the use of this developed AR environment in terms of the development of children with special education needs can be suggested.

Keywords Special education · Augmented reality · Real life experience · Design-based research · Using technology in special education · Students' performance

* Recep Cakir
recepcakir@gmail.com

Ozgen Korkmaz
ozgenkorkmaz@gmail.com

[1] Department of Computer Education & Instructional Technology, Faculty of Education, Amasya University, Amasya, Turkey

[2] Department of Computer Science, Faculty of Technology, Amasya University, Amasya, Turkey

1 Introduction

According to the I[st] and II[nd] Stage Education Program of the Special Education Application Center (School), the need for special education is a developmental disorder that shows limitations in social and communication skills such as initiating and sustaining interaction and is included within the pervasive developmental disorder (PDD) diagnosis group (Orgm 2013). In this program, it is emphasized that children with special education needs exhibit behaviors that differ according to each child such as persistence against the routine, repetitive interests and behaviors in developing age-appropriate peer relationships and in the functional use of the language for communication purposes. Therefore, it is necessary to organize the education and training process by taking into account these characteristics of children with special education needs. It is emphasized that it can be possible to enable children with special education needs to gain independent life skills, to reduce their behavioral problems and to acquire the skills they need by the provision of a structured and enriched learning environment in which appropriate education programs are applied from an early age (Orgm 2013). This is also highlighted in international studies. Such studies underlined that children with learning disabilities due to a wide variety of cognitive and physical disorders need more extra assistances in their learning processes (Adam and Tatnal 2017; Adam et al. 2006; Teoh et al. 2008).

The mathematics, reading and writing, physical education, visual arts, music, culture of religion and knowledge of ethics, social studies, language and speech development, nutrition education, social adaptation skills and traffic and first aid education courses have been included in the Special Education Application Center's program. While determining these courses, the characteristics of the development areas of children with special education needs are taken into consideration (Orgm 2013). Class and age grouping have not been applied to the objectives and behaviors in the program due to the mental, social, and physical characteristics and individual differences of children with special education needs. Meeting the needs of children who have been diagnosed with special education needs, developing their skills, the functional use of communication skills, have been taken as a basis for selecting the subjects in courses and organizing the objectives. The necessity of preparing an individualized education program is emphasized by considering the individual characteristics of the student within the objectives/behaviors to be included in the teaching phase of the program. In the program, it is emphasized that the Individualized Education Program (IEP) is a program that envisages the highest level of utilization of appropriate education environments and support services to meet the development of the individual with special education needs or the educational needs in the disciplines required by the program applied to that individual. Teaching activities for children who need special education can be planned based on the key point that the performance of these children is very different from each other due to their individual differences (Bölte et al. 2010; Browder et al. 2008). Browder et al. (2008), as a result of their meta-analysis, makes recommendations for more effective methods and practices in the education of disabled people with special education needs. In this context, many different teaching methods are suggested in the curriculum (Orgm 2013). While some of these methods can be used greatly in learning environments, some of them are rarely used because of the lack of infrastructure, teaching materials or experience. In particular, the modeling method

by video recording, computer-assisted teaching, and multi-sensory based teaching method can be considered in this context (Ayres et al. 2009; Doğan 2015; Yalçınkaya 2012)

The process in which students with special education needs produce a behavioral change by creating their own experiences with a constructive approach is a very difficult process (Yalçınkaya 2012). In particular, it cannot be expected from these students to create these experiences through trial and error in the natural environment (Eliçin 2015). Therefore, controlled environments to ensure children with special education needs gain experiences come to the forefront (Özgüç 2015). In this context, augmented reality practices are thought to provide an extraordinary contribution to special education.

In this study, the developed AR teaching materials offer the opportunity to act in an unreal space where the three-dimensional model created in the computer environment exists and significantly supports the comprehension and perception abilities. When it is viewed from this aspect, the developed materials are thought to be useful in terms of allowing children with special education needs to meet their basic needs with their own efforts without being dependent on others within equal opportunities and being useful to their family and the society. Accordingly, the purpose of this study was determined as the Bdesign, development and effectiveness of the AR environments aimed at providing individuals with special education needs with concrete experiences". In this context, answers were sought for the following questions:

1.1 Sub-problems

1. Is the prepared augmented reality teaching material appropriate to meet the real-life experience requirements of children with special education needs?
2. How does the prepared augmented reality teaching material contribute to the attention times of children with special education needs?
3. How does the prepared augmented reality teaching material contribute to the academic development of children with special education needs?

1.2 Literature review

In the studies carried out, it has been emphasized that interactive technologies such as multimedia technologies and 3D virtual technologies affect learning outcomes (Choi and Baek 2011; Dalgarno and Lee 2010; Yalçınkaya 2012). In the study for example, Yalçınkaya (2012) entitled as the development of social skills education in the computer environment with the web-based distance education system in children with mild mental disabilities, children with mental disabilities participating in different activities such as drawing on a drawing tablet, shooting short videos within the framework of planned, technology-enriched extra-curricular activities. The research results have shown that extracurricular activities enriched by technology have positively affected the cognitive and physical development of students. In his study on the effects of technology-supported extracurricular activities on students with mental disabilities, Doğan (2015) also concluded that extracurricular activities enriched by technology have positive effects on the cognitive and physical development of students.

Achmadi et al. (2012) performed an application for the use of speech production tool on the iPod device in children with ASD, and these applications were found to contribute to the development of children. In their study on the effectiveness of computer-assisted programs on the communication skills of children with ASD, Hetzroni and Tannous (2004) found that computer-assisted program has positive effects on improving communication skills of all subjects. Ayres et al. (2009) carried out a study in which the acquisition and generalization levels of chained skills along with the computer-assisted video teaching in children with ASD were examined. As a result of this study, it was observed that the students gained the skills in questions at the acquisition and generalization level by the computer-assisted video teaching method. As a result of the study of Cihak et al. (2010) including the least hint system, the use of video model with iPod Video to improve the transition skills of students with ASD who continued the general education class, they were found to act more independently in transitions. In a study carried out by Doenyas et al. (2014), it was aimed to provide students with ASD with ordering skills with a picture by the web-based iPad application, and this application was concluded to contribute to students. In a study carried out by Escobedo et al. (2012), an auxiliary tool in real life conditions was developed to support the social skills of children with ASD. As a result of this study, it was concluded that this tool facilitated the learning and application of social skills and strengthened social interaction qualitatively and quantitatively. In the study on the effectiveness of touchpad applications to improve the social skills of children with ASD, Hourcade et al. (2012) emphasized that tablet programs are effective for improving the social skills of ASD students. In summary, the use of technology-supported materials in education by visualizing the topics helps children with special education needs understand the real world situations and problems, and it is emphasized that such applications should be carried out on a regular basis (Doğan 2015). When the literature is examined in this sense, it is noteworthy that augmented reality technology emerged as noteworthy new technologies in the education process.

Augmented Reality (AR) is the reflection of a shape or any object viewed through computers or smartphones as an augmented reality by converting it into information, content, survey or visuals such as photograph and pictures on the screen to the user. When the literature is examined, AR is defined as receiving the image simultaneously as a result of connecting to specific points of the image with special software while the materials of real objects created on the computer are displayed on the camera (Dunleavy et al. 2009; Ivanova and Ivanov 2011; Kirner et al. 2012). In other words, AR is the fact that an object or shape displayed over computers or mobile devices are converted into visuals and that shape is displayed as if it were real on the screen to the user. In other words, this system allows you to see through the screen of the device in the palm of your hand that there is a moment or an event that is not in real life. AR enables the digital display of printed materials or objects. When that object or material is analyzed with the help of cameras in computers, mobile devices or tablets, the previously integrated digital or electronic contents are visible. Thus, it seems inevitable for printed materials to take place both on smartphones and tablet computers through the AR applications (Liu et al. 2010). With this system, it is also possible to add a phone number, picture, video, 3D model which can link to any web site as a digital content. The AR technology that has recently started to

be used at developed universities around the world especially enriches the education and training environments and makes learning more amusing and permanent (Bacca et al. 2014; Radu 2014).

The AR technology is seen as a technology capable of designing real-life, near-real-time educational materials with three-dimensional and visual richness. AR has recently attracted attention as a technology that adds virtual objects created through computers onto the real world, enabling them to drop virtual materials on them and allowing these objects to appear in the same space as the real world (Wu et al. 2013; Ibáñez et al. 2014; Cai et al. 2014). Another feature of the AR environments is that it is a technology that can coexist with the virtual reality and real world elements in the same environment by adding images, data and other contents to the real world (Solak and Cakir 2016). According to another expression, co-displaying at the same time process can be performed by adding predefined or designed virtual materials on the image of the real world by this technology. AR is also seen as an extension of the virtual reality. However, the virtual reality replaces the simulation of the real world and the existing reality, and this technology can be thought to be a bridge between reality and the virtual world (Cai et al. 2014; Lee et al. 2010; Solak and Cakir 2016). According to Azuma et al. (2001), the fact that the AR systems run through the combination of real and virtual objects in a real environment and virtual objects appear as real-time and interacting with each other is seen as an important feature.

The AR applications reflect the images with the logic that the data received from the real-world via the imaging device (camera or sensors, etc.) are passed through a process, and its image is transferred to the real environment. The processes of monitoring, sensing, imaging and interacting should be performed to be able to create reality in the AR applications (Küçük 2015). Software such as AR Toolkit, Studier Stube, Metaio, Layar, Aurasma, Vuforia enabling the realization of these processes has been developed (Krevelen and Poelman 2010). The visual pointer codes or physical objects to be detected by the AR system are used with this software. AR software allows the display of the augmented virtual content with the data it receives from the pointer on this defined pointer. Thus, the image in the book or written material is reflected on the screen as augmented reality due to the systems embedded in the contents prepared in book forms.

The AR applications are usually performed in high technology centers and universities and it seems that its adaptations have just started in the field of education. However, the spread of portable devices and computers with high technical specifications in which the AR applications can be implemented in recent years has accelerated studies in this field (Wu et al. 2013). The spread of smartphones and AR scanners, especially since 2007, has made this technology, which has attracted the attention of researchers, attractive in many fields (Krevelen and Poelman 2010). The development studies on the use of the AR technology in various fields, such as mobile communication, broadcasting, and advertising have been ongoing in recent years (Krevelen and Poelman 2010). It is stated in the literature that the AR technology provides students with benefits in many ways and also enables them to achieve significant gains when it is used in the education process (Bacca et al. 2014; Radu 2014). The AR applications are very effective in the education process in terms of facilitating meaningful learning and transfer. Such applications concretize the subject by visualizing the invisible structures or the structures with analogies created by simulation applications as three

dimensional and make complex issues more understandable (Wu et al. 2013). In addition, the provision of the interaction with the 3D view of the object from different angles improves the skills and abilities of students and enables them to gain practical application skills (Cheng and ve Tsai 2012; Hsiao and Rashvand 2011; Kerawalla et al. 2006). However, the AR technology provides instant feedback with its own real-time interaction and allows students to control their learning process (Bujak et al. 2013; Küçük 2015; Yuen et al. 2011).

It is seen that the AR applications provide different possibilities to ensure that students have access to the content and increase their effectiveness during the courses. Liu et al. (2010) suggest that all phone manufacturers will only produce smartphones in the near future, and this also means that it is at their fingertips that students have access to the AR content. It seems inevitable that the AR applications will take place both in smartphones and on tablet computers in the near future. The use of visual objects as 3D in the AR applications increases students' participation and motivates them by attracting them. In addition, it gives different perspectives on the subjects (Kerawalla et al. 2006).

The benefits of the AR applications in limited studies on teaching and learning practices can be summarized as follows;

1. It helps to teach experiments in the fields of astronomy, geography, chemistry, physics, etc. that are difficult to do in the real world, and the subjects that are complex to explain and costly (Shelton and Hedley 2002; Cai et al. 2014).
2. AR improves co-operation between student-teacher and student-student by enabling collaborative tasks (Wu et al. 2013)
3. It helps the development of student's creativity and imagination (Yuen et al. 2011; Klopfer and Yoon 2004)
4. AR can be applied for learning, entertainment or educational games by increasing the students' interaction with the real world (Cai et al. 2014; Ternier et al. 2012)
5. Students can receive customized education according to their own pace in the AR applications in which virtual trainer is used (Hamilton and Olenewa 2010; Makina and Salam 2011)
6. It has been found to be effective in teaching concrete concepts (Dori and Belcher 2005) and in the development of critical thinking and problem-solving skills of students (Dunleavy et al. 2009)
7. It is effective in increasing students' interest and motivation towards the course (Ibáñez et al. 2014; Di Serio et al. 2013; Solak and Çakır 2015)

In recent years, it has been noteworthy that technological developments such as AR have been actively used in the fields of education and training (Dalgarno and Lee 2010; Mikropoulos and Natsis 2011; Di Serio et al. 2013; Chen et al. 2016). While the original studies of the AR technology date back to the 1950s (Caudell and ve Mizell 1992), the expression of Augmented Reality was firstly used by Tom Caudell (Siltanen 2012). Milgram and Kishino (1994) proposed a mixed AR technology model that combines reality and virtuality. This model constituted the main principles of the AR technology in the development process (Cheng and ve Tsai 2012). In the study carried out by Azuma et al. (2001), it was stated that real and virtual objects are combined in a real environment, and attention was paid to the studies carried out on this issue with the

emphasis on providing interactive and virtual environments interacting with each other in real time. Di Serio et al. (2013) emphasize that very few studies have been carried out to prove these allegations although researchers see AR as a technology with great effects on the cognitive and affective learning of students. There are also researchers who try to apply the AR applications in elementary school and even pre-school education. The results of the study carried out by Silva et al. (2013) for the development of the reading-writing skills of first-grade primary school students with the AR technology showed that the materials developed with the AR technology increased the educational performance of students. Moreover, according to the results of the study, it was also noticed that teachers' efforts to use these materials were high. Shumaker (2013) used pre-school students as a means to improve learning processes and augmented reality content and analyzed their applicability. As a result of the study, it was found out that the AR environments make a significantly greater contribution to the development of students.

Some studies have started to be carried out, although they are limited, to prepare an environment for augmented reality in the recent times in Turkey, its importance and usage areas have recently started to be noticed. For instance, Tülü and ve Yılmaz (2012) developed an iPad application using the computer programming language (lens C), Unity 3D gaming application and the data matrix system. In the application, when you look at a target image specified by the developed application, an object that is not actually there seems as if it is on the application screen. When the target is rotated around the image or when the target is approached and moved away, it gives a feeling of approaching and moving away from a real object. In another study conducted by Erdoğan (2010), it was aimed to develop software to analyze the anatomical model desired by the user in real time in a 3D environment and to interact with it. In addition to the stated purpose of the software to be developed, it was aimed to simulate reactions under different load states in a 3D virtual environment in real time depending on the material properties of the models and to prepare the necessary hardware infrastructure. Consequently, the studies carried out with the AR technology have usually been technical, have been limited to software development studies, its adaptation to the field of education is not much seen. From among the limited studies, in the study carried out by Abdüsselam and Karal (2012), it was observed that students had shorter attention times and their interest is disrupted in traditional classroom and laboratory environments, however, students' attention times were increased due to the fact that the device used in the AR environment was integrated with technology, concretized the abstract concepts that were tried to be given to students and facilitated the comprehension. In the study carried out for university students, Çakır et al. (2015) concluded that the materials developed with the AR technology increased students' motivation for learning English. Küçük (2015) conducted a dissertation entitled as the effect of learning anatomy with mobile augmented reality (MAR) on the academic success and cognitive burdens of medical students, and students' opinions for practice. According to the study results, it was found out that the students in the experimental group in which the MAR applications were used were more successful and had lower cognitive loads compared to the students in the control group, and students' opinions on learning with MAR were positive.

In this context, in national and international studies, it has been seen that the AR technology has recently begun to be used in education-training processes and has had

positive effects on the performance of the students. In Turkey, it is obvious that increasing the number of these studies is important in terms of education and training processes. Consequently, based on the studies shared above, it is possible to conclude that AR contributes to students' academic success, attitudes and their attention times and that students positively react to such practices.

It can be said that children with special education needs are in need of real-life experiences to be able to correct their problematic behaviors and make them gain vital basic skills, therefore, activities to meet these real-life experiences and requirements are particularly emphasized in the curriculum. The studies carried out show that the effectiveness and efficiency of learning are directly proportionate to the resemblance of the content with real life (Di Serio et al. 2013; Cai et al. 2014). In other words, the effectiveness and efficiency of education increase as the resemblance and relationship of the content with real life increase. In this context, it is thought that augmented reality environments can meet these real life experiences that students need more easily and safely.

2 Method

2.1 Research design

In this study, the design-based research design was used. This method enables to obtain objective and in-depth information by using both quantitative and qualitative data together (Creswell and Clark 2007). The design-based study is the formative investigation of educational designs based on the theoretical basis (Collins et al. 2004) and is a research method emerging as a result of the need to move the interaction of design, theory, practice triple to a higher point (Kuzu and Çankaya 2011).

The steps of the design-based study may vary depending on the context. However, the path generally followed in this study is as follows: firstly, the AR environments for the topics which were included in the study by the researchers were designed and the first version of the design was developed. This developed version was applied with six students in the selected pilot school. How the design worked in practice was observed by researchers and practice teachers (two special education teachers), and the reactions of the students were measured. During the 8 weeks of the application, these observations were reviewed weekly, and the design was regularly examined by the researchers in accordance with the experience gained from the specified application, and the corrections were made. This cycle was carried out twice within the scope of this study for 8 weeks, and the errors of the design were corrected. The application steps adopted in this study are presented in Fig. 1.

According to Collins et al. (2004), there are several viewpoints that can be used to assess the success of the design. The environment is examined according to these viewpoints while analyzing the application of the design. These viewpoints can be summarized as cognitive level, interpersonal level, group or class level, resource level, and institution or school level. The cognitive level and interpersonal level were taken as a basis as the study was performed with children with special education needs and as experience-oriented within the scope of this study. At the cognitive level, the answer

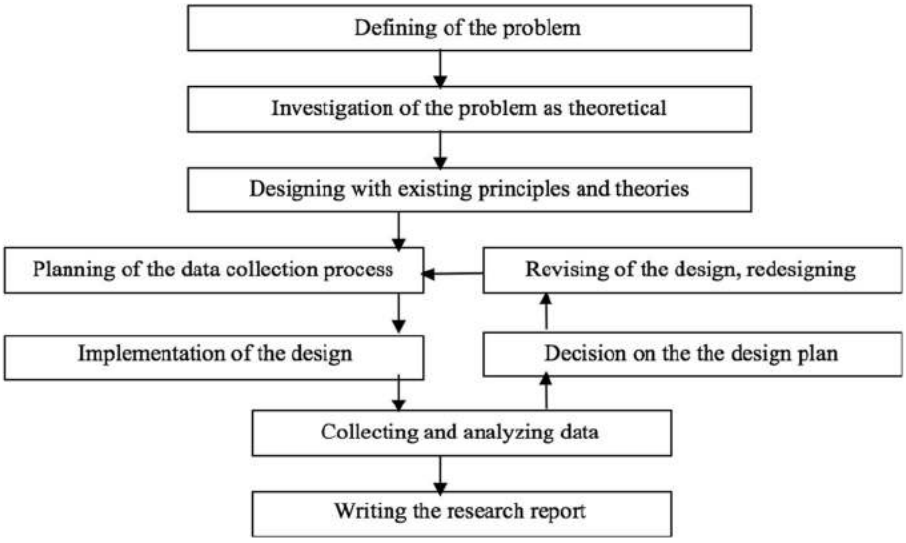

Fig. 1 Application steps of the design-based study (Kuzu and Çankaya 2011)

was sought to the question of Bwhat are the levels of comprehension and attention of the learners before the application, and how do their comprehension and attention vary during the application process?". The criterion-referenced assessment tools were used to reach this information. At the interpersonal level, what the reactions of the students to the teaching material designed in the group were, was investigated. For this purpose, the observation reports of both the application teachers and the class teachers were used.

2.2 Study group

Four teachers (to ask their opinions on the appropriateness of the designed AR material) and 6 students studying in the Special Education Application Center operating in Amasya city center constituted the study group of the study. This center a private institution serving under the supervision of the provincial directorate of national education. Institution has 40 students who have learning disabilities and need special education. It has also 8 special education teachers with more than 5-year experience in teaching learning disabilities. Teachers have special trainings and adequate experience in this field. In line with the opinions and approvals of these teachers, 6 students were selected for this application.

The individual characteristics of the students are as following:

SC: with Cerebral Palsy (CP) (partial paralysis of the brain): He has physical and hearing disabilities. He has a problem while talking. He has a moderate mental retardation. SÇ needs verbal help due to the language-speech inadequacy.
SK: with Cerebral Palsy (CP) (partial paralysis of the brain): There is a problem in seeing and hearing. He has a moderate mental retardation.
YG: Autistic moderately mentally retarded. He has behavioral problems.
AK: The growth retardation, moderately mentally retarded. No physical problem.

AA: There is a moderate mental deficiency with Down's syndrome. AA needs verbal help due to the language-speech inadequacy.
AH: There is a moderate mental deficiency with Down's syndrome. There is a physical growth retardation.

2.3 Teaching materials

During the study, the sample AR studies were carried out to determine the standards and potential risks of the augmented reality environments designed. In this context, the issues of the parts of the house, day and night, animals, occupations, seasons, the parts of the school, numbers, forms, traffic rules and relations between entities were discussed, and the sample augmented reality environments were prepared for these issues.

Cinema 4D, Unity 3D, Ar Media and Vuforia programs were used while creating the samples. The designs were created with Cinema 4D, and animations were prepared with Unity 3D. The prepared animations were made ready to use with Vuforia. In the sample AR material, a common input animation was initially prepared for the animations. Other animations can be accessed via this entry animation. The entry animation was composed of a falling house, bank and car, a garden surrounded by fences and a tree that can change according to weather events. Scenarios were first created while starting the animations, then, the objects needed to perform the scenario were designed. In this regard, the trial version of the AR environment to be used in the project was designed. The following examples can be given for the augmented reality environments that were included in the trial version:

1. Day and Night: As it is seen in Fig. 2a, b, the weather is dark when the animation first starts. But it is about to be morning. In order to create this feeling, the sun will start moving slowly behind the mountains. Shadows moving with the sun are visible. As the evening begins, the sun sets and then the moon appears.
2. Snow and Autumn: As it is seen in Fig. 3a, b, the floor is not green but white as there is an animation expressing snowfall. It will begin to snow in the environment. There will be snow accumulations on the ceiling of the house, on floors, trees, and banks. It is expressed that the snowy weather is cold by the fact that smoke is coming out of the chimney of the house. The meadows and tree leaves will begin

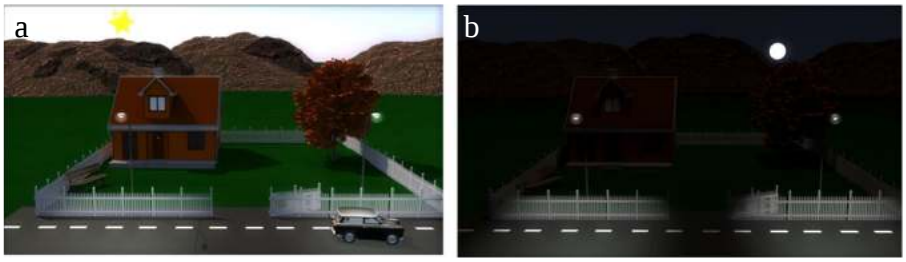

Fig. 2 a Daytime view. b Night view

to turn yellow as proceeding to autumn. There will be the wind in the environment, and the leaves of the tree fall with this wind.

3. Important Vehicles: As it is seen in Fig. 4, each important vehicle passes through the road in the entry animation created, and they play their own siren voices while passing. The lights that indicate the vehicle are also on.

A pre-designed marker suitable for the use and objective was determined in the augmented reality environment used in this study. This marker was designed for the camera to recognize it and work on animations. The objects prepared in Cinema 4D were converted into animations in Unity 3D program and prepared by taking a printout by Vuforia, AR program. The prepared media can work on both Android and IOS based devices.

2.4 Data collection tools

2.4.1 Design observation forms

The prepared augmented reality environments were introduced to the classroom teachers of the students constituting the study group, and model applications were performed. In addition, during the applications, the class teachers as well as the application teachers were in the application class and observed the designed AR environments. Interviews were held with these teachers by the researchers to determine teachers' observations.

2.4.2 Student attention observation form

In each application, students were observed every 30 s during the 10-min application process both before and after applying the AR materials, and whether they were interested in the teaching material at that time or something else which was out of the course was observed. These observations were also recorded on the attention observation form as + if they were interested in the teaching material and as - if they were not interested. Thus, an attempt to determine students' attention levels was made.

The form in Table 1 was filled in separately for the traditional teaching practice and then for the AR application every week for each student, and attention to the teaching material ratios were calculated.

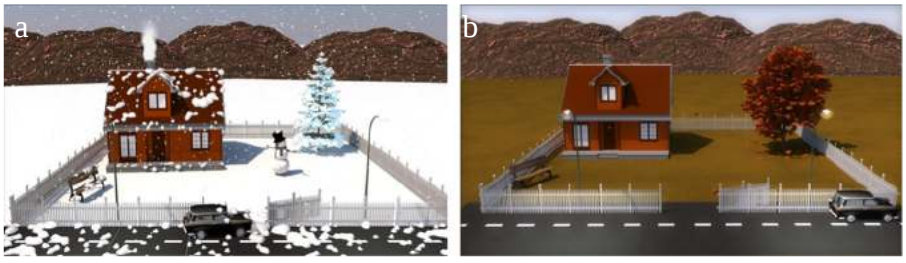

Fig. 3 a Snowfall. b Autumn

Fig. 4 Important vehicles

2.4.3 Criterion-referenced assessment tools

According to the program (Orgm 2013), the individual's level of being engaged in educational functions is defined as the description of what an individual can do, which is prepared based on detailed or rough assessment results. While it is stated that the description of the level of performance is extremely important for the development to be seen in the program, the fact that these descriptors ensure that evaluation results are clear and understandable and also that the certain needs of the individual are identified and prioritized are stated as the reasons for this.

In this context, two different evaluation processes as rough and detailed evaluation are proposed according to the curriculum (Orgm 2013). In the rough evaluation, whether or not the student shows the behaviors that underlie each objective is observed. The evaluation is made by marking as B+" if the behavior is shown, and as B- Bif it is not shown. In the detailed evaluation, the purpose in the multiple opportunity method is to determine whether the child can independently perform the each step of the skill or by which clue he/she performs it. The steps performed independently by the child are recorded as BindependentB in front of the relevant step in the criterion-referenced assessment tool. If the child cannot perform a skill step independently or performs it incorrectly, he/she is stopped and given a verbal clue about that skill level. If the child performs the skill step when he/she is given the verbal clue, it is recorded as Bverbal clueB in front of the relevant step in the criterion-referenced assessment tool. Even if the child cannot perform the skill step when verbal clues are given, the teacher performs that skill step by explaining with the materials in front of him/her and asks the child to do it. If the child performs the skill step when the teacher shows the skill step by explaining, it is recorded as Bbeing a modelB in front of the relevant step in the criterion-referenced assessment tool. If the child cannot perform the skill step when the teacher is a model, it is recorded as Bphysical help" in front of the relevant step in the criterion-referenced assessment tool.

Within the scope of the study, the BCriterion-Referenced Assessment Tool" was developed separately for each objective, and the assessment tools were ensured to be

Table 1 Student attention observation form (sec)

1. 30	2. 30	3. 30	4. 30	5. 30	6. 30	7. 30	8. 30	9. 30	10.30
11.30	12.30	13.30	14.30	15.30	16.30	17.30	18.30	19.30	20.30

filled by making observations by two separate teachers for each student. In the assessment tool, the skill levels expressed by Success (S), Verbal Clue (VC), Being a Model (BM) and Physical help (PH) were scored as 4, 3, 2 and 1, respectively, the point value given for each behavior was determined. Each objective was scored by taking the sum of behavior points. The discussion of incompatible assessments was provided by teachers, and the re-assessment process was performed with two teachers in case of the lack of consensus. Thus, an attempt to ensure that the assessment process would be valid and reliable was made.

All the scales used in the study process are observation-based measurement tools. Therefore, observations were conducted separately by two practice teachers to ensure the validity and reliability of these measurement processes. Video recordings were also taken during the practices based on the permits taken from school administrators and students' parents. Each observation was discussed and an attempt to reach a consensus was made by resorting to video recordings in cases where there were differences by comparing the observation results obtained.

2.5 Implementation

The teaching application performed using augmented reality materials lasted for 8 weeks. The detailed lesson plans were made separately for each week. All of the applications are in the form of individual application with the group. In other words, the basic information about the topic was given by the practice teacher at the beginning and the AR teaching material was brought to the classroom by being projected on the screen through projection. Then, each student was provided with a tablet, and students were ensured to monitor and interact with the present subject-specific AR application individually. Every week, the application was performed for two course hours (90 min). In all groups, the applications were performed by two practice teachers who are experts in special education at the application workshop. Both teachers were in the same classroom for all applications, one of them was making the observation while the other one was performing the application. These teachers are the teachers who also gave lessons apart from experimental applications, are recognized by students and the presence of which in the classroom is seen normal.

The applications were also recorded during this interaction by making observations. The criterion-referenced assessment tool prepared for each subject was evaluated using before and after teaching. The verbal support was provided in answering the questions asked to AA and SÇ who had language and speech problems. The students who did not participate in weekly application lessons during the application process were excluded from the assessment made in that week. In this context, the activities performed during the first three weeks can be summarized as following in terms of setting an example (Table 2):

In the other weeks, the subjects of the season of winter, sound education, the season of spring, the season of summer and the parts of the school were addressed in a similar way.

2.6 Data analysis

In this qualitative based study, the collected qualitative data were analyzed by the document review method. The participation times of the students were observed by

Table 2 Activities performed during the first three weeks

Week	Subject	Application
Week 1	The meaning of the lights in traffic signals for pedestrians	The teacher tried to attract the attention of the student on the subject by stating that he saw the traffic lights on the way to school and crossed over using the traffic lights. He introduced the subject by stating that he stopped when the red light was on, got ready when the yellow light was on and crossed over when the green light was on. The traffic environment was transferred to the classroom by using the augmented reality program to support these expressions. This point was focused by means of the program while the teacher was explaining the traffic lights, and what the lights mean was also taught, and the vehicles in traffic were also introduced to students during this expression. At the end of the course, an attempt to reinforce the subject was made by repeating the subject. Tablets were distributed to students after this repetition, and the relevant section was opened and the students were allowed to travel in the virtual environment through the tablets, and how the traffic light works was taught by the teacher by focusing on the traffic light. At the end of the course, the assessment was made according to the steps in the criterion-referenced assessment tool using the AR environment and mini traffic material.
Week 2	Seasons - autumn season	The teacher speaks about daily weather condition to attract students' attention to autumn. The teacher, who tried to attract attention to the subject by asking questions about the weather condition outside, introduced the subject of autumn with the help of the AR environment program after a while. The teacher shows the situations such as the changes in the air during the autumn season, raining, severe blowing of the wind and increase of the clouds with the help of the projection using the AR teaching material. The education was assessed by asking students questions about the subjects told. Successful students were rewarded with crackers. At the later stage, students were informed about the changes around us during the autumn season and their effects on people with the help of the augmented reality teaching material. Trees with leaves that turn yellow and fall down, fading of flowers, migration of storks, carrying umbrellas to protect from rain, and the fact that students go to school were explained to the students through the program. It was aimed to reinforce the subject by repeating the subjects at each stage. The use of the augmented reality teaching material in these short repetitions enabled students to focus their attention on the subject. After a short repetition, the tablets were distributed to the students to make what students learned permanent and reinforce the subject, and they were ensured to examine and use the images related to autumn by focusing on what they wanted using the program individually. After performing the overall subject repetitions after the course, students were asked to answer the questions about the subject. Those who answered the questions correctly were rewarded.

Table 2 (continued)

Week	Subject	Application
Week 3	Mathematics - rhythmic counting	The teacher entered the classroom by counting rhythmically up to 10 while starting the lesson to attract the attention of the students and asked the students to guess by giving the students clues about what he would teach in that lesson. After this section, the teacher started the lesson by expressing that they would learn the numbers in this course and they would count them all together. The teacher used the augmented reality teaching material by projecting it on the stage while teaching the numbers. While the teacher was saying the number 1, the number 1 in the augmented reality teaching material came in front of the students by walking and introduced itself as BI'm number 1". At that time, 1 ball dropped down. This process was performed for numbers up to 10. The numbers were aimed to be permanent by being repeated frequently. At the end of the lesson, the individual use of the AR teaching material was provided by distributing the tablets to the students. It was noticed that the students began to use the tablets independently as of the 3rd week. The students' attendance to the lesson and listening to lessons by following rules were rewarded.

filling in the form in Table 1 separately for the traditional teaching practice and then for the AR application every week for each student. Then, attention to the teaching material ratios were calculated and compared.

3 Findings

3.1 Teachers' opinions about the appropriateness of the augmented reality environments to meet the real-life experience requirements of children with special education needs

The opinions of the classroom teachers of the students, who followed the applications and constituted the study group, were taken on whether the developed AR teaching environments were appropriate for children with special education needs and in terms of bringing them real-life experiences. In this context, teachers' opinions can be summarized as following:

> Teacher AI (AK's Teacher): The fact that our student named AK was eager to participate in lessons in which the project was applied attracted our attention. During the days of the application, the student frequently asked when he would come to the course and when he would use the tablets in the application. After the application time was over, AK happily came to the classroom and excitedly told what they did in the application and the subjects they learned. The statement of classroom teacher AI Bthe fact that AK's level of readiness for the course was quite high when we started to teach the season of spring compared to his situation at the beginning of the application, and that AK was better than the other students in terms of the permanence level of the subject among the students after teaching the subject attracted our attention" is considered to be extremely important.
> Teacher YB (YG and AH's Teacher): It is remarkable that two of our students eagerly participated in the application courses. In particular, the fact that YG with distractibility told excitedly and long-term what were done after the application, and that he answered my questions related to the course taught reveal the effect of the application on the student. AH started to tell what he did in the project application as soon as he entered the classroom without being asked by us. It is observed that the transfer of subjects into the class environment increased student's interest in the subject, and the fact that they led the course using their own tablets was more effective compared to the traditional lecture that we apply in the classroom.
> Teacher BB (AA's Teacher): AA was a student who was introvert due to the lack of language and speech insufficiency, had a problem of self-confidence, and thus had difficulties in participating in activities. However, the fact that he was eager to participate in project application courses and went out of the classroom to go to the application class to participate without any objection surprised me as his teacher. This structure of our student causes us to have difficulties in the study of making a sound during the courses. However, the fact that my student gave reaction to us in giving some subjects and did not any difficulty in making a sound after these project applications has attracted our attention. When we talked to practice

teachers, it was found out that we taught the same subjects and therefore our students' reaction level increased.

Teacher AK (SC and SK's Teacher): My two students participated in the application lessons eagerly and without any objection. It is remarkable that students who returned to the classroom after application, especially SK were eager to tell something about the course taught during the application. It takes some time for them to get rid of the effect of the project application after returning from the application. SK continued to talk about the applications during lectures, and revealed the effect of the applications by saying Byes, we have learned it in the other class". While the lights and traffic rules in traffic class were taught in the classroom, SK was relatively more active than non-participating students and had a higher level of answering the questions correctly. While the students who did not participate in the application, among the students who were assessed after the subject of Seasons was taught, showed two of four seasons correctly, the students who participated in the application showed all of them correctly. In particular, the fact that SÇ was successful in the questions asked about the seasons and the characteristics of seasons reveals the success and permanence of these applications.

When the above opinions are examined, it is seen that teachers usually mentioned the following themes about students for the AR applications:

- They are very eager and enthusiastic to participate in courses where AR is applied.
- He reveals his impatience by frequently asking when to go to class, when to use the tablets.
- They happily return to the traditional class after the application.
- It was observed that the level of readiness to the course was considerably higher than that at the beginning of the course.
- The student was better than the other students in terms of the permanence level of the subject.
- The transfer of subjects into the class environment by concretizing increases student's interest in the subject.
- The fact that they lead the course using their own tablets seems to be more effective.
- It is remarkable that the student gave a reaction in some subjects and did not have any difficulty in making a sound after these applications despite the problem of self-confidence.
- The student continued to talk about the applications during lectures and revealed the effect of the applications by saying Byes, we have learned it in the other class".
- The student was relatively more active than non-participating students and had a higher level of answering the questions correctly.

Based on these opinions, it can be said that the designed AR teaching material makes positive contributions to students' levels of willingness, enthusiasm, motivation, self-confidence, academic achievements, persistence and readiness levels, and that the developed AR teaching material is appropriate and sufficient in terms of contributing to the development of children with special education needs by bringing them real-life experiences.

Table 3 Students' attention times to the course

Weeks	Students	Traditional Practice	AR Application		Weeks	Traditional Practice	AR Application	
		Participation	1. Course Participation	2. Course Participation		Participation	1. Course Participation	2. Course Participation
1.	SK	40	100	100	5.	40	100	100
	SÇ	40	70	–		–	–	–
	AA	30	45	65		30	70	65
	AH	50	95	85		30	90	85
	YG	50	70	65		30	65	65
	AK	40	100	75		50	80	75
2.	SK	50	100	100	6.	40	100	100
	SÇ	30	55	85		–	–	–
	AA	–	45	55		–	–	–
	AH	50	100	80		60	85	100
	YG	10	60	70		40	70	75
	AK	40	95	100		30	85	100
3.	SK	40	100		7.	40	100	95
	SÇ	50	75	70		30	–	80
	AA	40	55	60		30	50	55
	AH	50	–	70		40	100	90
	YG	50	55	–		20	75	75
	AK	50	100	90		30	100	100
4.	SK	40	100	100	8.	40	100	100
	SÇ	40	–	100		–	–	–
	AA	30	50	90		30	70	45
	AH	10	100	–		30	90	100

Table 3 (continued)

Weeks	Students	Traditional Practice	AR Application		Weeks	Traditional Practice	AR Application	
		Participation	1. Course Participation	2. Course Participation		Participation	1. Course Participation	2. Course Participation
	YG	30	85	90		30	65	70
	AK	40	85	90		40	80	80
Mean	SK	41	100	99				
	SÇ	38	67	67				
	AA	32	55	62				
	AH	40	94	87				
	YG	33	68	73				
	AK	40	91	89				

3.2 The contribution of the augmented reality teaching material to the attention times of the children with special education needs

The contributions of the AR teaching material to the students' attention times for the course and teaching material by weeks are presented in Table 3.

When Table 3 is examined, it is seen that the students' attention times during traditional teaching are between 10% and 60%, and there is not any significant change by the weeks. When the eight-week average attention times during the traditional teaching practice are examined, it is seen that SK, SÇ, AA, AH, YG, and AK could focus their attentions on the course or teaching material during 41%, 38%, 32%, 40%, 33% and 40% of 10-min course, respectively. Accordingly, it can be said that the students were interested in the course or teaching material only about 4 min of the 10-min traditional teaching practice.

In Table 3, it is seen that the 8-week attention times of the students during the teaching application performed with the augmented reality teaching material varied between 45% and 100%, and there was no significant change by the weeks. When the eight-week average attention times during the experimental teaching practice are examined, it is seen that SK's attention time in a 10-min course increased from 41% to 100%. SK had a moderate mental disability as well as sight and hearing impairment. The fact that the attention time increased from 45% to 100% despite the sight and hearing troubles can be considered as an indicator of the fact that the augmented reality teaching material will be effective in children with sight and hearing troubles.

It is seen that AH's attention time increased from 40% to about 90%, AK's time increased from 40% to about 90%. AH had physical growth retardation as well as the moderate mental retardation. AK had no physical growth retardation, unlike AH, despite having a moderate level of mental retardation. The fact that the attention time of AH increased from 40% to about 90%, in a similar way to AK, despite the physical growth retardation, can be considered as an indicator of the fact that the augmented reality teaching material will be effective in children with physical growth retardation.

The attention time of YG increased from 33% to about 70%. It is possible to say that this increase is slightly less than the other students. When the personal characteristics are examined, it is seen that YG is a romantic student with some negative behaviors depending on age and condition. Nevertheless, an increase in the attention time from 33% to about 70% can be considered as an indicator of the fact that the augmented reality teaching material will be effective in children with behavioral problems.

The attention times of SÇ and AA increased from 38% to 67% and from 32% to 58%, respectively. These are the students whose attention times increased at the lowest level in the study group. When the personal characteristics of these two students are examined, it is seen that they both need verbal help due to the lack of language-speech inadequacy. Accordingly, it can be said that the AR teaching material makes less contribution to the attention times of the students who need verbal help due to the lack of language-speech inadequacy compared to other students.

Table 4 Students' criterion-referenced assessment results regarding the life science

Course name:		Life science course									
Objective	Questions/Instructions	Criteria	Preliminary assessment (Pre test)					Post assessment (Post test)			
			RE	S	VC	BM	PH	RE	S	VC	BM	PH
Objective 50–52. Knows the changes in autumn / winter.	1. Displays weather changes from a variety of materials.	4/5	–	–	–	–	–	++++++	++++++			
	2. Tells the changes in the air.	4/5	–	–	–	–	–	++++−-	++++−-	++		
	3. Shows the changes in plants from various materials.	4/5	–	–	–	–	–	++++++	++++++			
	4. Says changes in plants.	4/5	–	–	–	–	–	++++−-	++++−-	++		
	5. Shows the changes in animals from various materials.	4/5	–	–	–	–	–	++++++	+++−++			
	6. Tells the changes in the animals.	4/5	–	–	–	–	–	++++−-	++++−-	++		
	7. Shows the changes in our clothing from various materials.	4/5	–	–	–	–	–	++++++	++++++			
	8. Tells the changes in our clothes.	4/5	–	–	–	–	–	++++−-	++++−-	++		
	9. Shows the changes in our food from various materials.	4/5	–	–	–	–	–	++++++	++++++			
	10. Tells the changes in our food.	4/5	–	–	–	–	–	++++−-	++++−-	++		
Objective 7: Knows the parts of the school.	1. Shows the part spoken	4/5	–	–	–	–	–	++++++	++++++			
	2. Tells the name of it, when the part is shown	4/5	–	–	–	–	–	++++−-	++++−-	++		
	3. Tells the school sections.	4/5	–	–	–	–	–	++++−-	++++−-	++		
	4. Tells the work done, when the name of the sections is mentioned	4/5	–	–	–	–	–	++++−-	++++−-	++		

Table 5 Students' criterion-referenced assessment results for traffic, reading and writing and mathematics courses

Course name:		Traffic, Literacy, Mathematics										
Objective	Questions/Instructions	Criteria	Preliminary Assessment (Pre test)					Post assessment (Post test)				
			RE	S	VC	BM	PH	RE	S	VC	BM	PH
Objective: Knows the meaning of the traffic lights used for the pedestrians.	1. Tells the need to stopped in the red light	4/5	–	–	–	–	–	++++−-	++++−-	++		
	2.Tells the necessity to cross when the green light is on.	4/5	–	–	–	–	–	++++−-	++++−-	++		
Objective: Writing / reading according to the rules of letters	1. Writes/Reads capital letters with arm and hand movements at the desk etc.	%100	–	–	–	–	–	++++−-	++++−-	++		
	2. Writes/Reads capital letters with objects.	%100	–	–	–	–	–	++++−-	++++−-	++		
	3. Write/Reads capital letters in line range	%100	–	–	–	–	–	++++−-	++++−-	++		
	4. Writes/Reads small letters with arm and hand movements at the desk etc.	%100	–	–	–	–	–	++++−-	++++−-	++		
	5. Write/Reads small letters in line range	% 100	–	–	–	–	–	++++−-	++++−-	++		
Objective: Counting with rhythmic	1. Counts one by one rhythmic, from 1 to 10	4/5	–	–	–	–	–	++++−-	++++−-	++		
	2. Counts one by one rhythmic, starting from any given number to 10	4/5	–	–	–	–	–	++++−-	++++−-	++		
	3. Counts one by one rhythmic with objects, from 1 to 10.	4/5	–	–	–	–	–	++++−-	++++−-	++		

3.3 The contribution of the augmented reality teaching material to the academic development of children with special education needs

The academic development of students was evaluated firstly by rough evaluation (RE) and then in detail before and after the application using the criterion-referenced assessment tool. The results of these assessments were collected in one form for each unit and for all students. The markings in each category on the form belong to SK, AH, AK, YG, AA, and SÇ, respectively. Moreover, the skill levels are expressed by Success (S), Verbal Clue (VC), Being a Model (BM) and Physical help (PH).

Students' criterion-referenced assessment results for the life science course are summarized in Table 4.

When Table 4 is examined, it is seen in the rough evaluation that none of the students had skills related to the variables in the Autumn/Winter seasons and the parts of the school before the application on the augmented reality material. As a result of the detailed evaluation made, it is seen that students cannot show these skills independently and also cannot show by verbal clue, being a model and physical help. In the rough evaluation made as a result of the application, it was observed that all students except for AA and SÇ could perform the skills related to seasons and the school sections, but AA and SÇ could not perform them. In the detailed evaluation made, it was seen that while SK, AH, AK and YG could perform these skills independently, AA and SÇ could perform these skills with the help of verbal clues. As it was mentioned previously, AA and SÇ need verbal help due to the lack of language-speech as well as the moderate mental retardation. Accordingly, it can be said that while the augmented reality teaching material contributes to the performance of the students with language-speech difficulty at the verbal clue level in all skills in the subjects of seasons and school sections in the science life, it contributes to the development of all other students including the students with physical development retardation and behavioral problems at the level of the independent realization.

Students' criterion-referenced assessment results for traffic, reading and writing and mathematics courses are summarized in Table 5.

When Table 5 is examined, it is seen as a result of the rough evaluation (RE) that none of the students had skills related to the meanings of the lights in traffic lights used for pedestrians, reading/writing the letters according to the rules and rhythmic counting before the application on the augmented reality material. As a result of the detailed evaluation made, it is seen that students cannot show these skills independently and also cannot show by verbal clue, being a model and physical help.

In the rough evaluation made as a result of the application, it was observed that all students except for AA and SÇ could perform these skills, but AA and SÇ could not perform them. In the detailed evaluation made, it was seen that while SK, AH, AK and YG could perform these skills independently, AA and SÇ could perform these skills with the help of verbal clues. As it was mentioned previously, AA and SÇ need verbal help due to the lack of language-speech as well as the moderate mental retardation. Accordingly, it can be said that while the augmented reality teaching material contributes to the performance of the students with language-speech difficulty at the verbal clue level in all skills related to the meanings of the lights in traffic lights used for pedestrians, reading/writing the letters according to the rules and rhythmic counting as well as in the science life course, it contributes to the development of all other students

including the students with physical development retardation and behavioral problems at the level of the independent realization.

4 Conclusion and discussion

According to the results of the study, it is seen that the developed AR teaching material is appropriate and sufficient in terms of contributing to the development of children with special education needs by bringing them real-life experiences. It was observed that students were more eager and enthusiastic about the lesson during the course of application, they were happy at the end of the lesson, their level of readiness to the lesson increased, they were impatient about buying the tablets, their permanence level was higher, their interest in the subjects increased, their self-confidence increased, and they were relatively more active and more likely to respond correctly to questions compared to students who did not participate in the study, and they were more successful. According to the results, students show that they are interested in the course or the teaching material only about 4 min of the traditional 10-min teaching practice. Students become distracted in the remaining six minutes. The AR teaching material significantly increases the attention times of the children with vision and hearing problems, physical growth retardation and behavior problems as well as the children with special education needs. However, it makes less contribution to the attention times of students who need verbal help due to the lack of language-speech compared to other students. It was determined by the rough evaluation that none of the students had the skills related to the application subject before the application regarding the AR teaching material. As a result of the detailed evaluation made, it was seen that students cannot show these skills independently and also cannot show with a verbal clue, being a model and physical help. Besides, while the AR teaching material contributes to the performance of the students with language-speech insufficiency at the verbal clue level in all skills on life science lessons, seasons and school sections along with the meanings of the lights in traffic lights used for pedestrians, reading/writing the letters according to the rules and rhythmic counting, it contributes to the development of all other students including the students with physical development retardation and behavioral problems at the level of the independent realization. In brief, it has been concluded that the designed AR teaching material makes positive contributions to the students' levels of willingness, enthusiasm, motivation, self-confidence, academic achievements, persistence and readiness levels. Although there is not enough evidence regarding the direct contribution of augmented reality to children with special education needs in the literature, it is possible to find evidence for the contributions of technology-supported environments (Alghabban et al. 2017; Ayres et al. 2009; Bakker et al. 2016). In this context, Herrera et al. (2006), in their study in which they used the virtual reality in teaching individuals with autistic spectrum disorder (ASD) abstract concept and imagination, emphasized the importance of making real-life examples three-dimensional with certain software programs. The virtual reality based adaptive behavior technology was developed for children with ASD by Lahiri et al. (2013), and they found out a visible increase in the performances and social communication skills of ASD subjects.

As can be seen, the findings of this study support the studies examined in the literature. It is seen that students who have learning difficulties develop their skills in

technology supported environments positively. This may be due to students' interest in technology-enriched environments. As a matter of fact, the findings obtained from the interviews with the teachers and the results of the observation support this statement. Therefore, it is recommended to continue the practices of these environments in line with the opinions of the teachers. Especially new approaches such as AR can be tried in different applications in classroom environments of individuals with Special Education Needs.

Within the scope of this study carried out, it can be said that the results obtained based on teacher observations are also consistent with the literature. In similar studies in Turkey, it is seen that there are studies regarding the fact that technology-supported environments positively affect the cognitive and physical development of students with mental retardation (Doğan 2015; Yalçınkaya 2012). In another study carried out, the applications in which simple-level devices and timers such as cassette players with audio output and audio recording feature used with visual and written hints, and tape recorders were used were defined as the Bapplications using technology at the moderate level", it was emphasized that this application was used in teaching autistic children academic skills, communication skills, language skills and social skills, and also they were used in reducing the problem behaviors of autistic children, increasing their attention and motivation and improving their organizational skills (Eliçin 2015). In the same study, video camera, computer, tablet computer, computer or television with touch screens, smartphone, and various software were classified as advanced technologies. It was emphasized that the applications using these technologies are effective in reducing the problem behaviors of autistic children, providing them with social skills, academic skills, and self-care skills, that autistic children learn more effectively with touch screens, alternative mice, and keyboards. It was also emphasized to provide important contributions in terms of language skills, social skills, problem-solving skills in addition to the skills described above. According to this classification made by Eliçin (2015), it can be said that the augmented reality needs to be evaluated in advanced technologies.

As a limitation, this study was carried out with only 6 students because of the difficulty of conducting study with individuals in need of special education. According to the feedback from the teachers, these students behaved more differently than their normal classes. However, by conducting a different study, two groups of students with similar characteristics can be compared and the differences can be revealed more in depth and comparatively.

Consequently, when it is taken into account that the AR applications have recently begun to be used actively in the fields of education and training, it can be said that the augmented reality environments that include the subjects of house sections, day and night, animals, occupations, seasons, school sections, numbers, forms, traffic rules and relations between entities for children with special education needs within the scope of this study are suitable environments to meet children's real-life experience needs and make important contributions to the attention times and academic developments of students. In this context followings can be suggested;

1. The use of this developed environment in terms of the development of children with special education needs

2. Increasing the augmented reality environments for different subjects for children with special education needs
3. Designing and spreading classrooms with substructures like tablet and projection device in special education schools in addition to augmented reality teaching materials can be proposed.

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