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Investigating the Effectiveness of STAR Strategy in Math Problem Solving

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Abstract

Focusing on students with mild disabilities, this study aimed to examine the effect of STAR problem solving strategy on their a) solving change problems involving one-step addition and subtraction, b) maintaining their acquisition of solving change problems involving one-step addition and subtraction after 1, 3, and 5 weeks, c) generalizing their performance in solving problems to the classroom environment. Three students with mild mental disabilities participated in the study. A multiple probe across participants design was used in the study. The number of problems that students solved correctly was determined by scoring the data. The data are shown graphically and analysed visually. Findings emphasized the effectiveness of STAR strategy for students with mild mental disabilities when solving change problems that involve a one-step addition and subtraction, indicating that those who acquired this strategy could demonstrate the same problem solving performance 1, 3, and 5 weeks after the intervention. Also, students were observed to generalize their strategy performance to the classroom environment. The findings of the research were discussed within the framework of the relevant literature and theoretical views, and suggestions were made for teachers in terms of interventions and for researchers considering further studies.

Keywords: Math Problem Solving, STAR Strategy, Cognitive and Metacognitive Strategies, Mental Disability.

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INTRODUCTION

Being among the main objectives of mathematics, problem solving is the focal point of many countries' educational programs (MoNE, 2005; NCTM, 2000). It has been identified as the main theme to be discussed in "Principles and Standards for School Mathematics" published by the National Council of Teachers of Mathematics (NCTM). This activity adopts the understanding of improving the problem solving ability of each student as well as the view that "problem solving should be the focus of school mathematics" was adopted (NCTM, 2000). Math problem solving forms a large part of the general and special education curriculum (Parmar & Cawley, 1997; Rivera, 1997). It is a process that involves problem-solving, combining and analysing skills (Cawley & Miller, 1986), consists of one and/or more steps (Fuchs, Fuchs & Prentice, 2004), requires the necessary calculation processes to be used in the solution process (Carpenter et al., 1993), and rarely contains irrelevant or distracting information (Passolunghi, Marzocchi & Fiorillo, 2005). This process involves the implementation of knowledge, skills, and strategies (Fuchs et al., 2004).

Due to the complexity of problem solving processes, math problem solving is regarded as a difficult skill for both students with special needs and normal development (Jonassen, 2003). Strategy knowledge of many students with problem solving practice develops naturally. The apparent disabilities of some students naturally cause them to suffer from the development of strategy knowledge and also decrease their school performance (Montague, 1997). Students with mental disabilities have difficulties in transferring mathematical information and conceptualizing problems (Rivera, 1997). When teaching them how to solve math problems, they should be taught not only what to do but also how to do it (Goldman, 1989). Interventions applied to students with mental disabilities target basic processing skills (Miller & Hudson, 2007) instead of teaching the problem solving process and how to implement the specified process (Foegen, 2008; Maccini, Mulcahy & Wilson, 2007). Especially for students with mental disabilities who have limitations in managing their learning process and cognitive processes, knowing the problem solving stages is not enough for them to be a good problem solver. Therefore, with a process-based regular and strategic education (Montague, 2007; 2008; Whitby, 2009), students with mental disabilities should be taught appropriate strategies that help them to solve problems within the process (from planning to reaching the final solution) (Jitendra & Hoff, 1996; Karabulut & Özmen , 2018). Studies examined process-based teaching that focused on teaching students cognitive and metacognitive strategies and operations in the mathematical problem-solving process (Bennet, 1982; Case & Harris, 1988; Hutchinson, 1993). Process-based teaching basically includes problem solving stages. However, in these stages, the aim is to provide appropriate strategies to students in order to perform cognitive processes. The process is monitored and questioned in the metacognitive strategies. These skills are both necessary for successful problem solving skills and are highly associated with overall mathematics achievement (Bryant, Bryant, & Hammill, 2000).

The focus should be on how to solve the problem to students, the information that will contribute to the solution, how to represent the problem (table, figure, a concrete object, etc.), and how the strategy to be chosen and its representation will facilitate the solution (İpek & Malaş, 2013). One of such strategies is the STAR strategy. The STAR strategy (**S**earch the problem; **T**ranslate the words into an equation in picture form; **A**nswer the problem; **R**eview the solution) was developed by Maccini and Hughes (2000). It is one of the cognitive strategy teaching models that allows students to remind general problem solving steps in solving math problems. Each letter of the STAR strategy marks a cognitive strategy step. Table 1 presents the main and intermediate steps of the STAR strategy.

Table 1. Steps of the STAR strategy

Main Steps of the Strategy	Intermediate Steps of the Strategy
Search the word problem	Read the problem carefully Ask yourself such questions: What facts do I know? What do I need to find? Write down facts
Translate the words into an equation in picture form	Select a variable Identify the operation(s) Represent the problem using the concrete intervention of CSA (Concrete-Semi-Concrete-Abstract) Draw a picture of the representation (Semi-Concrete) Write an algebraic equation (Abstract)
Answer the problem	Answer the problem
Review the solution	Reread the problem Ask yourself such questions: Does the result make any sense? Why? Check the answer

As is seen in Table 1, it is aimed to help students to understand the problem considering *search the word problem*; express the problem visually (pictorial) before solving the problem in *translate the words into an equation in picture form*; write the solution using mathematical expressions in the problem regarding *answer the problem*; ensure that the student reviews all the steps in the strategy and the process is correct for *review the solution* (Maccini & Hughes, 2000). The first step of STAR (search the word problem) helps the student to read the problem carefully and to organize this information by considering the information given in the problem. The second step of STAR (translate the words into an equation in picture form) adopts the concrete-semi-concrete-abstract approach. The concrete-semi-concrete-abstract approach is a teaching approach, which includes the concrete, semi-concrete and abstract stages, respectively (Marita & Hord, 2016). In the concrete stage, the first stage, it is aimed to solve the problem by expressing it with concrete objects. The second stage, the semi-abstract stage, aims to solve the problem by representing it visually through pictures, drawings, and two-dimensional shapes. In the last stage, the abstract stage, the problem is expressed in the language of mathematics by using the symbols and equations and the solution is realized (Strickland & Maccini, 2012). Literature abounds in studies using problem solving interventions for students with learning disabilities by applying concrete-semi-concrete-abstract approach (Hunt & Vazquez, 2014; Scheuermann, Deshler & Schumaker, 2009; Strickland & Maccini, 2013). The interventions increased the problem solving performance of students with learning difficulties in algebra, geometry, ratio and proportion. Also, the fact that the STAR strategy includes visualization of the problem increases its effectiveness. Accordingly, the use of visualization strategy is described as a strong problem representation process in the problem solving process. The use of visual images can be an important variable in the solution of problems in solving different types of problems (Polya, 1957). Owens and Clements (1998) advocate that the use of visual images plays an important role in ensuring understanding of a problem, determining the processes to be chosen for problem solving, and recalling information from memory. This strategy (translate the words into an equation in picture form) has been found to improve students' problem solving skills (Ives, 2007; Van Garderen, 2006, 2007). The third step of STAR (answer the problem) helps students to answer the problem by looking at the visual drawings of the problem. The fourth step of STAR (review the solution) helps students to check the suitability of their answers.

There are studies investigating the effectiveness of the STAR strategy in math problem solving regarding different disability groups such as learning disability (Maccini & Hughes, 2000; Maccini & Ruhl, 2000) and emotional behavior disorder (Peltier & Vannest, 2016). In Turkey, considering the effectiveness strategy examined in this article, only one study was conducted to support students' problem solving skills (İpek & Malaş, 2013). This research was conducted with students with normal development. Regarding research carried out in our country in order to support math problem solving skills of students with mental disabilities, there are a limited number of studies examining the effects of different problem solving intervention programs (Karabulut & Özmen, 2018; Karabulut, Yıkmış, Özak & Karabulut, 2015; Tufan & Aykut, 2018). The number of studies using cognitive strategy and self-regulation strategies together in teaching problem solving skills to students with mental disabilities is limited (Karabulut & Özmen, 2018). This research will ensure the generalizability of strategy interventions to different disability groups as it applies the effectiveness of STAR strategy teaching with students with mental disabilities. Besides, the strategy teaching applied in the research is thought to create a different perspective for researchers and practitioners on problem solving teaching. Accordingly, the overall aim of this study is to determine the effectiveness of the STAR strategy in problem solving skills of students with mild mental disabilities. To achieve the general purpose, the following questions were asked:

1. Is the STAR strategy effective for students with mild mental disabilities in solving change problems involving one-step addition or subtraction?

2. After teaching with the STAR strategy, do students with mild mental disabilities maintain their change problem solving performance after 1, 3, and 5 weeks?

3. After teaching with the STAR strategy, can students with mild mental disability generalize their performance of change problems involving one-step addition or subtraction to the class environment?

METHOD

Research Design

This study adopted a multiple probe across participants design which is among single-subject research models. In this design, the effectiveness of a method on a target behaviour is investigated in multiple subjects of the same feature (Gast, 2010). When applying a multiple probe across participants design, the initial level (baseline) data of at least three consecutive sessions are collected for the first participant; a probe data is received from the second and third participants. When the baseline data of the first participant shows stability, the first subject is treated. When the performance of the first participant reaches the criterion level and the data show stability with the independent variable, the initial level is measured for the second participant and a probe data is taken for the third participant. When the baseline data in the second participant are stable, an independent variable is applied to the second participant. When the independent variable applied to the second participant and his/her performance reaches the criterion level and the data show stability, the initial level is measured for the third participant. When the baseline data shows stability, an independent variable is applied to the third participant (Gast, 2010). In other words, a multiple probe across participants design was used in this study to determine the effectiveness of the STAR strategy on problem solving skills of students with mild mental disabilities. The similarity between the subjects was ensured by the subjects fulfilling the determined pre-requisite behaviors, and the independence was achieved by teaching the subjects one-to-one strategy in the educational environment where the implementation was carried out.

Selection of the Participants

Participants were three students with mild mental disabilities who were studying in special education classes at secondary school. They were recruited according to some criteria: a) having a diagnosis of mental disability in the disability health board report, b) not having any additional deficiencies, c) being able to analyse without spelling at the instructional level (90% -95% accuracy), d) be able to perform addition and subtraction at 80% accuracy, which requires addition with regrouping and subtraction with regrouping, e) solving correctly at least 1 and maximum 3 out of 10 change problems that involve a one-step addition and subtraction process, f) attending school regularly.

To select the participants, state schools in the central district of Eskişehir, with special education classes and inclusive interventions, were determined. Legal permission was obtained to conduct research in these schools. Interviews were conducted with the class teachers of these schools. Students with mental disabilities were determined based on the interviews. The guidance teachers of the students determined were interviewed, and information about their diagnosis was obtained.

A prerequisite assessment was made to assess whether students diagnosed as mild mental disabilities meet the criteria. Students are expected to have a certain level of reading skills in mathematics problem solving studies. Thus, firstly, students' decoding skills without spelling at the instructional level were evaluated. Accordingly, one descriptive text was used. It was prepared by using textbooks or encyclopaedias, which students did not meet before and were allowed to be taught by the Board of Education. Second, ten operations were given to the students to examine whether they could make addition with regrouping, and the students who performed these operations with 80% accuracy were determined. Besides, ten arithmetic operations procedures that require subtraction and addition with regrouping were given to them, and students who performed these operations with 80% accuracy were determined. Finally, to determine the students' performance of one-step addition and subtraction problems, students were given one-step change problems that include ten additions and ten subtractions, and they were asked to solve. Their one-step addition and subtraction performances were evaluated by the researcher, and students who solved correctly at least 1 and maximum 3 out of 10 problems were recruited. Permission was obtained for the students to participate in the study by Interviewing them, their teachers and their families. Accordingly, three students (who were allowed to participate in the study by their parents) were determined as research subjects.

Characteristics of the Participants

The first participant was a 13-year 4-month-old female student with a mild intellectual disability, with an intelligence score of 68, who was studying in special education classes at secondary school in 6th grade. She was able to make 9 of the 10 addition with regrouping operations correctly and 8 of the 10 subtraction with regrouping operations. She could solve 2 out of 10 change problems that correctly includes one-step addition and subtraction. She had no additional disabilities and no school attendance problems.

The second participant was a 14-year 5-month-old male student with a mild intellectual disability, with an intelligence score of 66, who was studying in special education classes at secondary school in 6th grade. He was able to make 10 of the 10 addition with regrouping operations correctly and 9 of the 10 subtraction with regrouping operations. He could solve 2 out of 10 change problems that correctly includes one-step addition and subtraction. He had no additional disabilities and no school attendance problems.

The third participant was a 13-year 8-month-old female student with a mild intellectual disability, with an intelligence score of 65, who was studying in special education classes at secondary school in 6th grade. He was able to make 9 of the 10 addition with regrouping operations correctly and 9 of the 10 subtraction with regrouping operations. She could solve 3 out of 10 change problems that correctly includes one-step addition and subtraction. She had no additional disabilities and no school attendance problems.

Dependent and Independent Variable

The dependent variable is the percentage of solving change problems involving a one-step addition or subtraction. The independent variable is the STAR strategy.

Ensuring Internal Validity of the Study

A multiple probe across participants design is a design with high internal validity. Internal validity refers to the fact that there is no change in the baseline and probe data before the treatment is applied to the participants, and there is an observable change in the student's performance when the treatment is applied (Gast, 2010). Apart from controlling students' learning situations and responsiveness, to ensure internal validity, these practices were followed: a) to control the impact of external factors, that they do not apply any additional programs to the student other than the program followed by the family and the teacher when getting baseline level data from student and while applying STAR strategy training, b) prerequisites were determined to prevent participant bias and participant loss, c) the artificial environment effect was minimized by working in the environment where the work would be carried out one week before study, d) intervention reliability was calculated to ensure that the intervention sessions were implemented as planned, e) in order for the collection method of the dependent variable to remain unchanged, intervention reliability was calculated for the evaluation processes, and f) inter-observer reliability was calculated to ensure the reliability of the data related to the dependent variable.

Competencies of Researchers

Two of the researchers have a Ph.D. in Special Education and one is a Ph.D. candidate (at the dissertation stage). They published research on mathematics for students with special needs (Karabulut, 2015; Karabulut et al., 2005; Karabulut & Özmen, 2018; Karabulut & Özkubat, 2019; Özkubat, 2019; Özkubat, Karabulut & Akçayır, 2020; Özkubat, Karabulut & Özmen, 2020; Özkubat & Özmen, 2018; 2020). Besides, the researchers took the Cognitive Strategy Teaching course within their doctorate education.

Context and Time

The intervention process of the research was carried out in support education room in the school. The support education room is 4 m x 5 m in size. The participants sat at a rectangular table, and the researcher sat in front of them. The sessions were carried out between 09:30 and 11:30 every weekday, as one session per day.

Intervention

The intervention process was carried out in five stages. These are baseline session, instruction session, post instruction assessments, generalization, and follow up sessions.

Baseline Sessions

In this stage, the performances of the participants to solve change problems involving one-stage addition or subtraction were determined. Students were asked to solve the worksheets, which consisted of 10 one-step addition or subtraction, consisting of change problems. Students' baseline (initial) level performances were calculated as percentages and graphed.

Instruction Sessions

Instruction sessions were started with the participants who obtained stable data at the baseline level. The instruction sessions continued until students solved change problems involving one-step addition or subtraction with the STAR strategy with 90% accuracy and until it showed stable data. Please see Appendix 1 for the sample form of the STAR strategy. In instruction sessions, worksheets consisting of change problems, including 10 one-step addition or subtraction, were used. In this process, the questions were presented to the students one by one. Firstly, the questionnaire was given to the student and asked to read it carefully. Then the practitioner asked the student to tick the "Read the problem carefully" box, which is located in the first step of the strategy form. Then, in the second step, the students were asked to answer what they knew and what they needed to find in the questions. In this step, they were asked to mark the parts related to the question about what is known and desired and to express it verbally. After this step, students were asked to tick the box opposite the instruction (Ask yourself such questions What facts do I know? What do I need to find?) which was located in the second step of the STAR Strategy Form. Then, the student was asked to write down what was given in the problem. The data given at the root of the problem and used in the solution were written across the third step in the form. Then, it was time for the second step (Translate the words into an equation in picture form). At this stage, the students were asked to visualize the data at the root of the problem with various icons and images. The visualization process was left to the imagination of the students, and it was not intervened as long as it was correct. Later, after passing on to the next step (Answer the problem), they were asked to reach the result by using the icons and pictures they drew. The result reached was written as a transaction to the relevant step of the form. During the solution of the problem, the solution process was supported by using various verbal cues in line with the needs of the students. Finally, in the last stage of STAR strategy (Review the solution), students were asked to read and check their solutions and write the steps they accomplished in return for each step as stated in the form. This process was repeated for each question in the worksheets consisting of 10 questions used in each teaching session as well as sessions. After the instruction sessions, the post instruction assessment session started.

Post Instruction Assessment

In post instruction sessions, the process carried out in the baseline sessions was followed. Students were asked to solve worksheets consisting of change problems including 10 one-step addition or subtraction. The worksheets were evaluated, students' post instruction assessment were calculated as a percentage and graphed. After reaching the 90% accuracy level, (the criterion determined for each student) and obtaining stable data for three consecutive sessions, each stage of the process was repeated for the next student by ending the teaching and post instruction sessions.

Generalization Sessions

Generalization sessions were organized in order to determine the generalization levels of students' performance in change problems, including one-step addition or subtraction. Generalization data were collected with pre-instruction pre-test and post-instruction post-test data. While collecting generalization pre-test data, students were given worksheets consisting of 10 change problems, which include addition or subtraction in the classroom, and asked to answer the questions. The correct answers percentages were determined through the student answers and they were graphed. At the post-instruction, generalization post-test sessions were conducted. As in the pre-test sessions, students were given worksheets consisting of 10 change problems that include addition or subtraction and asked to answer the questions. Also, the answers given by the students were evaluated and the correct answer percentages were determined and graphed. Students were observed to use the STAR strategy in solving the problems in the post-test sessions.

Follow Up Sessions

Following the post-instruction, follow up sessions were initiated. In the follow up sessions, it is aimed to determine the students' level of maintaining the STAR strategy after 1, 3, and 5 weeks after the post-instruction. The follow up sessions were held in the classroom where the students were studying. Similar to the post-instruction assessment sessions, students were asked to solve the worksheets, which consisted of 10 one-step addition or subtraction and change problems in these sessions. Then, students' post-instruction assessment performances were calculated as percentages, and they were graphed. A follow up session was organized for each student in the weeks determined, follow up data were collected and the percentages of correct responses were graphed.

Data Analysis

Solving data of change problems, which include one-step addition and subtraction, were shown with a line chart and visually analysed. The graph showed the number of sessions on the horizontal axis and the percentage of correct answers on the vertical axis. The data level obtained at the baseline level was compared with the data level obtained at the post-instruction practices. The increase in the data level after introducing independent variable demonstrates the effect of the strategy applied. Follow up data were compared with post-instruction data and whether there was a level difference was identified.

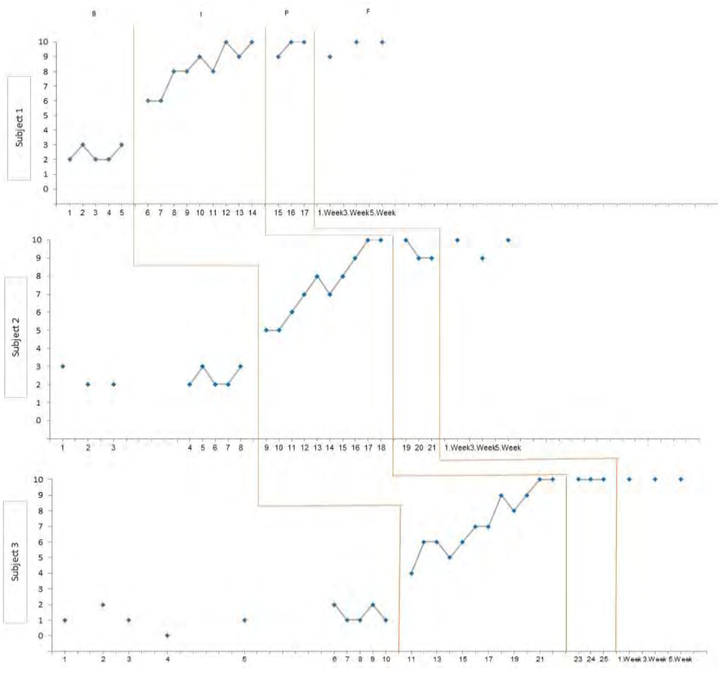
Inter-Observer Reliability and Reliability of Implementation

Inter-observer reliability is calculated by dividing the total consensus of researchers and observers by the sum of consensus and disagreement and multiplied by 100 (House, House & Campbell, 1981). Observers were told how to score the data and they were asked to fill out the yes and no columns on the Observer Reliability Registration Form by evaluating the students' answers as incorrect or correct. The observer was a research assistant who completed his MA in special education. Inter-observer reliability was found to be 100%.

Intervention reliability was calculated by dividing the observed researcher behaviour by the planned researcher behaviour (Billingsley, White, & Munson, 1980). Intervention reliability for each of the three subjects was found to be100%.

FINDINGS

Graph 1 shows the baseline, instruction, post-instruction, and follow up findings regarding the level of change problem solving involving one-step addition and subtraction.



Graph 1. Findings Regarding the Level of Problem Solving

While the first participant responded correctly to a total of 2 problems (at least 2 and maximum 3) of 10 change problems including 5 sessions of addition or subtraction at the baseline level, she responded correctly to an average of 7 problems (at least 6 and maximum 10) at the end of the STAR strategy intervention. In post instruction sessions, she correctly answered 9, 10, and 10 problems respectively. In the follow up sessions, she correctly answered 9, 10, and 10 problems after 1, 3, and 5 weeks respectively. No decrease occurred in the number of problems the participant solved during the follow up sessions regarding post-instruction.

The second participant responded correctly to a total of 2 problems (at least 2 and maximum 3) of 10 change problems including 5 sessions of addition or subtraction at the baseline level. The probe data received at the beginning of the experiment process did not differ from the baseline level data received before starting intervention. He responded correctly to an average of 8 problems (at least 5 and maximum 10) at the end of the STAR strategy intervention. In post instruction sessions, he correctly answered 10, 9, and 9 problems respectively. In the follow up sessions, he correctly answered 10, 9, and 10 problems after 1, 3, and 5 weeks respectively. No decrease occurred in the number of problems the participant solved during the follow up sessions regarding post-instruction.

The third participant responded correctly to a total of 1 problem (at least 1 and maximum 2) of 10 change problems including 5 sessions of addition or subtraction at the baseline level. The probe data received at the beginning of the experiment process did not differ from the baseline level data received before starting teaching. She responded correctly to an average of 7 problems (at least 4 and maximum 10) at the end of the STAR strategy intervention. In post instruction sessions and the follow up sessions, she correctly answered all problems. No decrease occurred in the number of problems the participant solved during the follow up sessions regarding post-instruction.

As a result, there was no difference between the initial level of all participants and the number of correct answers given to problems that include a one-step addition and subtraction at the end of the STAR strategy intervention. As can be seen in Graph 1, the level of the data path obtained at the post-instruction in all subjects is higher than the baseline level. All three subjects met the criteria determined at the post-instruction. This progress was not observed before applying the independent variable but after the intervention of the independent variable. For this reason, the STAR strategy was found effective in solving the change problems involving one-stage addition and subtraction. Moreover, there was no decrease in the follow up sessions held after teaching compared to the post-intervention. This finding shows that the STAR strategy is effective in maintaining the performances in change problems involving one-step addition and subtraction after 1, 3, and 5 weeks.

Figure 1 presents the pre and post-intervention findings related to the participants' problem solving performance of change problems involving one-step addition and subtraction to class environment.

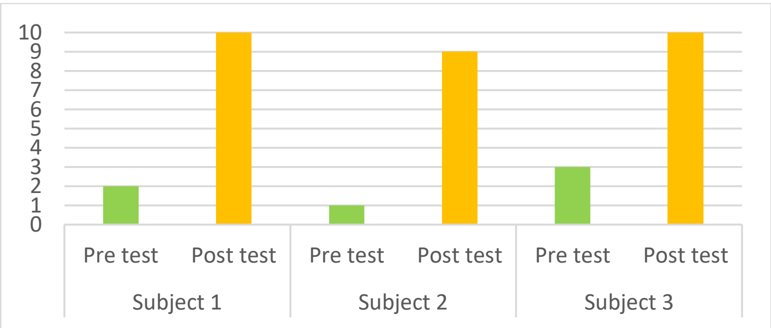


Figure 1. The Generalization Levels of Participants' Problem Solving Performance of Change Problems Involving One-Step Addition and Subtraction to Class Environment

While the first participant responded correctly to 2 of the 10 change problems involving one-stage addition and subtraction in the generalization pre-test stage, she answered all of the problems correctly after applying the STAR strategy. The second participant responded correctly to 1 of the 10 change problems involving one-stage addition and subtraction in the generalization pre-test stage, but he answered 9 of the problems correctly after applying the STAR strategy. While the third participant responded correctly to 3 of the 10 change problems involving one-stage addition and subtraction in the generalization pre-test stage, she answered all of the problems correctly after applying the STAR strategy. As a result, there was no difference between the pre-test data and post-test data of all three subjects. The participants reached an accuracy level between 90% and 100% in solving change problems at post-teaching. Therefore, they generalized their problem solving performances in change problems to the classroom environment.

DISCUSSION

The current paper investigated whether the STAR strategy was effective in solving change problems involving a one-step addition or subtraction process in students with mild mental disabilities. The STAR strategy used in this research was found effective in problem solving. These findings indicate that STAR strategy has an impact on problem solving performance students with mental disabilities. In the literature, the STAR strategy has been tested and found to be effective only on students with learning disabilities (Maccini & Hugles, 2000). However, this study examined its effect on students with mild mental disabilities and emphasized its effectiveness. This confirms the results of the research carried out by Maccini and Hugles (2000).

The steps of STAR strategy (search the word problem, translate the words into an equation in picture form, answer the problem, review the solution) were used respectively. The first step (Search the word problem) was observed to make it easier for students to read and analyse the problem, distinguish what is given in the problem by asking themselves questions, and determine what the desired information is in the problem. The second step (Translate the words into an equation in picture form) helps students to identify important procedures that guide the student in solving the problem, allows students to visually analyse the problem and to plan to lead it to a solution, determine the steps to be taken in problem solving, and helps to decide which action to choose. The third step (Answer the problem) was found to be useful for students to make the necessary calculations for the solution of the problem. Finally, the last step (Review the solution) made it easier to check all the steps from *search the word problem* to *review the solution*. The combined implementation of these steps enables students to use cognitive strategies and cognitive processes that stimulate the problem solving process; therefore, it plays a role in appropriate problem solving (Montague, 1992).

This study indicates the metacognitive strategy of self-questioning as one of the reasons why STAR strategy affects students' problem solving skills. Metacognitive strategies include self-observing, self-evaluating, self-controlling, self-monitoring, self-instructing, and self-questioning processes; these strategies emerge especially when a new or difficult task is encountered and they are stated to be useful in completing the task (Lucangeli & Cabrele, 2006). Students apply to metacognitive strategies to organize cognitive processes used in math problem solving, to manage these operations and to organize their problem solving performances (Montague, 1992). Besides, students use metacognitive strategies to understand how strategies are implemented, develop effective strategies and manage these process operations (Lucangeli & Cabrele, 2006). Montague (1992) introduces metacognitive strategies used in math problem solving as self-correction, self-instruction, self-question and self-monitoring. The questions in the first step (What facts do I know? What do I need to find?) and last step (Does the result make any sense? Why?) of the STAR strategy are self-questioning strategies. Self-questioning refers to thinking the problem and solution steps and is necessary for strategy knowledge and use in problem solving process (Montague, 1992). There are studies examining the strategy teaching activities aimed at increasing students' mathematics performance (Karabulut & Özmen, 2018; Montague, 1992; Sweeney, 2010). For example, they can ask themselves questions about the related cognitive strategies using questions such as "Now I have read the problem, have I fully understood it? Did I underline the most important expressions or words in the problem? Do the drawings represent the problem? What will be the first step of this plan? What will be the next step of the plan? Which numbers in the problem can be used? Does my answer look correct? Is my answer close to my guess? Have I reviewed every step in my answer and checked the work I did? Thus, as in this research, self-questioning helps students choose and implement appropriate strategies in math problem solving process. That's why, self-questioning is thought to have a great role in obtaining effective results in problem solving.

Another reason for the effect of STAR strategy on students' problem solving skills is the visualization strategy (translate the words into an equation in picture form). The literature supports this finding. Van Garderen (2006) examined the relationship among visualization strategies, visual-spatial abilities and problem solving skills used by students with normal development, students with learning disabilities, and gifted students. They found that students with learning difficulties had poor visual spatial-skills compared to their peers in other skill groups, and solved problems by using fewer visualization strategies. It may be related to the visualization of the curriculum applied in mathematics courses in our country as an approach rather than a strategy (Işık & Konyalıoğlu, 2005; Konyalıoğlu, 2003). In other words, visualization is used only in geometric concepts and problems related to geometric concepts rather than being used in the solution of word problems, and it is not considered as a step in solving word problems (MoNE, 2005). However, Polya (1957), who introduced the first problem solving model, prepared a list of suggestions based on his own mathematical experience and recommended students to shape and visualize the problem to be successful in problem solving. Polya argued that it is possible to draw shapes even if the problem is not a geometry problem, and creating a visual depiction is an important step for the solution (Polya, 1957). This argument is still valid today. Research has also shown that visualization strategies improve the problem-solving skills of peers with special needs and normal development (Gersten et al., 2009; Hughes et al., 2003; Ives, 2007; Van Garderen, 2006; 2007). Due to the difficulties that students experience related to working memory and problem solving steps, visual strategies that help organize and present information provide great benefits in problem solving (Geary, 2004; Hughes et al., 2003). Schematic editors and other visual supports (pictures, drawings) increase the students' understanding of the problem by bringing together different information included in the problem (Ives, 2007; Van Garderen, 2006; 2007). Students' placing the problems they understand in the schematic organizer leads them to understand and solve the problem correctly (Ives, 2007; Van Garderen, 2007), enables the storage of information and thus speeds up the processing of the information by supporting the working memory (Keeler & Swanson, 2001). With the implementation of the curriculum with the visualization strategy, it was found that the number of schemas used by students with learning difficulties in the problem solving process increased, their level of use of the schemes improved, and that they generalize the use of the schema to different problems (Van Garderen, 2007) and perform better in solving the problems (Ives, 2007). Visualization is a useful strategy in attracting student's attention, motivating the student, making learning meaningful by concretizing learning, organizing the student's own knowledge, and associating concrete and abstract expressions (Ives, 2007; Karabulut & Özmen, 2018). Therefore, using visualization in elementary school level, especially in math problem solving, will add a new dimension to mathematics education.

STAR strategy includes the supporter used in cognitive strategy teaching to make students independent in the strategy. This is a STAR Strategy Structured Worksheet. It includes the steps of the STAR strategy and helped students learn the strategy steps by marking the steps they did while solving the problem. Marshall (1995) states that the supporters used in strategy teaching make it easier to identify the problem in problem solving and to select the appropriate action. Also, schemes help students understand how to show problems with schemes and how to choose the right process when solving problems (Jitendra et al., 2002; Jitendra et al., 2010).

This study focused on students with mild disabilities intending to examine the effect of STAR problem solving strategy on their generalizing the change problems involving one-step addition and subtraction. Besides, it examined the effectiveness of the strategy in maintaining the generalized skills for 1, 3, and 5 weeks. While participants responded correctly to at least 1 and maximum 3 problems out of 10 problems given in classroom environment at the baseline level, they answered at least 8 and at most 10 problems correctly at the post-intervention. These findings show that subjects generalize their problem solving performance to the classroom environment. It was observed that those who did not use any strategy in the pre-test started to use the STAR strategy steps in their post-intervention problems. This shows that the strategies learned in the intervention sessions are generalized to a different environment. The reasons for generalizing the strategy to the classroom environment are seen as strategy knowledge acquired as a result of STAR strategy intervention routines, supporters guiding the use of strategy, the use of expressions of self-questing, and metacognitive experiences as the correct results are achieved. The findings obtained in terms of generalizing the strategy performances to the classroom environment are similar to the findings of previous research conducted with students with mental and learning disabilities. Research displays that problem solving performances in various disability groups are generalized to different problems types or different environments (Case et al., 1992; Chung & Tam, 2005; Cote et al., 2010; Daniel, 2003; Huffman, Fletcher, Grupe, & Bray, 2004; Iseman & Naglieri, 2011; Maccini & Gagnon, 2001; Maccini & Hugles, 2000; Mancl, 2011; Montague & Dietz, 2009; Montague, 1992; Montague, 2008; Naglieri & Gottling, 1995; Naglieri & Johnson, 2000; Rosenzweig et al. ., 2011). In this study, the results of the generalization show that students were effective in using the change problems involving one-step addition and subtraction in the classroom environment and they maintained this use in the generalization sessions held after the intervention of the STAR strategy.

This study has three main limitations. The first one is that the research is limited to three students with mild intellectual disabilities. Second, the generalizability of the single-subject experimental designs used in this study is limited. Third, social validity data of the intervention were not collected. Based on the research findings, there are suggestions for education, practice and further studies. This study found that STAR strategy teaching was effective in the ability of students with intellectual disabilities to solve math problems. It is recommended to use the STAR strategy while teaching problem solving skills to teachers working with students with mental disabilities. Therefore, it can be recommended to use the STAR strategy while teaching problem-solving skills to teachers working with students with intellectual disabilities. Also, to increase the generalizability of the research findings, this paper can be repeated with participants with learning disabilities, students in different educational environments, and with different researchers, using different problem types. Further studies can be conducted to compare the STAR strategy with traditional teaching methods in terms of effectiveness and efficiency over math problem solving skills. Besides, by examining the effects of each of the elements in the STAR strategy package (visualization, self-questioning, etc.), it may be possible to determine which of the followings is effective: the problem solving performances of students with mild mental disabilities, their perceptions of performance towards mathematics, their attitudes towards mathematics and math problem solving, and math problem solving strategy knowledge.

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Appendix 1. The sample form of the STAR Strategy

Problem: *Ahmet is 8 years old. His brother is 5 years younger than Ahmet. Thus, how old is Ahmet's brother?*	
Search the word problem Read the problem carefully	[√]
Ask yourself questions such as What facts do I know? What do I need to find?	[√]
Write what is given in the problem.	Ahmet is 8 years old. His brother is 5 years younger than him
Translate the words into an equation in picture form	Ahmet's age His brother is 5 years younger than him 😊 😊 😊 😊 😊 😊 😊 😊 😊 😊 😊
Answer the problem	8 – 5 = 3
Review the solution Reread the problem Ask yourself questions such as Does the result make any sense? Why? Check the answer.	I checked my answer. I made subtraction. If I subtract 5 out of 8, it remains 3.