Van Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi, 2023; 20(2), s.484-504.

Van Yüzüncü Yıl University Journal of Education, 2023; 20(2), p. 484-504. DOI:10.33711/yyuefd.1284401

Teaching Addition to Students with Intellectual Disabilities: TouchMath Presented Through a Game

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Abstract: The aim of this study was to determine the effectiveness of the TouchMath technique presented through games in teaching addition to individuals with intellectual disabilities. Additionally, this study investigated whether students could maintain the skills they learned after 7, 21, and 35 days and whether they could generalize them across different individuals and settings. Three students with moderate intellectual disabilities were the participants of the study. This study was conducted using the multiple probe design across participants, which a single-subject research method. The dependent variable of the study was the capacity of the students to perform addition operations, while the independent variable was the teaching process using the TouchMath technique presented through a game. The results of the study indicated that the teaching process was effective, permanent, and generalizable. Additionally, the social validity data showed that teachers had positive views on teaching with this technique.

Keywords: TouchMath, addition, students with intellectual disabilities.

Zihinsel Yetersizliği Olan Öğrencilere Toplama İşlemi Öğretimi: Oyun Yoluyla Sunulan Nokta Belirleme Tekniği

Öz: Bu çalışmanın amacı zihinsel yetersizliği olan bireylere toplama işleminin öğretiminde oyun yoluyla sunulan nokta belirleme tekniğinin etkililiğini belirlemektir. Ayrıca, bu çalışmada öğrencilerin öğrendikleri becerileri 7, 21 ve 35 gün sonra da sürdürüp sürdüremedikleri ve bunları farklı kişi ve ortamlara genelleyip genelleyemedikleri araştırılmıştır. Araştırmaya orta düzeyde zihinsel yetersizliği olan üç öğrenci katılmıştır. Bu çalışma tek denekli araştırma yöntemlerinden katılımcılar arası çoklu yoklama deseni kullanılarak gerçekleştirilmiştir. Araştırmanın bağımlı değişkeni öğrencilerin toplama işlemlerini yapabilme düzeyleri, bağımsız değişkeni ise oyun yoluyla sunulan nokta belirleme tekniği ile yapılan öğretimdir. Araştırmanın sonucunda yapılan öğretimin etkili, kalıcı ve genellenebilir olduğu görülmüştür. Buna ek olarak sosyal geçerlik verileri, öğretmenlerin yapılan öğretimlere ilişkin olumlu görüşlere sahip olduğunu ortaya koymuştur.

Anahtar Kelimeler: Nokta belirleme tekniği, toplama işlemi, zihinsel yetersizliği olan öğrenciler

Geliş tarihi/Received: 17.04.2023 Kabul Tarihi/Accepted: 07.06.2023 Makale Türü: Araştırma Makalesi

This article was produced from the first author's master's thesis.

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Atıf için/To cite: Şentürk, F., Yıkmış, A. & Terzioğlu, N. K. (2023). Zihinsel yetersizliği olan öğrencilere toplama işlemi öğretimi: Oyun yoluyla sunulan nokta belirleme tekniği. *Van Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi*, *20*(2), 484-504. https://doi.org/10.33711/yyuefd.1284401

Introduction

Intellectual disability is defined as the stagnation of the mind or the inability to complete its development, especially occurring during the developmental period, which affects aspects regarding the general intelligence level of the person such as cognition, language, motor, and social skills (World Health Organization [WHO], 1996). Another definition characterizes intellectual disability as a condition in which individuals have below-average general intelligence and exhibit difficulties in displaying adaptive behaviors during their developmental period (American Association on Intellectual and Developmental Disabilities [AAIDD], 2010). It is known that these individuals have difficulties in acquiring and maintaining their math skills because they are behind their peers in terms of intelligence functions and have limitations in cognitive, social, motor, and other skill areas. Individuals with intellectual disabilities need to have math skills so that they can live independently, participate in society, establish a good academic future, and acquire a profession.

Just like their non-disabled peers, students with intellectual disabilities receive math education from primary school through their last year of high school. Math is an essential tool for the development of these students and plays a crucial role in their education. Math programs in schools attended by students with intellectual disabilities aim to achieve the competence of solving the problems that these students may encounter in daily life. In the math course curriculum, the sub-area of "Addition" is part of the learning area of "Numbers and Operations" and is taught at the 1st, 2nd, 3rd, and 4th grade levels (Republic of Türkiye Ministry of National Education, 2018a). The distribution of the content of the sub-learning domain of addition according to grade levels is given in Table 1. Furthermore, the math curriculum created specifically for individuals with moderate to severe intellectual disability and autism spectrum disorder encompasses the study of fundamental arithmetic operations, alongside their corresponding learning objectives (Republic of Türkiye Ministry of National Education, 2018b). Moreover, within this curriculum, the learning domain of the four fundamental arithmetic operations has been tailored to specifically focus on addition and subtraction operations, with careful consideration given to the cognitive capacities of individuals who have moderate to severe intellectual disabilities and autism spectrum disorder. Additionally, the program aims to teach the skill of addition without regrouping up to 50, which does not require manual manipulation, to these individuals.

As seen in Table 1, the targeted outcomes related to addition vary across the 1st, 2nd, 3rd, and 4th-grade levels (Republic of Türkiye Ministry of National Education, 2018a). It can also be seen that these targeted outcomes become more comprehensive and challenging as the grade level of the student increases. For instance, while the first grade includes the targeted outcome "Adds natural numbers up to 20," the second grade includes the targeted outcome “Adds without regrouping and by regrouping natural numbers up to 100." When moving to the 3rd grade, these targeted outcomes include the "Performs addition operations with at most three-digit numbers by regrouping and without regrouping" targeted outcome, and when moving to the 4th grade, they include the "Performs addition operations with at most four-digit natural numbers" targeted outcome. The effective teaching of addition skills and other math skills to students with intellectual disabilities requires setting goals and objectives based on the student's individual performance. The important thing here is the student's performance, and the aim is to teach functional math skills to the student.

Table 1

Distribution of Addition-Related Targeted Outcomes with Natural Numbers in Math Curriculum According to Grade Levels

Numbers and Operations			
Addition with Natural Numbers			
1st Grade	2nd Grade	3rd Grade	4th Grade
✓Understands the meaning of addition. ✓Demonstrates the ability to perform addition operations using natural numbers up to 20. ✓Understands the concept that the sum remains the same regardless of the order of the addends in an addition problem. ✓Finds the missing addend in an addition operation with numbers whose sum is less than or equal to 20. ✓Performs addition in their head.	✓Performs addition without and by regrouping with natural numbers whose sum is up to 100. ✓Finds the sum that is not given in the sum of two numbers. ✓Estimates the sum of two natural numbers and compares the estimation to the result of the operation. ✓Performs addition in their head. ✓Solves problems that require addition with natural numbers.	✓Performs addition without and by regrouping with maximum three-digit numbers. ✓Demonstrates that in an addition operation with three natural numbers, changing the order of the numbers will not change the result. ✓Estimates the sum of two numbers and compares the estimate to the result of the operation. ✓Performs addition in their head. ✓Finds what is not given in an addition operation. ✓Solves problems that require addition with natural numbers.	✓Performs addition operations with natural numbers up to four digits. ✓Estimates the sum of two natural numbers and compares their estimate to the result of the operation. ✓Adds natural numbers up to four digits that are multiples of 100 in their head. ✓Solves problems that require addition operations with natural numbers.

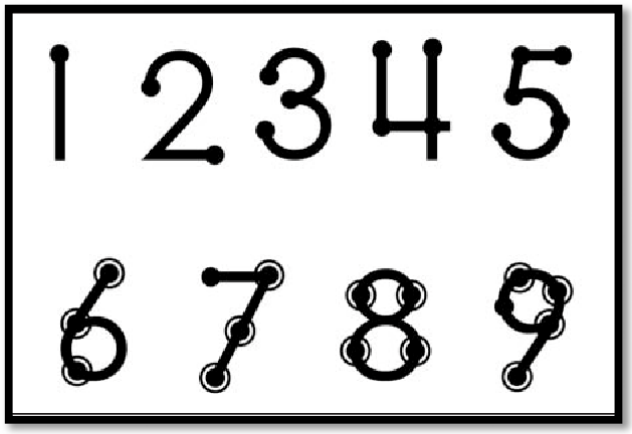
Math is considered a field closely related to abstract thinking, reasoning, comprehension, and communication skills. However, individuals with intellectual disabilities may face significant obstacles in these skills, and this can impact their math education negatively. Therefore, the learning process of math for these individuals may be different from the learning process of individuals with normal intelligence (Kearns et al., 2011).

Differentiating the learning processes of students with intellectual disabilities has led experts in the field to develop different methods, techniques, and strategies for these students. In the literature, there are many methods, techniques, and strategies used in teaching addition-related skills to these students. The most prevalently used ones among these methods are interactive units (Balçık, 2015; Dağseven, 2001; Yıkmış, 1999), concrete-representational-abstract strategies (Nar, 2020), and the TouchMath technique (Calik & Kargin, 2010; Eliçin et al., 2013; Fletcher et al., 2010; Pupo,1994)

TouchMath is used in the teaching of many mathematical concepts and skills, especially four-operation skills, to students with normal development and those with special needs (Eliçin et al., 2013; Fletcher et al., 2010; Scott,1993; Waters & Boon, 2011). As seen in Figure 1 (Avant & Heller, 2011), in this technique, there are dots placed on each number in a fixed direction aligning

with the drawing direction of the number. For the numbers 1 to 5, there are as many points as the value of each digit, while after the number 6, circles appear around some points. These circles indicate that the point will be counted twice (Cihak & Foust, 2008; Waters & Boon, 2011; Wisniewski & Skarbek, 2002).

Figure 1
TouchMath



TouchMath appeals to multiple senses due to its features such as placing dots on top of numbers by touching and seeing both numbers and dots together (Calik & Kargin, 2010; Scott, 1993; Vinson, 2004). Appealing to multiple senses is one of the greatest advantages of TouchMath. Therefore, the TouchMath technique, which utilizes a multi-sensory approach, is believed to be effective in mitigating or eliminating some of the challenges that students with intellectual disabilities face, including struggles with comprehending abstract concepts and operations. Another benefit provided by TouchMath is that it offers students a different method, such as counting dots, instead of traditional methods such as counting fingers and performing the four operations (Simon & Hanrahan, 2004).

In the literature, there are studies that have been carried out to assess the efficacy of TouchMath for students with intellectual disabilities and other special needs, as well as studies comparing the effectiveness and efficiency of this technique to another technique. As an example, Eliçin et al. (2013) investigated the efficacy of the TouchMath technique in teaching addition skills to students who had intellectual disabilities. The participants in their study were three students with intellectual disabilities, including two male students aged 4 and 21, and a 9-year-old female student. The study utilized the multiple probe design across participants, a type of single-subject research design, and the authors concluded that TouchMath was effective in teaching addition skills to students with intellectual disabilities. Another study (Calik & Kargin, 2010) employed the single-subject research design of multiple-probe across participants to examine the efficacy of TouchMath in teaching who to perform addition operations to three students with intellectual disabilities. The participants included two girls and one boy, between the ages of 8 and 10. The findings of their study indicated that utilizing the TouchMath technique was efficacious in teaching addition to individuals with intellectual disabilities. Fletcher et al. (2010) compared the effectiveness of TouchMath and the number line method in teaching addition to three students aged 13 to 14, one with an intellectual disability and the other two with both autism and intellectual disabilities. The study used a single-subject research design with the alternating treatment model, and at the end of

the study, it was observed that the students performed addition more quickly and accurately with the TouchMath method. Previous studies in the relevant literature have generally focused on the effectiveness and efficiency of methods. Additionally, in some of these studies, the TouchMath method has been presented along with another method. In these studies, it is concluded that TouchMath has generally been presented through the direct instruction method (Calik & Kargin, 2010). However, no studies in the literature presenting the TouchMath method through a game-based approach could be found.

Considering the advantages of TouchMath, it is believed that combining it with another concept that has other advantages, such as games, will provide significant contributions to the teaching of mathematical concepts and skills to students with intellectual disabilities. This is because games have an important place in the lives of both typically developing individuals and special needs students. All students should have time to play games, especially those with learning differences who need more of this time. This game time allows students to stay stress-free and cherish the freedom to have fun. In a fun environment during playtime, students can learn many things without the fear of failure. Games help students control their bodies, develop their social and emotional aspects, use their imagination, gain self-confidence, and become willing to learn. In this study, it is believed that this game-like approach, which combines the advantages of TouchMath with those of games, will be a valuable tool for teaching math concepts and skills to students with special needs (Macintyre, 2010).

The main focus of this study is to examine the effects of using games as a method of presenting TouchMath on the acquisition of addition skills among students with intellectual disabilities. In addition to the interest of the researchers, using games to present the already proven-effective TouchMath method is believed to be a valuable approach for teaching math concepts and skills to students with intellectual disabilities. This approach has the potential to address the common challenges that students with intellectual disabilities face in acquiring math skills, and it could contribute to the advancement of the field of math education for this population. This technique will make it easier for students who have difficulties in math to acquire mathematical concepts and skills. Additionally, the use of this technique will provide benefits to teachers of students with special needs. For example, if teachers start teaching math with an effective method such as TouchMath, this will make it easier for them to reach their goas for their students without wasting time. Therefore, the main aim of this study is to determine the effectiveness of the TouchMath technique presented through games in teaching addition skills to students with intellectual disabilities. Furthermore, the study also investigates the permanence and generalization effects of TouchMath presented through games. Additionally, the study attempts to determine the social validity of the results by obtaining feedback from the teachers of the participating students regarding the technique used and the study itself.

Method

Research Design

This study employed the method of multiple-probe design across participants, which is a single-subject research design. This design allows the examination of the effects of an independent variable on a dependent variable across three or more participants (Gast, 2010). Accordingly, in this study, baseline data were collected concurrently with three participants. When a stable data collection process was achieved in the baseline phase, the first participant started the intervention phase. The target skill was considered achieved, and stable data were collected when the

intervention phase was completed. Then, the first collective probe session was conducted simultaneously with all participants. When stable data were collected in the collective probe session, the second participant joined the intervention phase. The intervention phase ended when the participant achieved the target skill, and stable data were obtained. Then, the second collective probe session was conducted simultaneously with all participants. When stable data were collected in the second collective probe session, the third participant joined the intervention phase. The intervention phase ended when the participant achieved the target skill, and stable data were obtained. Then, the third collective probe session was conducted simultaneously with all participants. Thus, the effects of the independent variable on the dependent variable were demonstrated.

Independent Variable

Teaching via game-based TouchMath served as the independent variable in the study. This study combined the game "Hopscotch" with TouchMath. The instruction process was presented to the students by considering the steps of the direct instruction method. In the teaching processes, the steps of model teaching, guided practice, and independent practice in the direct instruction method were carried out one-on-one with the participants.

Dependent Variable

The dependent variable of the study measured the extent to which the participants could perform addition operations. There are several reasons why addition was chosen as the dependent variable in this study. First, addition is a prerequisite skill for learning more advanced math skills. Second, this skill is appropriate for students of different ages and grade levels. Third, learning addition contributes to the academic success of students. Finally, this skill supports the ability of students to live independently in their daily lives.

This study aimed to teach the addition of two single-digit numbers. In line with this goal, 10 addition problems were presented to the students in each session, and it was expected that the students would learn these addition operations at a rate of 100%. The analysis of the independent variable in the study was as follows:

1. The student states that the operation is an addition operation.
2. The student states that they will add the number on top to the number on the bottom.
3. The student states what the number on top is.
4. The student states what the number on the bottom is.
5. The student jumps on the dots on the floor with one or two feet and counts the dots.
6. The student states what the result is.

Participants

Three students diagnosed with moderate intellectual disability participated in the study. These students were selected based on their ability to perform prerequisite skills necessary for the addition. The prerequisite skills expected from the students were: a) counting objects, b) rhythmic counting from 1 to 50, c) writing and pronouncing digits from 1 to 9, d) jumping forward on one or two feet, and e) following instructions that involve one or more actions. After obtaining permission from their families, the students themselves, and the involved institutions, the experimental process began with the students who met these prerequisite criteria.

Kerem

Kerem is a 10-year-old male student with a diagnosis of moderate intellectual disability. His specific diagnosis is Down syndrome. Kerem attends the fourth grade of a special education application center in the Rize province of Türkiye. Additionally, he participates in three hours of individual education sessions per week at a special counseling and education center. Kerem's receptive language skills are developed, and he can express himself using one or two words. He can recognize and write numbers from 1 to 10 and can count rhythmically from 1 to 100. Although Kerem constantly needs motivation and reinforcement to start and continue working, he is willing to participate in games and gamified activities.

Ela

Ela is a 10-year-old female student diagnosed with moderate intellectual disability. She attends a special education class at a state school in Rize. Ela also receives support from a private education and rehabilitation center for eight hours a month. Additionally, she participates in two hours of individual education sessions per week at the private counseling and education center where this study was conducted. Ela's receptive and expressive language skills have developed. She can express herself using three or more words and can follow multiple-action instructions. In math, she can count rhythmically from 1 to 100 and recognize and write numbers from 1 to 10. Additionally, she can count by fives and tens up to 100. Ela is an outgoing and communicative student who enjoys playing individual and group games.

Aslan

Aslan is a 10-year-old male student diagnosed with moderate intellectual disability. He attends a special education class at a public school in Rize. Aslan can follow directions that require multiple steps. He can express himself using two or more words. In math, he is able to count rhythmically from 1 to 100 and recognize and write numbers from 1 to 10. Additionally, Aslan is willing to participate in physical activities.

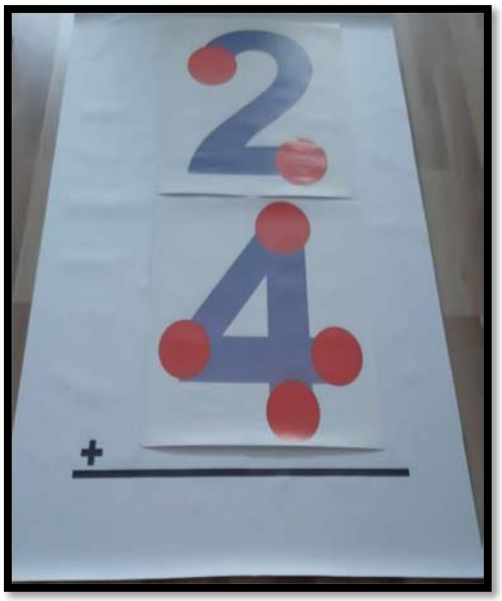
Setting

All sessions during the experimental process of the study were conducted in the private education room of the special counseling and education center, where the students received individual support services. This room, measuring 4x6 meters, contained a table, two chairs, and a cabinet. The study was carried out on a one-on-one basis with the students in this environment. Additionally, a camera was placed in the room to record the experimental process.

Materials

It is known that the gamification of instructional content facilitates and enriches the process of teaching in individuals with intellectual disabilities, just as it does in normally developing individuals. Especially for academic skills that students find challenging, gamification enables students to participate more actively in the teaching process. Therefore, for use in the experimental process of the study, vinyl banners measuring 40x40 centimeters with numbers 1-5 and dots marked according to the TouchMath method were prepared. Additionally, floor cover materials made of vinyl with the addition symbol and a line (+_____) were prepared. An example of the materials used in the study is shown in Figure 2. As seen in the figure, this material was prepared by taking the game called "hopscotch".

Figure 2
TouchMath Material Prepared According to the Game 'Hopscotch'



Procedures

Baseline

The baseline sessions of the study were conducted to evaluate the current performance levels of the students regarding the targeted skill. The baseline sessions were initiated with three students simultaneously, and they continued until stable data were obtained for the first student. These sessions were carried out one-on-one with each student. The evaluations in these sessions were made on a single opportunity basis. In other words, a + sign was put on the data recording forms for each correct answer of the student, and a - sign was put on their incorrect or neutral answers. Once stable data were obtained during the baseline sessions, the sessions were concluded, and teaching sessions were commenced with the first student.

1. The practitioner introduced the material to the student by showing the material seen in Figure 2 and saying "Have you ever played hopscotch? We will do addition by playing hopscotch."

2. The practitioner then said to the student, "When I ask you to do an addition, say aloud what the operation is, perform the operation, and say the result that you found." After this explanation, the practitioner asked the student, "Are you ready?" and when the student was ready or understood this question, (for example, by nodding their head), they began to work on the instruction.

3. After the student was ready, the practitioner presented the first tool set to the student and waited for their response.

4. The practitioner did not respond to the student's correct, incorrect, or neutral reactions during the process. In the baseline sessions, no clues were given to the student, and the student's

responses were recorded in the data chart for each operation. This process was repeated for each operation in the baseline sessions.

Intervention

The skill of addition was taught using the TouchMath method presented through games during the teaching sessions. In these teaching sessions, the practitioner followed the steps of the direct teaching method known as modeling and guided practice. When the students achieved the target skill with 100% accuracy, they proceeded to the independent practice stage. The teaching sessions were conducted five days a week, with one session per day and one-on-one with the students. The teaching sessions were carried out according to the following steps:

1. The practitioner attracted the student's attention by saying "We will play a game together, and while playing, we will learn how to do addition."
2. The practitioner explained the purpose and benefits of the lesson to the student by saying, "If you tap on the dots on the numbers like you're playing hopscotch and count these dots, you will have performed addition."
3. The practitioner told the student that they would receive a reward (reinforcement) if they followed the instructions.
4. Afterwards, the practitioner placed the teaching material seen in Figure 2 in front of oneself and the student (e.g., for the operation "2+4=?"). The practitioner gave the instruction, "First, I will do it, watch me." The practitioner showed the "+" symbol in the material to the student and asked, "What is this operation?" After the student's response, the practitioner answered, "This is an addition operation."
5. The practitioner then said, "Now we will add the number on top to the number below it." They showed the number on top and said it was "2." Then, they showed the number below and said it was "4." The practitioner then hopped on one foot on the dots on the material, counting them as "1, 2, 3, 4, 5, 6." They verbally said, "2+4=6," announcing the result of the operation.

Following the steps given above, the practitioner moved on to the guided practice stage after performing the operation, saying to the student, "Now, let's do the same operation together." The practitioner and the student performed the operation by following the modeling step in the material with the guidance of the practitioner. After this stage, the modeling stage was reached, and the practitioner gave the instruction, "Now, it's your turn." At this stage, the student was expected to perform the same operation independently with the material in front of them. After these stages were completed with all tool sets, the student was given reinforcement, and the teaching session was concluded.

Maintenance

The study included maintenance sessions conducted by the practitioner at seven, twenty-one, and thirty-five days after the intervention had ended. These sessions aimed to assess the retention of the target skill of addition by the student after the teaching process had concluded. The maintenance sessions involved using worksheets containing ten addition problems and following the same steps as in the initial stage.

Generalization

The study's generalization sessions were carried out using two methods: across individuals and across settings, after the students had acquired the target skill of addition. These processes were carried out in three sessions using the materials and tool sets used in the teaching sessions. In the generalization sessions that took place with their own teachers and in their own classrooms, 10 addition problems were presented to the students.

Data Collection

During the study, data were gathered in three different contexts: effectiveness, reliability, and social validity. Effectiveness data were collected by recording the correct and incorrect responses of the students to the questions in the sessions on data recording forms. At the end of each session, the effectiveness of the teaching method was measured by calculating the percentage of correct responses out of the total number of operations and multiplying the result by 100.

The reliability data of the study were collected in terms of inter-observer reliability and treatment reliability. To collect inter-observer reliability data, assistance was obtained from a special education teacher who had also completed a master's degree in special education, working at a special education vocational high school. Thirty-six percent of the videos recorded during the teaching, maintenance, and generalization sessions were selected through random assignment, and inter-observer reliability data were collected. The data were used in the formula "[(agreement) / (agreement + disagreement)] x 100"(Huberman & Miles, 1994). According to this formula, the inter-observer reliability rates of all students were equal to 99%.

The reliability data of the study's treatment were used to determine how faithfully the practitioner followed the plan they prepared for the sessions. Accordingly, the practitioner prepared a research plan and carried out their practices by following the plan. The special education expert, who assisted in collecting inter-observer reliability data, also helped the researcher here. The recordings, which constituted 36% of the videos selected by the unbiased assignment method in the study, were examined by this person. Steps such as meeting physical needs, informing the student about the study, preparation and introduction the material, and providing attention cues were introduced to this person, and they were explained how to use the data recording form. Treatment reliability was calculated with the formula "[(observed practitioner behavior/planned practitioner behavior) x 100]", and according to this formula, the session treatment reliability rates for all students were equal to 99%.

To assess the social relevance and impact of the study, the teachers of the students were interviewed. Prior to the interviews, the teachers were provided with comprehensive information regarding the study's objectives, materials, and measurement tools, as well as the teaching methodology that was employed. Following these briefings, a semi-structured interview form was administered to the teachers. The social validity data collection form included the following questions: 1) Do you think your student has learned [how to perform] addition operations? 2) Did you find the TouchMath technique presented to your student useful in teaching addition operations? 3) Would you like to apply the TouchMath technique presented in teaching addition operations in this study to other math skills your student is learning? 4) Would you recommend the TouchMath technique to families who have children struggling to learn addition operations? Accordingly, the form included the response options of "Yes," "No," and "Undecided."

Data Analysis

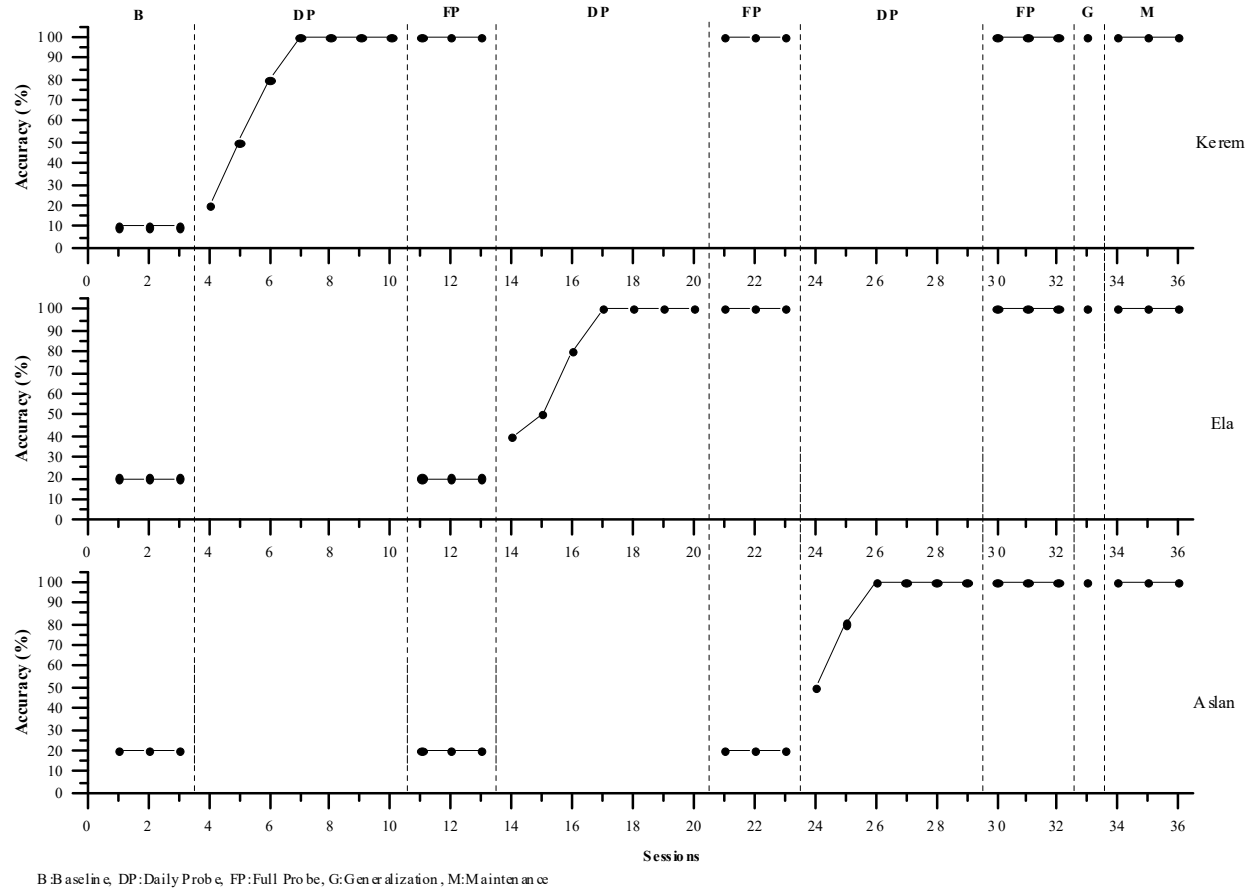
The effectiveness, maintenance, and generalization data obtained within the scope of the study were plotted on a line graph. This graph was analyzed through visual analysis. Visual analysis is a commonly used method of analysis in single-subject research. Therefore, the obtained data were carefully plotted and interpreted on the graph. The reliability data of the study were analyzed using the formulae mentioned above. The social validity data of the study were analyzed qualitatively, and the results were interpreted by calculating percentages.

Results

The purpose of this study was to investigate the efficacy of game-based direct instruction using TouchMath in teaching addition skills to individuals with intellectual disabilities. To achieve this goal, effectiveness data were collected throughout the study. Figure 3 presents the data obtained for Kerem, Ela, and Aslan which were analyzed using the visual analysis method. The graph shown in Figure 3 displays the correct response percentage of each student which was the quantitative expression of the dependent variable on the vertical axis (y) and the number of sessions or time on the horizontal axis (x). The following headings provide explanations of each student's performance levels before and after the intervention.

Figure 3

Accuracy (percentage) results of the addition skills of the students



Results for Kerem

As seen in Figure 3, Kerem responded correctly to 10%, 10%, and 10% of the ten addition operations presented in the three consecutive starting level sessions conducted to determine his pre-teaching performance. In other words, Kerem was only able to complete one of the ten addition operations that were presented to him. Thus, stable data were obtained in three consecutive sessions during the starting level phase, and the instructional sessions with Kerem commenced. During the daily probe sessions conducted after the instructional sessions, Kerem responded correctly at rates in the following order: 20%, 50%, 80%, 100%, 100%, 100%, and 100%. Thus, stable data were obtained during the daily probe sessions conducted after the instructional sessions. In the first full probe session conducted after the intervention sessions were completed, Kerem responded correctly at rates in the following order: 100%, 100%, and 100%. Furthermore, Ela and Aslan also responded correctly at rates in the following order in the second and third full probe sessions conducted after the intervention sessions were completed: 100%, 100%, and 100%. Additionally, in the maintenance data collected seven, twenty-one, and thirty-five days after the intervention sessions, Kerem responded correctly at rates in the following order: 100%, 100%, and 100%. During the generalization data collection process conducted to determine whether Kerem could generalize the skill he had learned across people and settings, he responded correctly to all addition operations presented to him and achieved 100% accuracy.

Results for Ela

As seen in Figure 3, during the three-session baseline phase conducted to determine Ela's pre-teaching performance, she provided responses that were 20%, 20%, and 20% correct, respectively. In other words, during the baseline sessions, Ela was able to complete two out of the ten addition problems presented to her. Thus, stable data were obtained in three consecutive baseline sessions, and intervention sessions were initiated with Ela. In the daily probe sessions conducted at the end of the intervention sessions, Ela responded correctly at rates of 40%, 50%, 80%, 100%, 100%, 100%, and 100%, respectively. This indicated that Ela provided stable data in the daily probe sessions conducted after the intervention sessions. During the first full probe session conducted after Kerem's intervention sessions were completed, Ela provided responses that were 20%, 20%, and 20% correct, respectively. Furthermore, during the second full probe session conducted after her own intervention sessions were completed, Ela responded correctly at rates of 100%, 100%, and 100%, and during the third full probe session conducted after Aslan's intervention sessions were completed, she responded correctly at rates of 100%, 100%, and 100%, respectively. Additionally, during the maintenance data collection processes seven, twenty-one, and thirty-five days after the intervention sessions, Ela responded correctly at rates of 100%, 100%, and 100%, respectively. During the generalization data collection process conducted to determine whether Ela had generalized the skill she had learned across individuals and settings, she responded correctly to all addition problems presented to her, indicating a 100% correct response rate.

Results for Aslan

As seen in Figure 3, it was observed that in the three-session baseline phase conducted to determine Aslan's pre-teaching performance, he gave correct responses at rates of 20%, 20%, and 20%, respectively. In other words, during the baseline sessions, Aslan was able to perform two addition operations out of the ten presented to him. Thus, stable data were obtained in three consecutive baseline sessions, and intervention sessions were initiated with Aslan. His accuracy in the daily probe sessions conducted after the intervention sessions was 50%, 80%, 100%, 100%,

100%, and 100%, consecutively. This indicated that Aslan achieved consistent results in the daily probe sessions held after the intervention sessions. In the first full probe session held after Kerem's intervention sessions, Aslan gave correct responses at rates of 20%, 20%, and 20%, respectively. Additionally, in the second full probe session held after Ela's intervention sessions, Aslan gave correct responses at rates of 20%, 20%, and 20%, respectively. In the third full probe session held after his own intervention sessions, Aslan gave correct responses at rates of 100%, 100%, and 100%, respectively. Moreover, in the maintenance data collection process conducted seven, twenty-one, and thirty-five days after the intervention sessions, Aslan gave correct responses at rates of 100%, 100%, and 100%, respectively. During the generalization data collection process conducted to determine whether Aslan could generalize the learned skill across individuals and settings, it was observed that he gave correct responses to all presented addition operations at a rate of 100%.

To summarize, the results of the study demonstrated that game-based TouchMath taught through direct instruction was effective in teaching addition skills to students with intellectual disabilities. The results also suggested that the students could maintain the addition skills they had learned for up to 35 days after the teaching processes had ended, and they could generalize these skills to different individuals and settings. Social validity data were also collected, and the results showed that the teachers had positive views on the intervention and strategies used in this study.

Discussion and Conclusion

This study examined the effectiveness of game-based TouchMath, presented through direct instruction, in teaching addition skills to students with intellectual disabilities. In addition to assessing the effectiveness of this technique, this study also explored maintenance effects, generalization effects, and social validity. The results showed that the game-based TouchMath technique was effective in teaching addition skills to students with intellectual disabilities, and these students were able to maintain these skills and generalize them to different individuals and settings. The social validity results revealed that the teachers had a positive outlook on the effectiveness of game-based TouchMath presented through direct instruction.

The TouchMath technique presented through games was found effective in teaching addition skills to students with intellectual disabilities, which was consistent with other studies in the literature. For example, Calik and Kargin (2010) and Eliçin et al. (2013) both demonstrated the effectiveness of TouchMath in teaching addition to students with intellectual disabilities. In comparisons to other techniques, Fletcher et al. (2010) compared the effectiveness of the TouchMath and number line techniques in teaching addition to three students, one with intellectual disabilities and two with intellectual disabilities in addition to autism. Using a single-subject alternating treatments design, they found that TouchMath resulted in quicker addition operations and a more accurate addition performance. Similar results were also found in studies examining the effectiveness of TouchMath in teaching math concepts and skills to students with other diagnoses such as hearing impairment and autism spectrum disorder (Avant & Heller, 2011; Yıkmış, 2016). For example, Yıkmış (2016) used a single-subject multiple-probe design to investigate the effectiveness of TouchMath in teaching addition skills to three male students aged between 8 and 10 who were diagnosed with autism spectrum disorder and found that the students were able to acquire and generalize addition skills with the TouchMath technique. In light of this information, it can be stated that the TouchMath technique is effective in teaching math to students

with special needs. It can be beneficial to use this technique in any disability group, including groups of individuals with intellectual disabilities, autism, learning disabilities, or others.

The second result of this study was that all students who participated in the study were able to maintain the skill they acquired through the TouchMath method presented through games seven, twenty-one, and thirty-five days after the end of the intervention. This result demonstrated the permanence of the TouchMath method presented through games in teaching addition. Considering the relevant literature, this result was consistent with the results of other studies (Calik & Kargin, 2010; Eliçin et al., 2013). Calik and Kargin (2010) conducted two maintenance sessions ten and twenty days after all probe sessions were completed, while Eliçin et al. (2013) conducted two maintenance sessions fifteen and thirty days after the end of the intervention sessions. Both studies showed that the addition skills acquired by students with intellectual disabilities became permanent.

The third result of this study was that students with intellectual disabilities were able to generalize the addition skills they acquired at the end of the instruction process to different individuals and settings. This result showed that the TouchMath method presented through games contributed to the ability of the students to generalize their learning to different individuals and settings. The generalization results of this study were consistent with the results of other studies in the literature (Badır-Polat & Yıkmış, 2019; Calik & Kargin, 2010; Eliçin et al., 2013; Scott, 1993; Simon & Hanrahan, 2004). For example, Badır-Polat and Yıkmış (2019) investigated the effectiveness, maintenance, and generalization of TouchMath in teaching subtraction to individuals with intellectual disabilities. As a result of their study in which three students with intellectual disabilities participated, it was observed that the students could generalize the skill they had learned to different individuals and settings.

The final result of this study was that the teachers of the students who participated in the study had positive views on the instruction process provided with the TouchMath technique presented through games. This situation showed that the technique used in this had social validity. This result was in parallel with the results of other studies in the literature (Badır-Polat & Yıkmış, 2019; Eliçin et al., 2013; Terzioğlu & Yıkmış, 2018).

Additionally, the baseline performance levels of the students participating in this study varied from each other. In the daily attendance checks conducted after the teaching sessions, the percentages of the correct responses given by the students also differed from each other. This situation indicated that although the students learned the same skill using the same method, their individual differences affected their learning speeds. Based on this, one may infer that personalizing the learning process according to the individual characteristics of the students could increase their learning speeds and performance.

There are studies in the relevant literature that have presented the TouchMath technique according to the steps of the direct instruction method (Terzioğlu & Yıkmış, 2018) and simultaneous prompting (Badır-Polat & Yıkmış, 2019). This situation shows that the TouchMath technique as an instructional method has a structure that can be used with different methods and presented in different ways. In this study, TouchMath was presented through games while adhering to the systematic nature of the direct instruction method. At the end of the study, it was seen that this was effective. The more systematic and planned teaching approach of the direct instruction method has facilitated the practitioner. Additionally, this method made it easier for the students to learn the targeted skill by having stages such as modeling and guided practice.

Recommendations

Considering the findings of this study, some recommendations can be made for future research and implementations. These recommendations are as follows:

1. The number of participants in the study was quite limited. This was due to the nature of single-subject research. Therefore, studies conducted with different approaches and larger groups of participants can provide stronger evidence of the effectiveness of this technique.
2. This study aimed to teach only the skill of addition. In future studies, this technique can be used to teach different mathematical concepts and skills, and its effectiveness in these areas can be examined.
3. This study also examined the ability of the students to generalize the skills they had learned to different individuals and settings. Further studies can examine how students apply these skills to their daily lives.
4. In this study, social validity data were collected from the students' own teachers. From a social validity perspective, the views of these teachers on the TouchMath technique presented through games are important. However, in future studies, the views of students, parents, and other stakeholders can also be examined.
5. Finally, the results of this study can be used in teaching practices. Teachers and experts working in the field are recommended to use the TouchMath technique presented through games to teach math to students with intellectual disabilities.

Ethics Committee Approval Information: This study was conducted with the approval of the Bolu Abant Izzet Baysal University Social Sciences and Human Research Ethics Committee with the decision dated 10/08/2019 and numbered 2019/08.

Author Conflict of Interest Information: There is no conflict of interest in this study, and no financial support has been received.

Author Contributions: The first author contributed by 50%, the second author contributed by 30%, and the third author contributed by 20% to this article.

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Geniş Türkçe Özet

Giriş

Bu araştırmada, nokta belirleme tekniğinin oyun yoluyla sunulmasının zihinsel yetersizliği olan bireylerin toplama işlemini öğrenmelerinin üzerinde nasıl bir etki yaratacağı, araştırmacıların ana merak konusudur. Araştırmacıların bu merakının yanı sıra matematik kavram ve becerilerini edinmede birçok güçlük yaşayan zihinsel yetersizliği olan bireylere etkililiği daha önce kanıtlanmış nokta belirleme tekniğinin oyun yoluyla sunulmasının sonuçlarının alana katkı sağlayacağı düşünülmektedir. Buradan yola çıkılarak bu araştırmanın ana amacı zihinsel yetersizliği olan bireylere toplama işleminin öğretiminde oyun yoluyla sunulan nokta belirleme tekniğinin etkililiğini belirlemektir. Bu amacın yanı sıra mevcut araştırmada, oyun yoluyla sunulan nokta belirleme tekniğinin kalıcılık ve genelleme etkisi de araştırılmıştır. Ayrıca araştırmaya katılan zihinsel yetersizliği olan öğrencilerin öğretmenlerinin oyun yoluyla sunulan nokta belirleme tekniğine ilişkin görüşleri alınarak, araştırmanın sosyal geçerliliği belirlenmeye çalışılmıştır.

Yöntem

Araştırma Deseni

Bu araştırmada tek denekli araştırma modellerinden denekler arası çoklu yoklama modeli kullanılmıştır. Bu modele göre araştırmada üç denekle eşzamanlı olarak başlama düzeyi verisi toplanmıştır. Başlama düzeyi evresinde kararlı veriye ulaşıldığında birinci denekle müdahale evresine geçilmiştir. Bu denek, hedef beceriye ulaştığında ve kararlı veri elde edildiğinde müdahale evresi sonlandırılmıştır. Ardından tüm deneklerde eş zamanlı olarak birinci toplu yoklama oturumu düzenlenmiştir. Toplu yoklama oturumunda kararlı veriye ulaşıldığında ikinci denekle müdahale evresine geçilmiştir. Bu denek, hedef beceriye ulaştığında ve kararlı veri elde edildiğinde müdahale evresi sonlandırılmıştır. Ardından tüm deneklerde eş zamanlı olarak ikinci toplu yoklama oturumu düzenlenmiştir. Toplu yoklama oturumunda kararlı veriye ulaşıldığında üçüncü denekle müdahale evresine geçilmiştir. Bu denek, hedef beceriye ulaştığında ve kararlı veri elde edildiğinde müdahale evresi sonlandırılmıştır. Ardından tüm deneklerde eş zamanlı olarak üçüncü toplu yoklama oturumu düzenlenmiştir. Böylelikle bağımsız değişkenin bağımlı değişken üzerindeki etkisi kanıtlanmıştır.

Bağımsız Değişken

Araştırmanın bağımsız değişkeni oyun yoluyla sunulan nokta belirleme tekniğiyle yapılan öğretimdir. Bu öğretimler doğrudan öğretim yönteminin basamakları dikkate alınarak öğrencilere sunulmuştur. Yapılan öğretimlerde model olma, rehberli uygulamalar ve bağımsız uygulamalar basamakları deneklerle bire bir olacak şekilde gerçekleştirilmiştir.

Bağımlı Değişken

Araştırmanın bağımlı değişkeni, deneklerin toplama işlemi becerilerini gerçekleştirme düzeyleridir. Bu araştırmada toplama işleminin bağımlı değişken olarak seçilmesinin bazı nedenleri vardır. Bu nedenlerden birincisi, toplama işleminin daha ileriki matematik becerilerinin öğrenimi için ön koşul beceri olmasıdır. İkincisi, bu beceri öğrencilerin yaşlarına ve sınıf seviyelerine uygundur. Üçüncüsü, toplama işleminin öğrenimi öğrencilerin okul başarısına katkı sağlamaktadır. Ve son olarak bu beceri öğrencilerin günlük yaşamda bağımsız bir şekilde yaşamalarını desteklemektedir.

Araştırmada toplama işlemi becerilerinin ilk basamağı olan tek basamaklı bir sayıyla tek basamaklı bir sayıyı toplama işleminin öğretimi hedeflenmiştir. Bu hedef doğrultusunda öğrencilere her bir oturumda 10 adet toplama işlemi sunulmuş ve öğrencilerin bu toplama işlemlerini %100 düzeyinde öğrenmeleri beklenmiştir.

Denekler

Araştırmaya orta düzeyde zihinsel yetersizlik tanısı almış üç öğrenci katılmıştır. Bu öğrenciler toplama işlemi için gerekli olan ön koşul becerileri yerine getirme durumlarına göre belirlenmiştir. Öğrencilerden sahip olmaları beklenen ön koşul beceriler a) nesne sayma, b) 1'den 50'ye kadar birer birer ritmik sayma, c) 1-9 arasındaki rakamları yazma ve söyleme, d) tek ayak veya çift ayak üzerinde öne doğru zıplama, e) bir veya daha fazla eylem bildiren yönergeleri yerine getirme şeklindedir. Bu ön koşul özellikleri yerine getiren öğrencilerin ailelerinden, kendilerinden ve gerekli kurumlardan izinler alındıktan sonra deneysel sürece başlanmıştır.

Ortam

Araştırmanın deneysel sürecindeki tüm oturumlar, deneklerin bireysel destek hizmeti aldıkları özel danışmanlık ve eğitim merkezinin bireysel eğitim odasında gerçekleştirilmiştir. 4x6 metre boyutlarında olan bu odada bir masa, iki sandalye ve bir de dolap bulunmaktadır. Bu ortamda deneklerle bire bir olacak şekilde çalışılmıştır. Ayrıca ortama deneysel süreci kaydetmek amacıyla bir kamera yerleştirilmiştir.

Araç-Gereçler

Bu araştırmanın deneysel sürecinde kullanılmak amacıyla 40x40cm boyutlarında vinil brandalara üzerinde nokta belirleme tekniğine göre noktalar bulunan 1-5 arasındaki rakamlar hazırlanmıştır. Ayrıca yine vinil malzemeden yapılmış üzerinde toplama işlemi sembolü ve çizgisi (+_____) olan materyal hazırlanmıştır. Ayrıca yoklama ve izleme oturumlarında çalışma kağıtları, kalem ve silgiden yararlanılmıştır.

Uygulama Süreci

Araştırmanın başlama düzeyi oturumları, hedef beceriye ilişkin öğrencilerin var olan performanslarını değerlendirmek amacıyla gerçekleştirilmiştir. Üç öğrenciyle eş zamanlı olarak başlama düzeyi oturumlarına başlanılmış ve ilk öğrenciyle kararlı veri elde edilene kadar sürdürülmüştür. Başlama düzeyi oturumları öğrencilerle bire bir olacak şekilde yapılmıştır. Başlama düzeyi oturumlarında kararlı veriye ulaşıldıktan sonra, bu oturumlar sonlandırılmış ve ilk öğrenciyle öğretim oturumlarına geçilmiştir.

Öğretim oturumlarında oyun yoluyla sunulan nokta belirleme tekniği ile toplama işlemi öğretimi gerçekleştirilmiştir. Bu öğretimlerde, uygulamacı doğrudan öğretim yönteminin model olma ve rehberli uygulamalar basamaklarını izlemiştir. Öğrencilerin %100 doğruluk düzeyinde hedef beceriyi doğru gerçekleştirme durumlarında ise bağımsız uygulamalar aşamasına geçilmiştir. Öğretim oturumları haftada beş gün, günde bir oturum ve öğrencilerle bire bir olacak şekilde yapılmıştır.

Araştırmanın izleme oturumları, öğretimler bittikten yedi, yirmi bir gün ve otuz beş gün sonra uygulamacı tarafından gerçekleştirilmiştir. Bu oturumlar öğrencilere hedef beceri olan toplama işlemi öğretildikten sonra bunu ne düzeyde koruyabildiklerini değerlendirmek amacıyla yapılmıştır. Üzerinde 10 adet toplama işleminin olduğu çalışma kağıtlarının kullanıldığı bu oturumlar, başlama düzeyi evresindeki aşamalar takip edilerek gerçekleştirilmiştir.

Araştırmanın genelleme oturumları, hedef beceri olan toplama işlemini öğrenciler kazandıktan sonra kişiler ve ortamlar arası olmak üzere iki şekilde gerçekleştirilmiştir. Bu oturumlar, öğretim oturumlarında kullanılan materyaller ve araç setleri kullanılarak üç oturum yapılmıştır. Öğrencilerin kendi öğretmenleri tarafından ve kendi sınıflarında gerçekleşen genelleme oturumlarında, 10 adet toplama işlemi öğrencilere yöneltilmiştir.

Verilerin Toplanması

Araştırma boyunca etkililik, güvenirlik ve sosyal geçerlik olmak üzere üç tür veri toplanmıştır. Etkililik verileri öğrencilerin oturumlara verdiği doğru ve yanlış tepkilerin veri kayıt formlarına kaydedilmesiyle toplanmıştır. Etkililik verileri, oturumların sonunda öğrencilerin doğru tepkide bulunduğu işlem sayısı, toplam işlem sayısına bölünüp yüzle çarpılarak hesaplanmıştır.

Araştırmanın güvenirlik verileri ise gözlemciler arası ve uygulama güvenirliği olmak üzere iki şekilde toplanmıştır. Gözlemciler arası güvenirlik verilerini toplamak için bir özel eğitim meslek lisesinde görev yapmakta olan aynı zamanda özel eğitim alanında yüksek lisans yapmış bir özel eğitim öğretmeninden yardım alınmıştır. Öğretim, izleme ve genelleme oturumları sırasında kaydedilen videolardan %36'sı yansız atama yoluyla seçilmiş ve gözlemciler arası güvenirlik verisi toplanmıştır. Bu veriler *"[(görüş birliği) / (görüş birliği + görüş ayrılığı)] x 100"* formülü ile hesaplanmıştır.

Araştırmanın uygulama güvenirliği verileri ise uygulamacının oturumları hazırladığı plana ne kadar sadık kalarak yaptığını belirlemek içindir. Bu nedenle uygulamacı, bir araştırma planı hazırlamıştır ve uygulamalarını planını izleyerek gerçekleştirmiştir. Gözlemciler arası güvenirlik verisini toplamaya yardımcı olan özel eğitim uzmanı burada da araştırmacıya katkı sağlamıştır. Araştırmanın yansız atama yoluyla seçilen, videoların %36'sını oluşturan kayıtlar bu kişi tarafından incelenmiştir. Bu kişiye fiziksel ihtiyaçların giderilmesi, çalışma hakkında öğrenciye bilgi verilmesi, materyali hazırlama ve öğrenciye tanıtma, dikkat sağlayıcı ipucu sunma basamakları tanıtılmıştır be veri kayıt formunu nasıl kullanacağı açıklanmıştır. Uygulama güvenirliği *"[(gözlenen uygulamacı davranışı/planlanan uygulamacı davranışı) x 100)"* formülüyle hesaplanmıştır.

Sosyal Geçerlik Verilerinin Toplanması

Araştırmanın sosyal anlamda önemini ve etkilerini belirlemek amacıyla öğrencilerin öğretmenleriyle görüşmeler yapılmıştır. Görüşmelerden önce öğretmenlere çalışmanın amacı, çalışılan materyaller ve araç gereçler, çalışılan öğretim yöntemi gibi konularda detaylı bilgi verilmiştir. Bu bilgilendirmelerden sonra öğretmenlere "Evet", "Hayır" ve "Kararsızım" yanıtlarından oluşan sosyal geçerlik formu uygulanmıştır.

Verilerin Analizi

Araştırma kapsamında elde edilen etkililik, izleme ve genelleme verileri çizgi grafiğine işlenmiştir. Bu grafik görsel analiz yoluyla analiz edilmiştir. Araştırmanın güvenirlik verileri ise yukarıda belirtilen formüller ile hesaplanmış ve analiz edilmiştir. Araştırmanın sosyal geçerlik verileri ise öğrencilerin öğretmenlerinden alınan görüşlerin betimsel analizi yoluyla çözümlenmiştir.

Bulgular

Araştırmanın bulguları zihinsel yetersizliği olan öğrencilere toplama işlemi becerisinin öğretiminde doğrudan öğretim yöntemiyle sunulan oyun tabanlı nokta belirleme tekniğinin etkili

olduğunu göstermektedir. Ayrıca öğrencilerin edindikleri toplama işlemi becerisini öğretimler bittikten yedi, yirmi bir ve otuz beş sonra da koruduğunu söylenebilir. Kalıcılığın yanı sıra öğrencilerin bu becerileri farklı kişi ve ortamlara da genelleyebildikleri sonucuna varılmıştır. Araştırmada ayrıca sosyal geçerlik verileri toplanmıştır. Sosyal geçerlik bulguları ise öğrencilerin öğretmenlerinin yapılan öğretime, kullanılan stratejiye yönelik olumlu görüşler bildirdiklerini ortaya koymuştur.