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Research Article

The effect of digital storytelling on geometry performance: a study on students with special needs[1]

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Abstract

The main purpose of this study is to determine the effect of geometry lessons taught through digital stories in the support education room of full-time inclusion/integration students studying at the secondary school level on student performances. In order to examine the effect of digital story teaching material on students' geometry performances, a one-group pretest-posttest quasi-experimental model was applied. At the beginning of the research process, the "Geometry Performance Test" created by the researcher was administered to the students as a pretest in the form of a short-answer test. After eight weeks of lessons in the support education room, the same performance test was reapplied to the students as a post-test. The research group was formed by criterion sampling, one of the purposive sampling methods, and students with skills such as answering questions, reading and writing were included in the study while Individualized Education Plans (IEP) were being prepared within the scope of full-time inclusion/integration education. In this context, the study was conducted with a total of 15 students diagnosed with four speech and language disorders and 11 students diagnosed with specific learning disabilities. The data obtained during the research process were analyzed with dependent groups t-test. It was determined that the difference between the students' pre-test and post-test scores was statistically significant and showed a result in favor of the post-test. These findings show that the digital storytelling method positively affects the performance of students with special needs in geometry lessons. Based on the results of the research, it is recommended that the QR code application in the Ministry of National Education of Turkiye textbooks should also be provided for students with special needs and the content should include digital stories related to the subject.

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Introduction

Students with special needs constitute an important component of our education system and their educational needs play an important role in the overall structure of society. Since one of the main goals of education systems is to ensure that all students have access to equal learning opportunities, the integration of students with special needs into general education classes, that is, mainstreaming education, has gained increasing importance in recent years. In our country, students with special needs are identified as severely, moderately and mildly deficient as a result of educational evaluations. Students with mild intellectual disabilities are included in the scope of mainstreaming/integration by

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making some changes in school environments in order to make their educational lives more efficient (Ministry of National Education [MoNE], 2013). Mainstreaming/integration education envisages full- or part-time education of students with special needs together with their peers in general education classes (MoNE, 2017). In this process, students are not organized according to the school, but the school is organized according to the students and every school is considered an inclusive school (Batu & Kırcaali İftar, 2011). In our country, support education services are provided to students who are subject to full-time mainstreaming/integration education and to students with special needs. While students with special needs are educated in the same classroom with their peers, they are taken out of their classrooms and educated in a different environment in order to receive support in areas where they need extra work (Batu & Kırcaali İftar, 2011). In the education carried out in the support education room, it can be said that the Individualized Education Plan (IEP), prepared in accordance with individual differences to meet students' needs, is an important element (Martin, Van Dycke, Greene, Gardner & Lovett, 2006). The Individualized Education Plan (IEP) is a document that specifies what the target behaviors are, how, where, for how long and when they will be acquired. In order to determine the degree of achievement of the goals, the evaluation method and the criteria used in the evaluation are also included in this document (Kargın, 2007). As a result, in order to meet the educational needs of all students with special needs studying in general education classes, Individualized Education Plans are prepared and educational activities are carried out in the support education room.

Mathematics has an important place in many areas of the lives of both students with normal development and students with special needs and includes skills that all individuals should acquire (Karabulut & Yıkmış, 2010). In order to improve the quality of life of individuals with special needs, it is necessary to develop mathematical thinking skills as well as numerical competence (Monei & Pedro, 2017). While individuals with normal development can discover mathematics naturally before starting school (Alptekin, 2015), individuals with special needs learn mathematical concepts and skills more slowly and need more attention than their peers. This is because mathematics involves the skills of understanding, comparing, and establishing complex relationships (MoNE, 2001).

Many studies have found that the academic achievement of individuals with special needs in mathematics is lower than that of their typically developing peers (Jitendra, Rodriguez, Kanive, Huang, Church, Corroy& Zaslofsky, 2013).This may be due to difficulties in basic skills such as attention, discrimination, and organizing information; rapid forgetting of information is also a factor affecting this situation (Green, Hughes & Ryan, 2011; Pullen, Lane, Ashworth & Lovelace, 2011; Çifci-Tekinarslan, 2014; Ege, 2006; Petner-Arrey & Copeland, 2014). Recall difficulties and weaknesses in visual and auditory perception of individuals with special needs are related to the attention level of the student in educational processes (Beirne Smith, Patton & Kim, 2006). Since individuals with special needs have short attention spans, they need more stimuli especially in teaching abstract concepts. These difficulties usually start in primary education and continue in secondary education (Miller & Mercer, 1997). The traditional methods of teaching mathematics to individuals with special needs make the teaching of abstract concepts even more difficult (MoNE, 2001). In this context, it is important for teachers to use different methods, techniques and materials in educational processes (Güven, 2009). Stein, Kinder, Silbert and Carnine (2006) state that multiple representation methods are effective in overcoming the difficulties experienced by students with special needs in mathematics learning. Concrete materials, visual supports and technological tools can facilitate the understanding of abstract mathematical concepts. Therefore, integrating technology into the educational environments of students with special needs allows them to meet their educational needs and to perform activities that cannot be performed in the traditional environment (Israel, Marino, Delisio & Serianni, 2014). Studies by Ok, Bryant and Bryant (2009) show that computer-assisted instructional practices have positive effects on the mathematics achievement of students with special needs and improve their attitudes towards learning. In this context, the interactive and multimedia elements offered by digital stories have the potential to attract students' attention and increase their motivation to learn mathematics (Chigona, Gachago, Ivala & Chigona, 2012). Robin (2016) defined digital stories as stories that are used to present the desired information by combining components such as graphics, recording, video, text and music. In recent years, digital stories that bring technology and education together have become a frequently used teaching material (Duman & Göçen, 2015). Digital stories are an effective

learning tool in the classroom environment by creating their own stories with different experiences such as choosing the story, doing research on the subject, writing a scenario, collecting pictures and recording (Robin, 2016). Younger students are motivated to learn the course content better by sharing their knowledge gained through computer-based materials such as digital stories in the classroom environment (Foley, 2013). In this process, students develop their communication skills as they apply what they have learned in the stages of researching, organizing information, analyzing their own information and sharing it with the class. It can also help students develop their creative thinking skills and support them to reveal their unrecognized talents. In this context, digital storytelling is used as an effective method in education by including the processes of writing and digitizing stories with multimedia tools (Akgül, 2018). For this reason, digital stories have become a recommended educational material for teachers and students to communicate with each other and gain research skills from preschool to higher education (Di Blas, Garzotto, Paolini & Sabiescu, 2009).

With the development and increased use of technology, digital stories have started to replace traditional stories (Condy et al., 2012). The difficulties encountered by students with special needs in learning mathematics are generally due to cognitive limitations, working memory capacity, attention span, and speed of information processing. Swanson and Jerman (2006) emphasize the importance of cognitive strategy instruction in overcoming these difficulties. For this reason, digital storytelling can reduce cognitive load and have positive effects on learning processes by allowing students to acquire information in visual, auditory and text-based formats. When digital stories are integrated into the lessons of students with special needs, they increase students' participation, improve their creativity and increase their self-confidence (Hull & Nelson, 2005; Weiss, Benmayor, O'Leary & Eynon, 2002). In addition to all these, the use of digital storytelling in mathematics teaching contributes significantly to the development of students' problem solving skills. Javorsky and Trainin (2014) emphasize that digital stories deepen students' conceptual understanding by allowing them to integrate mathematical concepts into daily life contexts. Similarly, Gould and Schmidt (2010) state that digital storytelling improves students' mathematical communication skills and supports them to use mathematical terminology more effectively. In this framework, digital storytelling can be considered as a teaching tool that contributes to mathematical thinking processes in various ways. When mathematics lessons are conducted through stories, it is considered as a powerful material that can help students understand the relationships between concepts, algorithms and rules that they do not associate with their experiences (Balakrishnan, 2008). The use of digital stories contributes to the development of different skills such as expressing data, algorithmic thinking, logical thinking, sorting and analyzing data (Kordaki & Kakavas, 2017). In addition, solving math problems in digital stories allows for the effective connection of relationships between visual, auditory and verbal representations (Walters, Green, Goldsby & Parker, 2018). When digital stories are used in the educational processes of students with special needs, it has been observed that they increase students' participation and improve their creativity (Hull & Nelson, 2005). For these reasons, in full-time inclusion/integration practices, it is a legal obligation for teachers to teach lessons within the framework of Individualized Education Plan (IEP) in addition to getting maximum efficiency from educational activities. Digital stories, when implemented within the scope of IEP, can provide an effective and different learning model for mathematics lessons (Goldstein, 2008).

It is important for teachers to teach in the support education room within the framework of the Individualized Education Program (IEP) in order to get maximum efficiency from educational activities and to fulfill legal requirements. A study conducted with 110 mathematics teachers who participated in support education classes showed that teachers spent one-third of their time teaching mathematics and that support education classes play a critical role in the mathematics education of students with special needs (Mercer, 1987). However, it is noteworthy that the number of studies on mathematics teaching for students with special needs in Turkey and internationally is limited (Gobadzade & Düzkantar, 2019).

The use of only lectures in teaching geometry, one of the learning areas of mathematics course, prevents students from making connections between daily life and geometry and directs them to abstract thinking. This abstractness can lead to a decrease in students' interest and, as a result, a decrease in their academic achievement (Şimşek, 2012). In general, the most important problem in geometry education is that the course content is abstract and separate from daily life.

Geometry, a field that requires three-dimensional and spatial thinking skills, is very difficult to teach with traditional methods. Therefore, it is necessary to utilize technology as much as possible in geometry lessons (Karal & Solak, 2008). In this context, it has been determined that teaching geometry and measurement subjects with technology support increases student achievement and geometry lessons are more easily understood by students (Bintaş & Bağcıvan, 2007; Forsythe, 2007; Yıldız, 2009; Şimşek & Yücekaya, 2014). Murphy (1999) states that the storytelling method is a very effective method in the education of students with special needs as well as individuals with normal development. In addition, it is recommended to write stories about geometry outside of school to support geometry lessons. For example, there are geometry-themed storybooks such as "Ruthless Geometry", "The Greedy Triangle" and "Not Enough Room" by Kjartan Poskitt. Muğlalı (2004) stated that such books can increase interest in geometry and enable students to realize the applications of geometry in daily life. Considering the effects of today's technological advances on the education of individuals with special needs, it can be said that the application of traditional stories in digital format will increase efficiency in support education courses.

When the literature was examined, it was found that the number of studies on the use of technology in teaching mathematics to students with special needs was limited. While individuals with normal development are more comfortable in the use of technology in their educational environments, there is a lack of materials and applications to support individuals with special needs with technological products (Türel & Akgün, 2021). In addition to all these, there is no study on the effect of digital story teaching material on student performance in mathematics lessons held in the support education room. In this context, it is aimed to guide and set an example for mathematics teachers participating in support education courses. When the studies on mathematics teaching in the field of special education are examined, most of the studies focus on the learning area of numbers and operations; there are not enough studies in the learning areas of geometry and measurement (Yıkmış, Kot, Terzioğlu & Aktaş, 2018). While there are studies on digital story-based instruction for individuals with normal development, there is no study conducted for students with special needs in Turkey.

In conclusion, the use of digital stories in mathematics education for students with special needs has the potential to provide a more interactive and personalized learning experience than traditional teaching methods. This study aims to make a unique contribution to the field by examining the effect of digital storytelling on the mathematics performance of students with special needs.

Problem of Research

This study aims to make a unique contribution to the field by examining the effect of digital storytelling on the mathematics performance of students with special needs. In this direction in this study, it was investigated whether the geometry lessons taught in the support education room with the help of digital storytelling had an effect on student performances. In this direction an answer to the question is:

- What is the impact of using the digital storytelling method in geometry lessons taught in the support education room on student performance?

Method

Research Model

This study examines the effect of using digital story materials in geometry lessons of students with special needs studying in a support education room on student performance. The study was conducted with a one-group pretest-posttest quasi-experimental design. This approach aims to analyze the effects of different teaching methods, techniques and programs on the participants (Büyüköztürk, Kılıç Çakmak, Akgün, Karadeniz & Demirel, 2023). Within the scope of the method, after the pretest was applied to the determined group, the process was continued with the independent variable. Then the post-test was administered and the relationship between the pre-test and the post-test was evaluated. If a significant increase is observed in the post-test, it can be concluded that this situation is due to the application (Karasar, 2015).

Participants

Criterion sampling method, which is among the purposeful sampling methods, was used to determine the research group. In this method, the study is carried out with individuals with appropriate characteristics in line with the criteria determined by the researcher (Yıldırım & Şimşek, 2018). Therefore individuals, events and similar situations that meet the necessary criteria are included in the research group. In this study, in order to examine the effects of the digital story teaching material on students' geometry performance, some skills determined as prerequisites were defined. Based on the data collected during the process of creating the students' Individualized Education Program (IEP), students who had the skills in the sub-learning areas of answering questions, reading, writing, and geometric drawings and shapes in the first grade mathematics curriculum were included in the study. The study was conducted with 15 students who were identified as full-time inclusion/integration students by the Guidance and Research Center (GRC) according to the results of their educational evaluation (Table 1).

Table 1. Information on the CRC diagnosis and grade level of the study group

Student Code	RAM Diagnosis	Class Level
S1	Speech Language Disorder	Grade 5
S2	Speech Language Disorder	Grade 5
S3	Speech Language Disorder	Grade 5
S4	Specific Learning Disabilities	Grade 5
S5	Specific Learning Disabilities	Grade 5
S6	Specific Learning Disabilities	Grade 5
S7	Specific Learning Disabilities	Grade 5
S8	Specific Learning Disabilities	Grade 5
S9	Specific Learning Disabilities	Grade 5
S10	Specific Learning Disabilities	Grade 7
S11	Specific Learning Disabilities	Grade 7
S12	Specific Learning Disabilities	Grade 7
S13	Specific Learning Disabilities	Grade 7
S14	Specific Learning Disabilities	Grade 7
S15	Specific Learning Disabilities	Grade 7

Research process

The data collection process was carried out with 15 full-time inclusion/integration students studying at a public school in Gölcük district of Kocaeli province during the 2021/2022 academic year. At the school where the study was conducted, a study group was formed from among the full-time inclusion/integration students and an Individualized Education Program (IEP) was prepared for each student. Since the focus of the study was on geometry and measurement, it was decided to teach geometry lessons using digital stories during the second semester. This approach ensured that the lessons carried out in the support education room were parallel to the subjects that the students covered in their classes. All of the students participating in the study were taking an Information Technologies and Software course and had experience in creating digital stories using various software in this course. It was decided to create the digital stories to be prepared for geometry topics with the "Storyjumper" program for ease of use.

The first stage of the research is to create students' Individualized Education Plans (IEP) for mathematics. In this process, students' current performance levels are evaluated and the basis for determining long and short-term goals is established. The performance status of students with special needs is usually determined through informal assessment tools. In this context, various informal assessment tools prepared by teachers are used. Methods such as observation, interviews, written exams, error analysis, work sample analysis, homework assignments, worksheets and criterion-referenced assessment tools are used to determine students' proficiency levels in a specific field (Kargın, 2007). At this stage, short- and long-term goals were defined, taking into account the special needs of the students and the mathematics curriculum. For example, it was observed that a student in the study group was studying at the seventh grade level but

his educational performance was at the fourth grade level. In such a case, goals appropriate for the fourth grade level should be taken into consideration when preparing the IEP (MoNE, 2013).

The geometry performance test developed by the researcher was finalized after pilot applications and validity and reliability studies and then applied to the research group as a pretest. Digital stories were prepared on the Storyjumper platform to cover all the objectives in the students' education plans.

The theoretical content of the digital stories was created by the researcher, while the script writing and vocalization stages were carried out in collaboration with the students in the study group. In this process, three hours a week were allocated to the support education courses and the studies were completed for a total of eight weeks. At the end of the eight weeks, the geometry performance test developed by the researcher was reapplied as a post-test. All prepared stories were made available at https://www.storyjumper.com/book/collection/Ilknuur/GEOMETR. Below are excerpts from the digital stories prepared with the students.

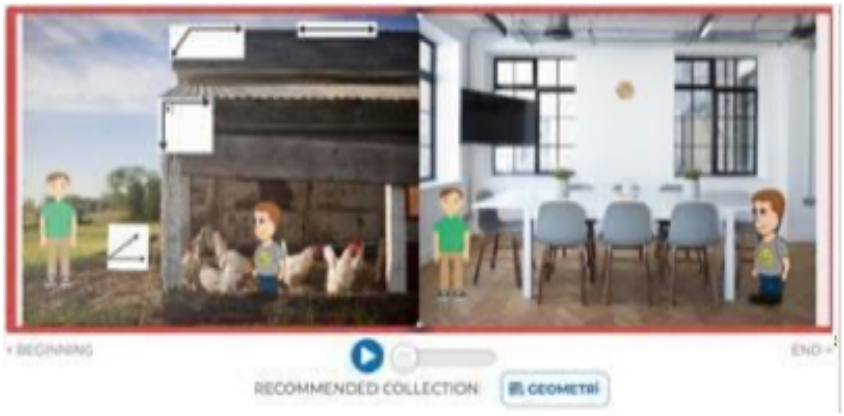

Figure 1. Excerpt from a digital story about angle types

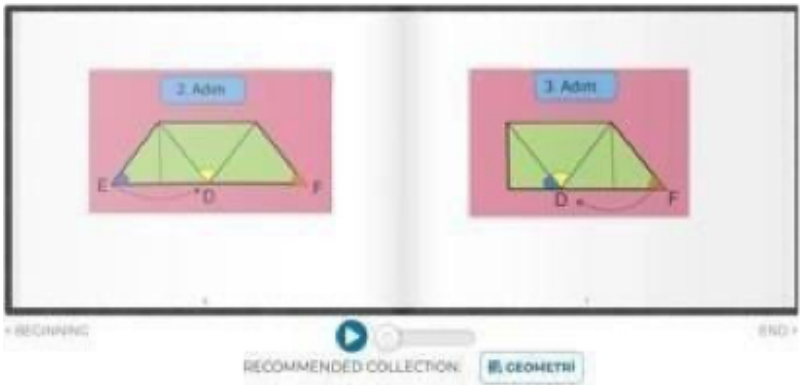

Figure 2. Excerpt from a digital story about the sum of the ic angles of a triangle

Figure 3. Excerpt from a digital story with a problem requiring perimeter calculation

Data Collection Tools

Short-term goals in the Individualized Education Plan are defined as measurable sub-steps between the individual's current performance level and long-term goals (Sucuoğlu & Kargın, 2014). In this context, the short-term goals in the students' plans determined the scope of the Geometry Performance Test developed in the study. In line with the short-term goals, the geometry performance test was created by the researcher to include at least three questions for each goal.

The purpose of including at least three questions from each objective was to identify and remove valid and unreliable items from the test in line with item analysis, student interviews and expert opinions and to ensure that questions covering each objective were included in the test.

A total of 40 questions in the performance test were prepared to cover each sub-heading of the relevant objectives. The draft test consists of short-answer and multiple-choice questions. The test was presented to an experienced teacher and lecturer to evaluate its suitability for the purpose, and then feedback was received from a Turkish teacher on the comprehensibility of the language of the questions. As a result of the evaluations, the draft performance test was finalized. The draft geometry performance test was applied to six students with specific learning disabilities outside the study group as a pilot study and preliminary interviews were conducted. In this process, it was observed that the multiple-choice items were marked randomly by all students. In order to eliminate the effect of chance success, multiple-choice items were removed from the test and the whole test was composed of short-answer items. In the light of the feedback received from the students and the evaluations of experienced teachers and lecturers, the geometry performance test consisting of 20 short-answer items was finalized.

The interviews conducted after the draft geometry performance test was applied to six students subjected to inclusion/integration education led to the necessary adjustments. In order to ensure the construct validity of the revised geometry performance test, the performance test was applied to students with normal development at the fifth, sixth and seventh grade levels. These interviews helped to identify ambiguities or narrative deficiencies in the test and to make the necessary corrections (Fraenkel, Wallen & Hyun, 2011). Students were asked to read the questions aloud and think aloud (Bowles, 2010). This practice was a method to determine whether the students perceived the questions in the same way and to identify and correct any misconceptions they might encounter during the application.

As a result of the interviews conducted at different grade levels, it was concluded that the questions were understandable and applicable. It was also reported that the figures used in the performance test were clear and legible. Fifth and sixth grade students had difficulty in completing the performance test in 40 minutes, while seventh grade students did not have any problems with time. For this reason, it was decided to conduct the performance test for two class hours (80 minutes) in order to avoid time problems for the experimental group.

Kan (2018) states that the items in the test can be provided with expert opinions to determine the construct validity. Construct validity of the test was ensured as a result of interviews with students with normal development at different levels and expert evaluations. Content validity is a concept related to the extent to which the measurement tool covers the feature to be measured. The feature to be measured should be adequately represented in the measurement tool (Atılgan, Kan & Aydın 2019). Therefore in order to ensure content validity, a performance test was prepared to include at least one question related to each short-term objective.

Data Analysis

It is stated that short-answer tests measure behaviors in more depth because the answer is written by the respondent (Turgut, 1988). Therefore, since the answers to short-answer test items are usually very short and the response time is short, many questions can be asked in one exam period (Tan, 2013). Increasing the number of questions enables the measurement of various target behaviors and eliminates the effect of chance achievement, which increases reliability (Thorndike & Thorndike-Christ, 2010). Although it is stated that the scoring process of short-answer tests is easy, it is known that it is not completely objective. Since the scoring does not include variables such as the aesthetics of the respondent's writing, the way he/she uses the paper, and the answers given are in accordance with a certain framework, it can be easily realized. However, respondents have the freedom to answer in any way they wish. This means that no definitive judgment can be made about the level of accuracy of the answers; therefore, the answers are considered partially accurate. In this context, it is important to create a scoring key for the scorer and to check the accuracy of the answers within this framework (Şalgam, 2016).

In the study, a detailed answer key was prepared before the scoring process started and student responses were examined by the researcher and the instructor. Inter-rater reliability refers to the agreement and consistency of two or more raters in the scoring process (Crocker & Algina, 1986). In this study, Pearson Product Moment Correlation

coefficient was calculated to determine the relationship between the scores given by different raters using the rubric. The Pearson Product Moment Correlation Coefficient obtained as a result of the scoring processes of the researcher and the instructor was found to be greater than 0.70, indicating that the scoring processes of the raters were consistent (Büyüköztürk et al., 2023). In other words, when the correlation coefficient, which is considered as a reliability coefficient, is greater than 0.70, it shows that the scores given by two raters have a linear relationship (Baykul, 2021).

Table 2. Code, code criterion and score information of the rubric

Code	Code Criteria	Score
Correct (d)	The answer is correct, the explanation is complete	2 points
Half True (yd)	The answer is correct, no explanation	1 point
	The answer is correct, the explanation contains a misconception	
	The answer is wrong, the explanation is right	
False /Null	Question left blank	0 points
	Scientifically unacceptable statement	

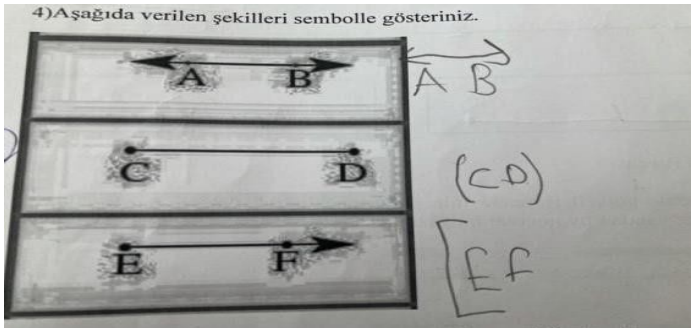

Figure 4. Example of a response coded as correct (d)

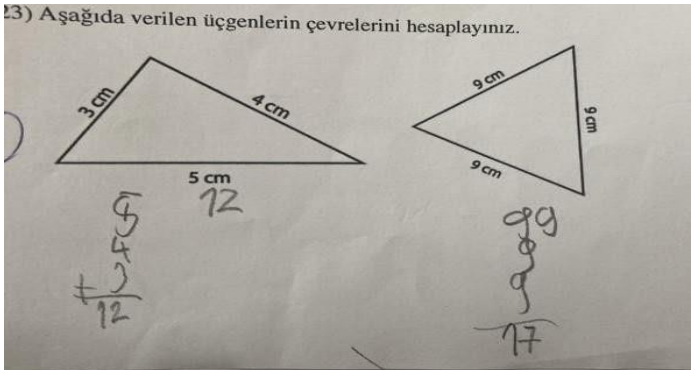

Figure 5. Example of a response coded as half correct (yd)

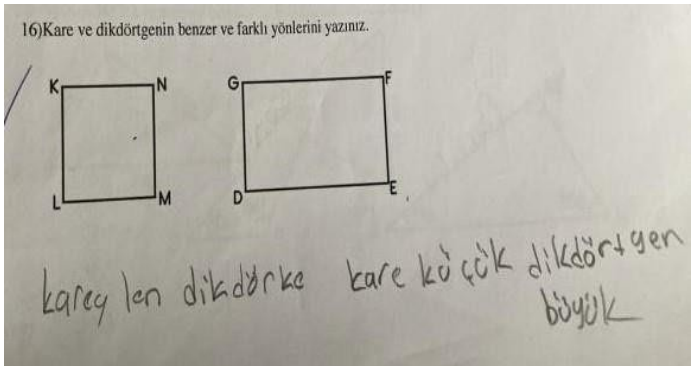

Figure 6. Example of an answer coded as wrong/empty

Since the responses of the inclusive/integrated student group before and after the lessons with digital stories were evaluated with the same performance test, the data were analyzed with the dependent groups t-test method. In this way, the significant differences between the measurements and the effect of digital stories on the students' performances were analyzed.

Research Ethics

Necessary permissions were obtained in order to collect the data needed in the study. For this purpose, permission numbered 178547 and numbered 3 was obtained from the Ethics Committee of Science and Engineering Sciences within Kocaeli University. After the research was deemed appropriate, the necessary permission was obtained by applying to the Provincial Directorate of National Education in order to start the implementation process.

Results

First of all, the normality distribution of the scores of the student group on the "Geometry Performance Test" before the application was examined.

Table 3. Normality results for the pretest

Test Name	N	$\bar{X}$	Kolmogorov- Smirnov (p)	Shapiro-Wilk (p)
Pre-Test	15	47.2	.200	.918

The Shapiro-Wilk test is more powerful than the Kolmogorov-Smirnov test when the sample size is below 50 (Mayers, 2013). As seen in the table, since the Shapiro-Wilk test value is .918> .05, the scores show a normal distribution.

Table 4. Dependent groups t test results of the students in the study group

Group	N	$\bar{X}$	ss	sd	t	p
Pre-Test	15	47.20	14.96	12.50	12.43	.00
Final Test	15	87.33	8.40			

As seen in Table 3, as a result of the dependent groups t-test conducted to determine whether the post-test scores of the students who studied with digital stories differed according to the pre-test scores, the difference between the pre-test and post-test scores of the students was found statistically significant (t=12,434; p<.05).

When descriptive statistics were analyzed, students' post-application scores ($\bar{X}$=87.33) were significantly higher than their pre-application achievement scores ($\bar{X}$ =47.20). This finding can be interpreted as geometry units taught with digital stories positively affected the academic achievement of inclusion/integration students.

As a result of the analysis, the effect of geometry units taught with digital stories on students' academic performance was evaluated. In the calculations made with Cohen's d method, the results of the pretest ($\bar{X}$ = 47.20, = 14.96) and posttest ($\bar{X}$ = 87.33) were compared. These calculations yielded a value of d = 2.68. This value indicates a large effect size (Cohen, 1988). This finding indicates that geometry units taught with digital stories significantly increased the academic achievement of inclusion/integration students. The results of the study support that digital stories can be evaluated as an effective tool in educational applications.

Below, the answers given by the students to the geometry performance test at the beginning of the process and the student answers given after the geometry lessons taught with digital storytelling are presented. The answers of the students coded S6, S13, S9 and S12 to the first question of the geometry performance test before and after the application are as follows:

Answers of students coded S6 and S13 to the test item related to the concepts of point, line, line segment and ray:

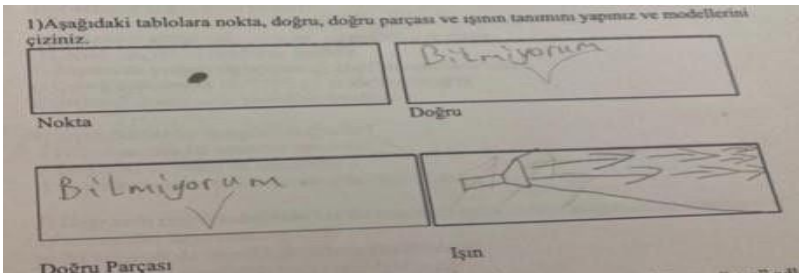

Figure 7. The response of the student coded S6 before the implementation

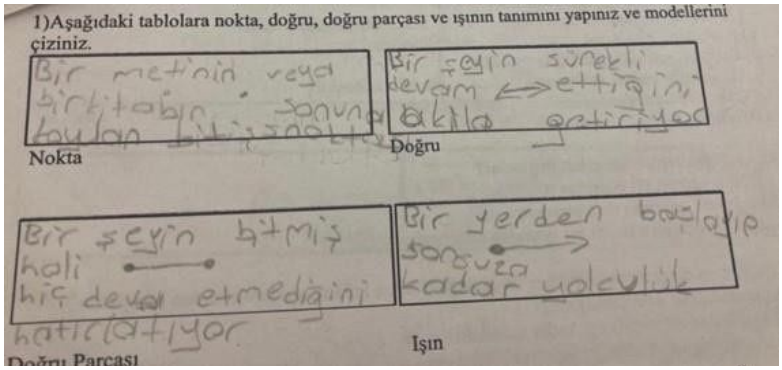

Figure 8. The response of the student coded S6 after the application

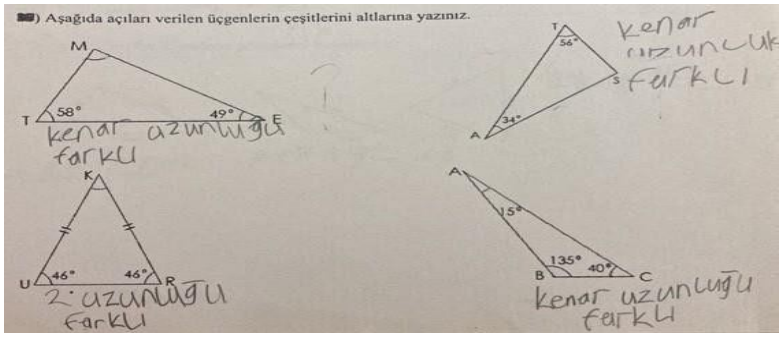

Figure 9. Student S13's response before the implementation

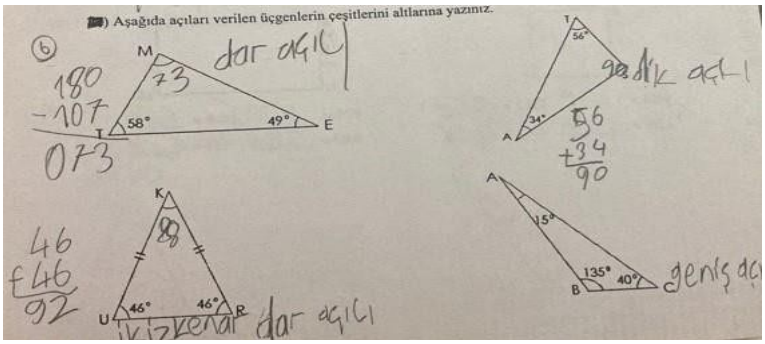

Figure 10. Student S13's response after the implementation

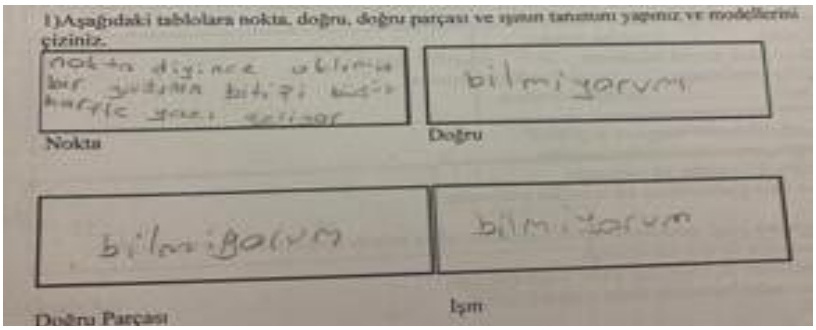

Figure 11. Student S9's response before the implementation

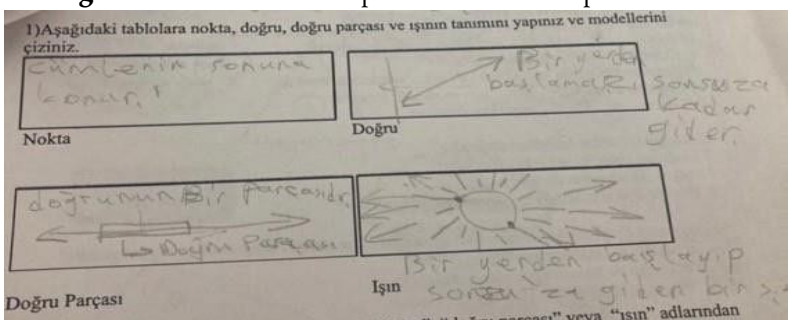

Figure 12. Student S9's response after the implementation

The response of the student coded S12 to the item about finding the ungiven angle of a triangle before and after the application:

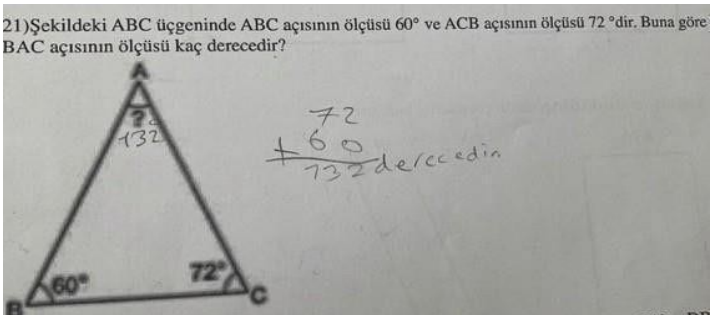

Figure 13. Student S12's response before the implementation

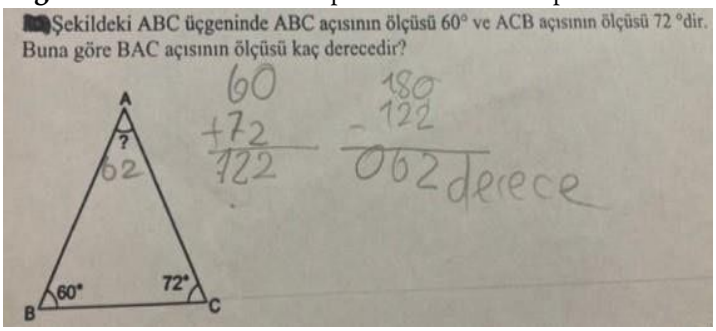

Figure 14. Student S12's response after the implementation

Discussion and Conclusion

This study contributes to the literature by examining the effects of digital storytelling method in mathematics teaching of students with special needs. In the study, the effects of geometry lessons supported by digital stories within the scope of individualized education plans of 15 students with special learning disabilities and speech and language disorders were evaluated. The findings show that digital stories are an effective tool in increasing students' academic achievement in geometry lessons. Especially the concretization and visualization of geometric concepts made significant contributions to students' learning processes. The findings reveal that digital stories have positive effects on students with special needs and provide significant improvements in their learning of geometric concepts. The results show that digital stories are not only a teaching tool but also an effective support material that facilitates learning processes. In this context, digital story-based instruction in geometry lessons of students with special needs increased their individual performance and the improvements observed in their academic achievement suggest that this method can be used as an effective tool in individualized education plans.

In the literature, conducting mathematics lessons with digital stories has been shown to have the potential to improve understanding of mathematical concepts, problem-solving skills, and mathematical literacy among children with intellectual disabilities (Dalim, Azliza, Ibrahim, Zulkipli & Yusof, 2019; Starčič, Cotič, Solomonides & Volk, 2015). Altındağ Kumaş (2024) examined the effects of digital storytelling on the early math skills of children with intellectual disabilities. In the study, it was observed that digital story applications provided significant improvements especially in the recognition and understanding of geometric shapes. Çopur and Tümkaya (2024) show that digital stories prepared with the Realistic Mathematics Education approach are effective in increasing mathematics achievement of 4th grade students. As a result of the seven-week implementation, it was determined that the achievement of students who studied with digital stories increased significantly. In addition, in the study conducted by Çiftçi (2022), the subject of money was taught to 2nd grade students with Scratch-supported Realistic Mathematics Education approach activities and it was determined that these activities had a positive effect on academic achievement. Katipoğlu, Katipoğlu and Sezer (2021) used the storytelling method on decimals in the 5th grade mathematics course and found that stories were effective in increasing students' achievement.

In their study, Tortorelli and Tortoriello (2024) describe how a hybrid methodology called Geometricoland aims to improve descriptive and classificatory thinking in geometry lessons through storytelling and game-based learning (GBL). This study, carried out in a fifth grade classroom in Italy, shows that students increased their understanding of geometric definitions and the relationships between subsets of quadrilaterals. The data obtained through placement and exit tests reveal a significant improvement in descriptive and classificatory thinking skills. In addition; Niemi, Niu, Vivitsou and Li (2018) emphasize the role of digital storytelling (DST) in geometry teaching; it is stated that while students learn basic geometric concepts such as area calculation, they create their own stories through group work and relate this knowledge to their daily lives.

Özpınar, Gökçe and Aydoğan Yenmez (2017) examine the effects of digital storytelling in mathematics teaching and teacher-student opinions. The study covers the topics of "Triangles," "Transformational Geometry" and "Probability of Simple Events" in the 8th grade mathematics curriculum. These topics were taught through digital storytelling method and their effects on students' academic achievement were analyzed. The results show that the academic achievement of the students in the experimental group was higher than that of the control group. However, no statistically significant difference was found. Çakıcı (2018) examined the effect of digital story-based teaching of the 4th grade "Fractions" unit on academic achievement and compared the post-test scores of the students in the experimental group using this method with those in the control group trained with the traditional method. The results showed that digital story-based instruction did not provide a significant increase in academic achievement. In other words, no significant achievement difference was observed between the two groups. Dinçer (2019) taught 6th grade "Whole Numbers and Algebraic Expressions" topics with digital stories created based on the context-based learning approach and examined their effects on students' academic achievement; however, the results of this study show that digital stories are ineffective in increasing students' mathematics achievement compared to the context-based learning approach. The fact that the effect of digital stories on academic achievement was not statistically significant can be attributed to the differences in the implementation design. When non-customized digital stories are not tailored to students' individual learning styles and needs, their impact may be limited. In addition, students' familiarity with digital content and their technical proficiency are also important factors affecting the learning process. The potential of digital stories to support conceptual learning may help to concretize abstract concepts, but this may not be enough to increase achievement based on procedural knowledge. In subjects that require more practice and application in mathematics, digital storytelling alone is not sufficient. The findings of Özpınar et al. (2017) study that digital stories did not make a significant difference on academic achievement may be due to students' familiarity with such content or their need for more traditional methods. The ineffectiveness in Dinçer's (2019) study may be due to the difficulties in implementing the context-based learning approach or the fact that digital stories do not provide sufficient context. In conclusion, the effect of digital stories on academic achievement varies depending on many variables such as content design, student profiles and learning goals. Therefore, it is important for future research to conduct more in-depth analyses taking these factors into account.

In this study, experimental and control groups were not used, instead, each student's individual performance was evaluated. This method differs methodologically from other studies in the literature because the digital storytelling method is usually handled comparatively with experimental and control groups (Dalim et al., 2019; Starčič et al., 2015; Ünal, 2022). Due to the individual differences of students with special needs and the inability to make unbiased assignments, each student was evaluated within himself/herself. This situation draws attention to the importance of the adaptability of digital stories according to individual needs and emphasizes the flexible structure of the method.

In conclusion, this study has shown that digital stories are an effective tool in mathematics learning for students with special needs. In particular, concretizing abstract geometric concepts and providing a flexible structure suitable for individualized education plans make digital stories an important place in education. In future studies, the effects of digital storytelling method can be investigated in other learning areas of mathematics by using larger samples and experimental-control groups. In addition, more customization in the design of digital stories in accordance with the individual needs of students is recommended. This study makes an important contribution in terms of showing that

digital stories contribute to the learning processes of students with special needs and provides a basis for future research on this method.

Recommendations

In the light of these findings, the following suggestions are offered for future research and educational practices:

- QR code applications to be integrated into Ministry of National Education (MEB) textbooks can be made applicable for students with special needs, and accessibility of digital stories on the subject can be ensured through these codes.
- The methods used in this study should not be limited to students with speech and language disorders and students with specific learning disabilities, but should also be applied to individuals with other disabilities to increase their general validity.
- This study, which focused on geometry, will pave the way for similar research in other mathematical learning domains, which will allow a more comprehensive examination of the impact of digital stories in mathematics teaching.

Limitations of Study

This study focuses exclusively on inclusion/integration students in secondary school mathematics courses conducted in a support education room. It does not include gifted students or those with mild intellectual disabilities who also participate in inclusion/integration education. The research specifically targets geometry objectives to evaluate the effect of lessons that employ digital storytelling on student performance. Additionally, the assessment of student performance in geometry is restricted to the digital stories used within the course content.

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