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Comparing the effectiveness of two verbal problem solving strategies: Solve It! and CUBES

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COMPARING THE EFFECTIVENESS OF TWO VERBAL PROBLEM SOLVING STRATEGIES: *SOLVE IT!* AND CUBES

By

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Dedications

This thesis is dedicated to my husband Don, who has given me the support, love, and encouragement I needed to succeed in graduate school. This accomplishment would not have been possible without his unlimited encouragement. This thesis is also dedicated to my children, Sara and Donnie, may this work prove to my children that anything is possible when you work hard and put your heart into it.

This thesis is also dedicated to the memory of my mom, Patti Reilly. The love she gave to her family and friends was unconditional and never ending. She was a true example of with love anything is possible.

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Abstract

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The purpose of this study was to find which problem solving strategy was more effective for special education students in the general education classroom; CUBES or *Solve It!* The students completed a pre-test, solving five single step and five multi-step word problems. The students then received four instructional and activity sessions on the CUBES and Solve It! strategies. The results indicated that the six fourth grade special education participants increased their problem solving skills after using each strategy. The *Solve It!* strategy resulted in a larger increase then the CUBES strategy. The students showed a slightly larger decrease in the number of single step incorrect problems using the *Solve It!* strategy. The CUBES strategy showed a slightly larger decrease in the number of multi-step problems incorrect. The research demonstrated that the use of CUBES and Solve It! was beneficially to the special education students who receive their math instruction in the general education classroom. This study demonstrated the high demand for all students to develop successful problem solving skills. The research also indicated that with the use of a problem solving strategy, special education students can increase their problem solving abilities. Further research is needed to determine all the factors that lead to an increase in the students' problem solving abilities.

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Chapter 1

Introduction

Problem solving skills are an important part of elementary, middle school, high school, and college math curriculum. Forbes Magazine (Adams, 2014) published a Top 10 List of what employers are looking for in 2015 graduates. Tied for first on the list is the ability to make decisions and solve problems. Other skills included in the Top 10 List are the ability to plan and organize, obtain and process information, and the ability to analyze quantitative data (Adams, 2014). These skills are components of problem solving skills. Schools are faced with the challenge of creating curriculum that enables students to develop, practice, and master all aspects of problem solving.

In order for students to be able to develop effective problem solving skills, they must develop both analytical and creative skills. There are several analytical components of problem solving. The students must identify problems, collect and organize data, develop possible solutions, determine the best solution, implement and test the solution, and analyze results. Problem solving also requires a creative component. The students must develop a fluency in producing many possible ideas, be flexible and cover a wide range of ideas, and have the ability to develop those ideas ("The Skills of Problem Solving" 2014).

The need for all students to develop problem solving skills has become evident with the implementation of the New Jersey Common Core Standards and the PARCC (Partnership for Assessment of Readiness for College and Careers) testing. The New

Jersey Department of Education adopted the New Jersey Common Core Standards in 2010 and they were fully implemented in the 2013-2014 school year. The Common Core Standards are designed to teach students the skills necessary to prepare them for college, careers, and life. The Common Core Standards in math require students to apply their math skills to solve real world math problems in every grade level ("Key Shifts in Mathematics", 2015). The Common Core Standards have been aligned to a new state assessment test, PARCC. The PARCC testing was administered for the first time in the spring of 2015. This assessment is designed to measure a student's ability to think critically and solve problems (The PARCC Difference, 2015).

Teaching problem solving skills to general education students is a challenge, but it is an even greater challenge when it comes to exceptional learners. Data from the New Jersey State Department of Education shows an increase in the number of special education students who spend more than 80% of their day in the general education classroom (Special Education Data, 2015). Teachers are going to need effective strategies for teaching these exceptional students in a general education classroom setting. *Solve It!* and CUBES are two instructional strategies that are used to increase students problem solving skills.

Solve it! is a problem solving routine that uses both cognitive and metacognitive processes. The *Solve It!* program breaks the problem solving task into seven steps:

1. read the problem for understanding

2. paraphrase the problem in their own words

3. visualize the problem by drawing a picture or diagram

4. hypothesis a plan to solve

5. Estimate or predict and answer

6. Compute or complete the computation needed to solve

7. Check their answer to make sure it is reasonable.

During each step the student is to say the name of the step aloud, ask themselves if they have understood or completed the step, and then check that the step has been done makes sense (Montague, Warger, Morgan 2000). CUBES is a letter strategy mnemonic device that students can use to remember the steps needed to complete a problem solving task. The C stands for circle the important numbers, the U stands for underline the question, the B stands for box the math action word, the E stands for eliminate the unnecessary information, and the S stands for solve the problem and check your answer.

Research Problem

This study will compare the effectiveness of two verbal problem solving strategies *Solve It!* and CUBES, for exceptional learners in an elementary level general education classroom. This study will determine which strategy can increase the problem solving skills of the exceptional learners in a general education classroom.

My hypothesis is that the exceptional learners using the CUBES problem solving strategy will be more successful in increasing their problem solving skills in an inclusion math classroom.

Key Terms

Problem Solving-a process where students apply math knowledge and skills needed to find a solution to a problem

Analyze- students must be able to determine if the plan they used generated a feasible solution to the problem

New Jersey Common Core Standards- a set of grade-level expectations that New Jersey students will need to master to ensure they are prepared for college or a career

PARCC (Partnership for Assessment of Readiness for College and Careers)- an assessment aligned to the Common Core Standards that measure a student's ability to think critically and solve problems

Solve It! - a problem solving strategy that uses a guided discussion technique to guide students through a problem solving routine

CUBES-a problem solving strategy that uses a mnemonic devise to help students identify all necessary information to solve a problem

Implications

The increase in an exceptional learner's problem solving skills will have major implications inside and outside of the classroom. Increasing problem solving skills for exceptional learners will increase their ability to master the math standards in the Common Core Standards in their classrooms and improve their overall math class performance. An increase in problem solving abilities will have a positive impact on

exceptional learners performance on state assessment tests; PARCC. The improvement of problem solving skills for exceptional learners will have a positive impact on their college or career goals.

Summary

Effective problem solving skills are in high demand. They are apparent in the math NJ Common Core Standards, PARRC assessments, and future employers. This study will compare the effectiveness of two problem solving strategies, *Solve It!* and CUBES, for exception learners in a general education classroom. The Solve It! strategy uses a guided discussion and problem solving routine to enable exceptional learners to obtain success in problem solving. The CUBES strategy is a mnemonic device that has student identify the necessary information needed to solve the problem. My hypothesis is that the CUBES strategy will be more effective in improving the problem solving skills of exceptional learners in the general education classroom. Being able to improve the problem solving skills of an exceptional learner will have major implications. These implications include: improved math performance in the classroom, improved performance on state assessments, and increases the exceptional learners ability to obtain college or career goals.

Chapter 2

Review of Literature

Problem Solving and the Exceptional Learner

Employers are expecting that students have highly developed problem solving skills when they enter the work force. Planning, organizational, analyzing, and decision making are all components of problem solving skills (Adams, 2014). Students with exceptional learning needs struggle with many of the components of problem solving. A student must be able to read and understand what is being asked, find and organize all necessary information, select a problem solving strategy that is appropriate, recall and apply the necessary steps in that strategy, make the computations needed and check to make sure their process was correct (Forbringer, L., & Fuchs, W., 2014).

The Common Core Standards were developed with an emphasis on problem solving requiring students to apply their learned mathematics skills to solve everyday problems. The PARCC test was aligned to the Common Core Standards. The Common Core Standards and the PARCC test were designed to better prepare our students for the demands of college courses and careers. The PARCC requires students to solve multi-step math problems that address real-life situations. The students are expected to think critically, reason mathematically, analyze quantities and demonstrate their understanding (The PARCC Difference, 2015). Developing effective problem-solving skills is crucial to the academic and future success of all students, including those with exceptional

learning needs. The problem-solving difficulties that the exceptional learners often encounter need to be examined in more detail.

Mathematical Problem Solving Difficulties

The problem solving abilities of eighth grade students with learning disabilities, low achieving students and average achieving students' problem solving skills compared in a study by Krawec (21014). The students had to meet specific criteria to be placed in the learning disabilities (LD) group, the low achieving (LA) group or the average achieving (AA) group. The students were given the same nine problems and were scored on their ability to paraphrase, visually represent relevant information and numbers accurately, and their problem solving accuracy. The results showed that the AA students had higher problem solving accuracy then both the LD and LA students. The AA students were able to paraphrase and visually represent the necessary information and numbers and left out more of the irrelevant information. The LA students paraphrased and visually represented more of the necessary information and numbers then the LD students but less then then the AA students. The LD students paraphrased and visually represented the least amount of necessary information and numbers. The results also indicated that the LD students may have a language based comprehension deficient that affects their problem solving abilities.

Alloway et al (2009), examined the working memory (WM) abilities of students between 8 and 10 years old who represented several different types of disabilities. Working memory is the ability to store and process information for a short period of time.

The participants were put into groups based on their identified disability. The groups were Specific Learning Impaired (SLI), Developmental Coordination Disorder (DCD), Attention-Deficit/Hyperactivity Disorder (ADHD), and Asperger's Syndrome (AS). The participants were given tests from the Automated Working Memory Assessment. This test measures three components: verbal short term memory, visuospatial short term memory, and working memory. Alloway concluded that SLI students had verbal and working memory weaknesses. The DCD students had significance weaknesses in all three areas, especially visuospatial memory abilities. The ADHD students scored in the age expected level for short term memory but had weaknesses in working memory. The AS students scored low on selective parts of the verbal short term memory test.

This study has several implications for each of the disability groups and their struggle with problem-solving. The students with SLI had deficits in verbal short term and working memory. The SLI group scored the lowest on the verbal short term and working memory test. This study identifies that students with SLI have deficits in not just storing information but storing and processing information. Students with DCD had significant deficits in visuospatial short term memory. The IQ test contained a motor component that required the students to touch the screen to turn and manipulate objects. The IQ tests were higher when there was no motor component. Once the motor component in the IQ score accounted for there was no significant difference in visuospatial short term memory.

Students with ADHD demonstrated deficits in both verbal and visuospatial short term memory. This study indicates that the students may have had trouble controlling

their behaviors which interfered in their ability to attend to the task. This idea was supported by research that showed improvements in working memory for students with ADHD who were receiving medication to regulate their behavior. The students with Asperger's syndrome results indicated deficits in verbal short term memory but scored in the typical range for the other tests. These deficits could also stem from the language and communication issues that AS students struggle with. Identifying the specific areas of weakness will enable educators to design instructional programs and methods to improve those weaknesses and improve the problem-solving abilities for all exceptionalities.

The Krawec and Alloway studies discussed the importance of and the difficulties of developing problem solving skills for exceptional students. The studies identified the skills of paraphrasing, visual representation of necessary information, verbal and visuospatial short term memory and working memory skills as key skills that students need to utilize when problem solving. The studies clearly demonstrated that most exceptional learners have deficiencies in several components that comprise problem solving. Both studies looked at the process and components of problem solving and recommended explicit instruction on these components to assist the exceptional students in further developing their problem solving skills.

Problem Solving Strategies

The need for students to develop their problem solving skills is apparent based on the Common Core Standards and PARCC testing. Furthermore, the research cited previously indicates that students with exceptional learning needs require explicit instruction on the key components of problem solving. Swanson et al (2015) looked at how a student's working memory capacity (WMC) influences the successfulness of a problem solving strategy. The students who participated in this study were second and third grade students who were identified as having math difficulties for the past two years. This study looked at the use of verbal strategies (underlining or circling relevant information), visual strategies (placing numbers into a diagram), and a combination of both verbal and visual strategies.

Swanson et al found that WMC plays a significant determining factor when it comes to successful implementation of problem solving strategies. The students with high WMC and math disabilities were most successful when using a visual only strategy. Students without math disabilities were more successful with a combination of verbal and visual strategies. Students who have a low WMC and math disabilities were more successful when using a verbal and visual combination strategy. The students with low WMC and no math disabilities were most successful with a visual only strategy. The research studies by both Alloway and Swanson identify a student's working memory as an important factor in problem solving and the strategies used to assist students when problem solving. Swanson identifies the more successful strategies to use depend on the

WMC of the student. The strategies vary based on the level of working memory the student has to work with.

Moran et al (2014) researchers looked at the effectiveness of paraphrasing as a strategy to improve problem solving skills for at risk third graders. The researchers used a pre-test and post-test experimental design when collecting their data. The students were randomly assigned to one of 3 intervention condition groups and a control group. The interventions were to paraphrase the question only, paraphrase the relevant numbers only, or to paraphrase both the question and necessary numbers. The students were given a pre-test then 10 weeks of tutoring on their specific intervention and then a post-test.

Moran et al concluded that students who have received interventions about paraphrasing relevant numbers or paraphrasing both the question and the relevant numbers outperformed those students who only restated the question and the control group. This study demonstrated that the use of paraphrasing the important numbers or paraphrasing the question and important numbers were effective strategies to help improve the problem solving skills of at risk math students. Both Moran's and Krawec's studies concluded the need for exceptional students to use paraphrasing as a tool to become successful problem solvers. Exceptional learners often encounter difficulties with several of the components of problem-solving. Programs that are tailored to the specific problem-solving needs need to be examined.

Solve It!

Solve It! is a researched-based problem solving strategy that helps students obtain and implement both cognitive and metacognitive processes and strategies that increase effective problem solving. The *Solve It!* strategy is a guided discussion technique that uses a regimented problem-solving routine. Montague et al (2000) identified seven cognitive components needed for a student to be an effective problem solver. The students have to be able to read the problem for understanding, paraphrase information in the problem, visually representing the problem using pictures or diagrams, organize and set up a plan, estimate the answer, make the computations, and verify the answer. *Solve It!* incorporates three metacognitive strategies: self-instruction, self-questioning, and self-monitoring to be utilized for each of the 7 cognitive steps. The metacognitive strategies can be used either overtly or covertly based on the needs and abilities of the students. The *Solve It!* strategy includes scripted lessons with instructional charts, activities, practice problems, and cue cards.

The first step in the *Solve It!* problem-solving strategy is to read the problem for understanding. The student says "read the problem" and then reads the problem. The student asks themselves "Did I read and understand the problem?" If they have understood they move to the next step, if not they must reread the problem. The student must then check by saying "check for understanding as I solve the problem". The second step is to paraphrase the relevant information in the problem. The student says "put the problem in my own words and underline the important information". Then the student must ask themselves "Did I underline the relevant information?" and "What is the

question?" The third step is to visualize the information into a picture or diagram. They student says" draw a picture or a diagram". The students ask themselves, "Does this picture fit the problem?" The student must then check the picture against the information in the problem.

The fourth step in the *Solve It!* problem–solving strategy is for the student to say "how many steps and what operations are needed to solve the problem". They then ask "If I implement this plan, will I get the answer to the question being asked?" The student must self-monitor by checking if their plan makes sense. If they are uncertain of their plan they can ask the teacher for help. The fifth step in the strategy is to estimate the answer. The student says "round the numbers". The students ask "Did I round the numbers up or down?" They then must check to make sure they used all the important information. The sixth step is to carry out the plan by completing the computations. The student says "Do the operations in the correct order". The students must ask themselves, "How does my answer compare to my estimate?" and "Does my answer make sense?" Then the student must check to make sure the operations were done in the correct order. The seventh step in the *Solve It!* strategy is to verify that all the steps taken are correct. The students say, "Check the computation". The students ask themselves. "Have I checked every step?" The students must check to make sure that everything is correct.

The *Solve It!* problem-solving strategy was developed using four proven instructional techniques: problem-solving assessment, explicit instruction, process modeling, and performance feedback. Montague et all studied a total of 84 students who were learning disabled; 6 learning disabled high school students, 6 sixth through eighth

grade learning disabled students, and then a larger group of 72 seventh through eighth grade learning disabled students. Montague et al used two types of problem-solving assessments. A pre-test consisting of 10 one, two, and three-step math word problems was used as baseline data. The students were periodically tested throughout the implementation of the strategy to monitor the progress of the participating students. The Mathematical Problem-Solving Assessment-Short Form was used to assess the knowledge and use of math problem-solving strategies of the students. This assessment was used as a diagnostic tool to identify the strengths and weaknesses of the individual students.

Teachers use explicit instruction techniques to guide the students through the *Solve It!* strategy. Explicit instruction includes highly structured and organized lessons. The teacher uses appropriate prompts and cues for students when needed. The students are allotted ample time for guided practice and are given positive corrective feedback. Explicit instruction is flexible allowing the teacher to tailor the instruction to the strengths and weaknesses of the students. However, Montague et al suggest following the scripted lessons of the *Solve It!* strategy. The teacher uses process modeling, where the teacher thinks aloud to demonstrate the *Solve It!* problem-solving strategy. Throughout the problem-solving process the teacher provides positive reinforcement and encourages students to praise the work of their peers.

The results of the study indicated that the appropriate developmental age for this strategy was seventh and eighth grade students. Students in the sixth grade were not able to reach mastery for using the strategy and successfully solving math word problems.

Further results indicated that the seventh and eighth grade students with learning disabilities were able to perform approximately at the same level as their average-achieving peers. The students were able to maintain their problem-solving skills for several weeks following instruction in the *Solve It!* strategy before showing signs of decline. The students were then given an additional lesson in the *Solve It!* strategy and then saw an increase in their problem-solving success.

The teachers involved in this study noted several limitations to the implementation of the *Solve It!* problem–solving strategy. Teachers were concerned about the time it would take to assess the individual strengths and weaknesses of all students in their general education middle school classrooms. The teachers also stated that not all the students would need explicit problem-solving instruction. Due to the intense structure of the *Solve It!* strategy, teachers would need to receive training to successfully implement in their classrooms. The teachers also noted that the strategy was successful in increasing the problem-solving abilities of students with learning disabilities.

Montague et al found the *Solve It!* strategy increased the problem-solving abilities for students with learning disabilities. Schafer Whitby (2013) studied the effects of using the *Solve It!* strategy with students diagnosed with Autism Spectrum Disorder (ASD). The study involved 2 seventh grade students and 1 eight grade student who spent more than 80% of their school day in the general education classroom. These students also had an IQ of 80 or higher and were classified as highly functioning students on the autism

spectrum. The procedures and materials were the same as mentioned previously in the Montague study. The students showed improvements in their problem solving abilities.

Schafer Whitby found that many characteristics of ASD impacted the successfulness of the *Solve It!* strategy. The student that participated in the study had a reading comprehension level above that needed to understand the math word problem. However, there were several examples of language interference. The students could paraphrase the necessary information but restated the question directly from the problem. Two of the three students could use estimation correctly but the other student didn't understand why an estimate was necessary. Schafer Whitby concluded that the students with ASD were able to successfully learn the *Solve It!* strategy but may require additional and longer support to be able to use the strategy successfully.

Montague et al (2014) studied the effectiveness of *Solve It!* for 7th grade special education students in an inclusion setting. The goal of this study was to replicate the effectiveness of *Solve It!* method for 8th grade special education students. This study was conducted in the Miami-Dade public school system in Florida. There were a total of 34 schools that participated, 19 schools that received the *Solve It!* intervention instruction and 18 comparison schools. The teachers who participated were nominated by their building principles and received 3 days of professional development training in the *Solve It!* method.

Montague et al measured the effectiveness of *Solve It!* through curriculum-based measures (CBM) and the results of the Florida Comprehensive Assessment Test (FCAT).

There were 7 CBM ‘s developed by using test questions from the *Solve It!* manual. The CBM’s consisted of 10 one-, two-, and three-step word problems that involved the four basic operations. The CBM’s were administered 7 times, first as a baseline then on a monthly basis for the remainder of the school year. The CBM’s were also administered to the comparison school’s students 4 times throughout the school year.

The results of the FCAT showed no significant improvement after the *Solve It!* intervention was concluded. There were significant improvements in the problem solving skills measured by the CBM’s. The improvements were more significant for the low-achieving students over the average students. A limitation noted was that the intervention students could have received more problem-solving instruction and practice then the comparison students. The implications of this study indicated a desire of the teachers to have more training in the Solve It! method. The teachers also expressed concern about how to incorporate *Solve It!* and still meet the curriculum and state testing demands. The *Solve It!* method needs to be embedded into the curriculum and not just a supplemental method. The questions used for Solve It! instruction and practice were taken from the district approved textbook.

In summary, the *Solve It!* strategy has been shown to improve the problem solving abilities for some exceptional learners. The strategy uses a combination of cognitive and metacognitive strategies together with proven instructional techniques to improve the problem-solving skills of exceptional learners. *Solve It!* teaches the students to read to understand the problem, paraphrase the important information, draw a picture or diagram, organize and implement a plan, find an estimate, and verify the accuracy of the steps

taken to solve the problem. *Solve It!* also increased the problem-solving abilities in students with ASD. These students found success but still encountered some language interference.

CUBES as a Mnemonic Device

There are many steps and skills required to solve a math word problem. The use of mnemonic devises has been shown to help students recall information. Mastropieri (1998) identified a mnemonic device as a strategy to improve the amount of information a student can recall. A mnemonic device helps students to connect new information to information that the student already knows. If a strong connect is made to previous information then the new information can be recalled easier. Mnemonic devices have also been proven effective across different lesson formats. Mnemonic devices are not a teaching method but a tool used to help students recall necessary information. Learning or creating a mnemonic device can often slow down the student's rate of learning.

Mnemonic devices are proven effective strategies to help students recall information. Test (2005) studied the effect of the mnemonic device, LAP (Look at the denominator and sign, Ask if the smallest denominator divides into the largest denominator evenly, Pick your fraction type) on the students' ability to add and subtract fractions. Test studied 6 eighth grade students who were receiving math instruction in a special education classroom. The students were identified as having deficits in math with no prior instruction in how to add or subtract fractions. The students had all mastered

basic multiplication and division facts. The students were paired based on ability and compatibility.

This study assessed the students' ability to master the mnemonic device and the skill of adding and subtracting fractions. The pairs had to master each step in learning both the LAP mnemonic device strategy and the skill of adding and subtracting fractions. The students were taught the intervention one pair at a time. The teacher modeled the mnemonic device aloud and then had the students repeat it. The students then participated in two activities to practice the mnemonic device. The students played a Fraction Baseball game and a card game called ZAP. The LAP Fraction Strategy test was then administered to the pair. The students had to achieve 100% mastery in the assessment in two consecutive sessions.

Once mastery was achieved for the LAP Fraction strategy, the students received instruction in each of the three steps. The students had to master each step before progressing to the next step. The students practiced each step using teacher created games like Fraction Football and Fraction Baseball. The students had to achieve 89% mastery on the LAP Fraction Test for 3 consecutive sessions. The students were also given the LAP Fraction Strategy Test and the LAP Fraction Test every 10 days for the next 6 weeks to assist students in maintaining their skills.

The results of Test's study indicated that the use of the LAP Fraction mnemonic device helped the students remember the steps needed to add and subtract fractions. 5 out of 6 students were able to master both the strategy and the skill. The one student who did

not master the skill due to computational errors was noted to have mastered the strategy. This study supports the idea that mnemonic devices are helpful to exceptional students who need to recall the steps to math problems. This study also suggests that exceptional learners are able to successful in solving complex math concepts.

A well know letter strategy is HOMES, where each letter is the beginning letter in the names of the Great Lakes. The first letter in the names of the Great Lakes conveniently made a word. However, teachers and students can create their own letter strategies mnemonic devices. Students trying to recall the order of the planets from the sun can use the first letter of each planet, MVEMSUNP to create a sentence like; My very educated mom sent us nine pizzas. A letter mnemonic device CUBES was designed to helps students remember the steps they need to follow to solve a math word problem. The C stands for circle the key numbers, the U stands for underline the question, the B stands for box the math action words, the E stands for eliminate unnecessary information, and the S stands for solve and check your work. Each letter directs the student to complete a step in the problem-solving process. The origin of the CUBES strategy is unknown and no research studies involving CUBES have been found. Since, there have been no research studies conducted using CUBES, that was a contributing factor to design a research study involving CUBES.

Summary

Employers and Colleges today are requiring students to have highly developed problem-solving skills. The PARCC assessment has been designed to assess the critical thinking and problem-solving skills of students. Researchers agree that there are several complex skills needed for students to be successful problem-solvers. Students need to be able to read and understand the problem, determine what the problem is asking for, identify relevant and irrelevant information, create and implement a plan, identify and apply the necessary computational skills, and check to make sure the answer is reasonable. The studies of Krawec and Alloway identify the aspects of problem solving that the exceptional students often struggle with. There is a need for educators to develop teaching strategies that will enable those exceptional learners to overcome their deficiencies and develop effective problem-solving skills.

Montague's *Solve It!* strategy combines both cognitive and metacognitive strategies aimed at improving the problem-solving skills of the exceptional learner. The *Solve It!* strategy provides highly structured explicit instruction through the use of a scripted routine. These strategies have been proven to increase the problem-solving success for those students. Effective problem-solving is a multi-step process that is challenging for exceptional students. The use of mnemonic devices has been proven to assist students in remembering more information. The students are able to connect new information with information that have already stored, making it easier for them to recall the information. CUBES is a letter strategy where each letter stands for a step in the

problem-solving process. The have been no research studies conducted using the mnemonic device CUBES.

Chapter 3

Methodology

Settings/Participants

This study involves six fourth grade students who receive math instruction in an inclusion setting. These students attend an upper elementary school in central New Jersey. The central New Jersey school district educates about 5,600 kindergarten through high school students. The district includes one small pre-school disabled program, 4 elementary schools, 1 upper elementary school, 1 middle school, 1 high school, and 1 administrative building. The upper elementary school consists of approximately 980 fourth and fifth grade students. The school also houses the pre-school disabled program. The students attend school for six hours and 45 minutes and spend 5 hours and 45 minutes engaged in academic instruction.

The New Jersey School Performance Report (New Jersey Department of Education, 2016) describes the upper elementary school population as 41% white, 20.8% Asian, 18.8% Hispanic, 17.2% African American, and 1.5% two or more races. The primary language spoken is English at 72.7 %, with Spanish at 6.2 %, Gujarati 3 %, Polish 2.7% Urdu at 2.3 % and Arabic at 2.1%. The student population has 29% students with disabilities, 37.3% economically disadvantaged, and 0.9% limited English students.

The students who are participating in this study are fourth grade students who have been identified as eligible for special education. These six students receive

their math instruction in the general education classroom. These students have various classifications but all of them have difficulties with their math problem solving skills.

Participant 1. JD is a Hispanic, fourth grade boy who is eligible for special education student under the classification Other Health Impaired. He receives his academic instruction in an inclusive classroom with the support of the general education teacher as well as a special education teacher. He has a condition called Macrocephaly Syndrome; his head circumference is greater than 2 standard deviations then that of his gender and age peers. This syndrome may also lead to other health issues. JD is frequently absent from school due to doctor appointments. When JD is in school he takes constant trips to the bathroom and the nurse's office. Even with inconsistent attendance, JD is an average student who struggles with organization and handing in his assignments and homework. JD can focus and picks up new skills easily but often receives his instruction in a small group and often one on one due to reoccurring absences. JD also receives speech instruction once a week in a small group setting.

Participant 2. JE is a fourth grade, African American boy student who is eligible for special education under the classification of Other Health Impaired. He receives his academic instruction in an inclusive classroom with the support of the general education teacher as well as a special education teacher. JE has a diagnosis of ADHD and exhibits difficulty with focusing, staying on topic, staying seated, and impulsivity. JE needs frequent reminders to slow down his thinking and to take his time to solve math problems. The rate that JE completes his work often leads to many simple mistakes or simple misunderstanding of the problem. JE often struggles with

organization and requires the support of the special education to make sure he is turning in the correct homework and assignments.

Participant 3. JF is a fourth grade, Caucasian boy who is eligible for special education under the Communication Impaired classification. He receives his academic instruction in an inclusive classroom with the support of the general education teacher as well as a special education teacher. JF struggles to express his thoughts and ideas both verbally and written. He often requires more time to gather and express his thoughts. He can have difficulties focusing and staying on task. He can be easily distracted by the other students around him. JF receives speech instruction once a week in a small group setting.

Participant 4. DF is a fourth grade, Caucasian student who is eligible to receive special education instruction under the Other Health Impaired classification. He receives his academic instruction in an inclusive classroom with the support of the general education teacher as well as a special education teacher. DF has a twin brother who also receives special education instruction under the same classification. DF has difficulties focusing during lessons, getting started with a task, and organizational skills. DF can be easily distracted by his belongings or others sitting around him. He receives speech instruction once a week in a small group setting.

Participant 5. AF is a fourth grade, African American girl who is eligible for special education services under the Autism classification. She receives her academic instruction in an inclusive classroom with the support of the general education teacher as

well as a special education teacher. AF is diagnosed with Asperger's Syndrome and ADHD. She struggles with organization, staying focused, staying seated, impulsivity, and behavioral outburst when frustrated. AF understands new concepts easily but has a very low frustration level. Once AF becomes frustrated, her emotional outbursts are hard to bounce back from.

Participant 6. KG is a Hispanic, fourth grade boy who is eligible for special education under the Other Health Impaired Classification. He receives his academic instruction in an inclusive classroom with the support of the general education teacher as well as a special education teacher. KG has a diagnosis of ADHD and often struggles with staying focused, staying seated and organizational skills. KG is very easily distracted by the other students seated around him.

Procedures and Design

The quasi-experimental group design began with a pre-assessment of each individual student's problem solving skills. The pre-assessment consisted of 10 word problems for the students to solve. The first 5 problems are one step word problems that require the use of addition, subtraction, multiplication, and division skills that have already been taught. The last 5 questions will require two steps and the previous listed skills in order to successfully solve the word problems. The results of the 10 question pre-assessment served as a baseline score of the students' problem solving abilities. Once a baseline score was established, the students received 4 twenty minute instruction and activity session about how to utilize the CUBES strategy.

The first two CUBES sessions focused on what each letter in CUBES stands for and how to identify that information. The students participated in the small group instruction and activities during their regularly scheduled math class. The students used example one and two-step word problems to practice identifying all aspects of the word problems that the CUBES strategy calls for. The last two CUBES sessions focused on the students implanting the CUBES strategy to solve one and two-step word problems. The students are given example problems and are asked to share how they used the CUBES strategy to solve the problem. After the 4 twenty minutes CUBES sessions they students are given a post-assessment. The post-assessment will consist of 10 word problems: 5 one-step problems and 5 two-step problems. The students are instructed to use the CUBES strategy to solve the word problems.

The next 4 sessions included the instruction and implementation on the *Solve It!* strategy. The students participated in small group instruction during their regularly scheduled math class. The first two sessions provided instruction on how *Solve It!* is used to help students solve word problems. The teacher modeled how the *Solve It!* strategy is used and the students verbally participated when *Solve It!* requires it. The last 2 sessions focused on the students applying the *Solve It!* strategy to solve word problems. The students solved both one and two-step word problems using the *Solve It!* strategy. After the 4 twenty minute sessions, students were given a post-assessment. The post-assessment consisted of 10 word problems: 5 one-step problems and 5 two-step problems. The students received instruction to use the *Solve It!* strategy to help solve the problems.

Variables

The independent variable in this research study was the instruction and the activities involving the CUBES and *Solve It!* problem solving strategies.

The dependent variables are the post-assessment scores for the CUBES strategy and the *Solve It!* strategy.

Chapter 4

Results

Summary

In this study, comparing the effectiveness of CUBES and *Solve It*! on the problem solving skills of exceptional learners in an inclusion classroom were analyzed. Six fourth grade students who receive their math instruction in the regular education classroom participated in the study. The students were instructed in both the CUBES and *Solve It!* strategies. The research question to be answered was: Which strategy, CUBES or *Solve It!* will increase the problem solving skills of the exceptional learners in a general education classroom?

This study started by determining a baseline of the problem solving abilities of the students. The students were given a 10 question word problem assessment. The first five questions were solved using one step and the last five questions required two-steps. The questions required the students to use their addition, subtraction, multiplication, and division skills that had previously been taught. The students were given 70 minutes to complete the assessment.

Group Baseline Results

Table 1 shows the baseline results for the six students who participated in the study. The table also indicates the number of one step and two-step problems that

were solve incorrectly by the student. The student's math teacher graded the pre-assessment.

Table 1

Baseline Assessment Data

Participants	Pre-Test Data	Number of 1 Step Problems Incorrect	Number of 2 Step Problems Incorrect
JD	30	2	5
JE	40	1	5
DF	20	3	5
JF	40	3	5
AF	50	1	4
KG	60	1	3
Average Scores	36.7	1.8	4.5

Intervention

The students attended four twenty minute small group instructional and activity sessions on how to use the CUBES strategy when problem solving. The students wrote down what each letter in CUBES stood for on a poster. They recited the words that each letter in CUBES represented. The students were given four example word problems to

read. The students then went through each letter and preformed each step. The four small group instructional sessions followed the same format. At the end of the fourth instructional session, the students were given a post-test to determine if any improvement in their problem solving skills had occurred. Table 2 shows the results of the post-test for the six students.

Table 2

Post Test Data for CUBES Strategy

Participants	Post Test Data for CUBES Strategy	Number of 1 Step Problems Incorrect	Number of 2 Step Problems Incorrect
JD	30	1	3
JE	30	2	5
DF	60	1	3
JF	30	3	4
AF	80	0	2
KG	90	0	1
Average Scores	53.3	1.2	3

The post-test results, from the six participants using the CUBES strategy, indicated an average score increase of 16.6 points. The average one step incorrect

problems decreased from 1.8 to 1.2 problems. The average two-step incorrect problems decreased from 4.5 to 3 problems. The CUBES strategy has shown an increase in the problem solving skills of the six participants.

The six participants then received 4 twenty minute small group instructional and activity session on how to use the *Solve It!* problem solving strategy. The students were given a chart that showed all the steps to implement the *Solve It!* strategy. The students recited the steps aloud and were given a small dry erase board to visualize the problem by drawing a picture or chart. After the group had recited all the steps, the students were given five practice problems to solve by using the *Solve It!* strategy. Table 3 shows the post-test results after the Solve It! strategy was taught.

Table 3

Post Test Data for Solve It! Strategy

Participants	Post Test Data for *Solve It!* Strategy	Number of 1 Step Problems Incorrect	Number of 2 Step Problems Incorrect
JD	60	0	4
JE	40	1	5
DF	60	1	3
JF	30	2	5
AF	80	0	2
KG	80	0	2
Average Scores	70	0.7	3.5

The post-test results, from the six participants using the *Solve It!* strategy, indicated an average score increase of 33.3 points. The average one step incorrect problems decreased from 1.8 to 0.7 problems. The average two-step incorrect problems decreased from 4.5 to 3.5 problems. The *Solve It!* strategy has also increased the problem solving skills for the six participants. Table 4 shows the comparison between the CUBES and *Solve It!* strategies.

Table 4

CUBES and Solve It! Comparison

CUBES and Solve It! Comparison	Pre-Test Results	CUBES Post-Test Results	*Solve It!* Post-Test Results
Average Test Results	36.7	53.3	70
Number of 1 Step Problems Incorrect	1.8	1.2	0.7
Number of 2 Step Problems Incorrect	4.5	3	3.5

The comparison between the CUBES strategy and the *Solve It!* strategy show an overall improvement in problem solving skills when either strategy is utilized. When compared to the average pre-test results, the *Solve It!* strategy resulted in an average improvement of 33.3 points and the CUBES strategy resulted in an average improvement of 16.6 points. Both strategies showed a decrease in the number of incorrect one step and two-step problems. The *Solve It!* strategy showed a slight decrease in the number of incorrect one step problems. The CUBES strategy showed a slightly larger decrease in the number of incorrect two-step problems.

A series of t-tests on the difference between the pre-intervention scores and each of the interventions indicated that the improvement in student score with the *CUBES* strategy, while in the desired direction was not statistically significant. However, the difference when the *Solve It!* method was used was significant ($t(10)=1.81$, $p<.05$.

Chapter 5

Discussion

Review

This study compared the effectiveness of two problem solving strategies, *Solve It!* and CUBES, for six fourth grade special education students who receive their math instruction in the general education classroom. The students completed a problem solving pre-test then received 4 instruction lessons and activities sessions on each strategy, and then completed a post-test after each strategy was taught. The pre- and post-test consisted of ten word problems; five single-step and five multi-step word problems. The results indicated that, while both strategies improved student performance in math problem solving, the *Solve It!* method resulted in a greater improvement than the *CUBES* strategy.

Research Comparison

Previous research by Montague et al (2000) indicated that the *Solve It!* strategy was developmentally appropriate for 7th and 8th grade students. The 6th grade students in the study were not able to reach the mastery level using the *Solve It!* strategy. The research of Schafer-Whitby (2013) also resulted in an increase in problem solving skills for 7th and 8th grade students with autism spectrum disorder. However, the *Solve It!* strategy did increase in the problem solving abilities of the younger fourth grade special education students. The *Solve It!* strategy improved the students problem solving skills more than the CUBES strategy.

The research of Test (2005) indicated that the use of LAP (a mnemonic device used to help students recall the steps to add or subtract fractions) improved the students adding and subtracting fractions skills. Mastropieri (1998) demonstrated that the use of a mnemonic device improves a student's ability to recall information. The results of the fourth grade special education students were similar to the results of Test and Mastropieri in that they were able to recall the steps in problem solving by using the CUBES strategy. The use of the mnemonic device CUBES strategy improved their problem solving skill.

Limitations

The results of this study indicated an increase in the students' problem solving abilities when math strategy interventions were used. One limitation of this study was that it did not distinguish between computational errors or errors made in the problem solving process. There were a few instances on both the pre- and post-test where the students were incorrect because there was a calculation error but the student had used an appropriate problem solving plan to solve the problem successfully. Another limitation may have been that the students participated in the 8 instructional sessions within the general education classroom. There were 18 other students in the classroom that were either working independently or on center activities. The noise level could have been a distraction or made it more difficult for the students to concentrate.

The CUBES strategy was the first problem solving strategy taught and many of the students found success using that strategy. A limitation of this study was that several students were reluctant to learn and use the second strategy; the *Solve It!* strategy. There

were many more steps involved in the Solve It! strategy compared to the CUBES strategy. The students were very reluctant to try to use so many steps to solve the problem. The students were instructed to use only the *Solve It!* strategy but some students were seen still using the CUBES strategy while trying to learn and practice the *Solve It!* strategy. Another limitation of this study was there was no control group used in the research design. A control group may have better determined that the increase in problem solving skills was due to the specific strategy and not just more exposure to problem solving process.

Implications

This research study implies that with specific teaching strategies, special education students who receive their math instruction in the general education classroom can increase their problem solving abilities. The special education students in this study increased their ability to solve problems successfully after they had received explicit instruction in two different problem solving strategies: CUBES and *Solve It!*. General and Special Education teachers need to incorporate more problem solving skills with the use of specific problem solving strategies into their classrooms. These strategies will assist special education students in remembering and implementing the steps need to successfully problem solve.

Future Research

A research study using a larger sample size is needed to further determine the effectiveness of the CUBES strategy. The research should include a control group to compare the effectiveness of implementing just one problem solving strategy. The study may also want to examine the effectiveness of the CUBES strategy for the general education students as well as the special education students. Future research should allow students to use calculators to eliminate the possibility of incorrect problems based on computational error only. A research should be conducted on the relationship between reading comprehension skills and problem solving abilities.

Conclusion

The purpose of this study was to find which problem solving strategy was more effective for special education students in the general education classroom; CUBES or *Solve It!* The students completed a pre-test, solving five single step and five multi-step word problems. The students then received four instructional and activity sessions on the CUBES and Solve It! strategies. The results indicated that the six fourth grade special education participants increased their problem solving skills after using each strategy. The *Solve It!* strategy resulted in a larger increase then the CUBES strategy. The students showed a slightly larger decrease in the number of single step incorrect problems using the *Solve It!* strategy. The CUBES strategy showed a slightly larger decrease in the number of multi-step problems incorrect. The research demonstrated that the use of CUBES and Solve It! was beneficially to the special education students who receive their

math instruction in the general education classroom. This study demonstrated the high demand for all students to develop successful problem solving skills. The research also indicated that with the use of a problem solving strategy, special education students can increase their problem solving abilities. Further research is needed to determine all the factors that lead to an increase in the students' problem solving abilities.

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