Effects of Daily Mathematical Problem Solving Instruction

on High School Special Education Students

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Abstract

The purpose of this study was to determine the impact of two variations of daily mathematical word problem instruction on high school special education students in self-contained algebra classes. One group of students received instruction on word problems that was designed around student interests, while the other group received instruction using generic word problems from the curriculum. The measurement tools were parallel 12 item pre- and posttests comprised of items reflecting six major types of algebraic word problems. The pretest, given prior to treatment, was followed by six weeks of instruction on mathematical problem solving using the 5-Step Problem Solving Plan. The posttest was given at the end of treatment. The results of the study indicated that both groups of students showed gains in mathematical understanding and written expression. However, there was no significant difference in mean achievement gains of the students who were instructed using real life personalized problems and those who were instructed using generic problems. Research should continue to assess ways to develop effective strategies for improving the mathematical problem-solving skills of special education students.

CHAPTER I

INTRODUCTION

Solving mathematical word problems is a longstanding area of concern for students at all grade levels. During the high school years, students are challenged with problem solving tasks that are based on real-world situations. These problems may delve into areas beyond simple calculations and include topics relating to technology, science, or reading and writing comprehension.

Students who receive special education services frequently struggle with problem solving activities due to learning disabilities, attention disorders, physical disabilities, behavioral disorders, or autism spectrum disorders. These students often have low reading comprehension levels, which hinder their ability to understand what complex mathematical problems are asking. Courses and assessments at the high school level require students to not only solve problems but also explain the rationale behind their answers. Many special education students become discouraged and frustrated in high school math classes due to the complexity of such problem solving tasks. This may result in failing course grades and low assessment scores. This is problematic and of interest to this researcher as all students, including those with special education needs, must receive passing grades in required algebra and geometry courses, as well as meet the minimum requirements on state assessments in order to fulfill high school graduation requirements.

Statement of the Problem

With the implementation of the Common Core State Standards and the Common Core Curriculum, students are now required to demonstrate real-world problem solving skills needed for success in the 21st-century. Traditional multiple choice assessments are being replaced by the Partnership for Assessment of Readiness for College and Careers (PARCC) assessment, which requires students to read mathematical problems, determine solutions, write explanations for their results, and apply solutions to other mathematical situations. Special education students need to develop and be able to apply strategies to use on assessments such as PARCC, on which tasks require them to combine their comprehension, written expression, and mathematical calculation skills to successfully solve complex word problems. Special education students require regular instruction on problem solving strategies in order to feel more comfortable with the complex nature of mathematical problems at the high school level. They also need opportunities to improve their comprehension of more technical problems and enhance their written explanations for the methods that are used to solve these problems. This study is designed to analyze whether the implementation of daily word problem instruction addressing these needs and reflecting their interests impacts mathematical understanding and related written expression for special education students in high school.

Hypothesis

It is hypothesized that there will be no difference in mathematical understanding and written expression for special education high school students before and after a daily word problem instructional intervention, one of which will receive problems relevant to personal interests and one of which will not. Additionally, it is hypothesized that the gains in mathematical understanding and written expression for the students who receive real life and personal examples will not differ significantly from the gains of those who receive generic problems.

Operational Definitions

Daily word problem instruction is defined as instruction through warm-up drills that require students to utilize the 5-Step Problem Solving Plan when given algebraic word problems and questions based on the information provided in the problems. Students will complete a visual organizer using the five steps of this plan for each problem.

- Step one: Students restate what needs to be solved.
- Step two: Students list the important mathematical information from the given problem.
- Step three: Students plan how they will solve the given problem based on options such as writing an equation, using a table or graph, finding a pattern, or setting up a ratio or proportion.
- Step four: Students show and work out all of the mathematical steps needed to solve the problem.
- Step five: Students justify their answers and explain in sentence form how they determined their solutions.

The *independent variable* is the provision of daily word problem instruction, the impact of which on mathematical understanding and written expression will be assessed. Additionally, while the two groups will practice similar word problems, one will have problems which contain personalized content derived from a survey of their interests and the other group will be assigned problems that are more generic and come from curricular materials not specifically chosen for their relevance to student interests.

The *dependent variable* is students' improvement in mathematical understanding and written expression. This is defined as the gains in student scores on tests of algebraic problem solving administered before and after the daily word problem instructional intervention.

CHAPTER II

REVIEW OF THE LITERATURE

This literature review attempts to explore the effects of implementing daily word problem instruction on the mathematical understanding and written expression of high school special education students. Section one provides an overview of the types of mathematical word problems that students will encounter at the high school level. In section two, special education services, types of classifications, and student difficulties with mathematics will be reviewed. Section three examines different methods and interventions that are utilized in classrooms to improve mathematical problem solving.

Mathematical Problem Solving

Throughout history, mathematics has always been an important aspect of life and education. One of the key concepts in mathematics education is problem solving. In order to live independently, people must be able to solve problems, such as making payments or maintaining a budget (Jansen, De Lange, & Van der Molen, 2013). The new Common Core standards for mathematics require students to demonstrate a deeper conceptual understanding of mathematical ideas. Math classes no longer focus on rote memorization in order to determine the correct answers. Teachers and students are moving beyond right and wrong in order to explore why it is important to understand mathematical problems (Strom, 2012). Students are now applying mathematical concepts to more real-world problem-solving applications.

Mathematical tasks generally involve a given amount of information and a goal. Sometimes the problems are purely numerical, but others are based on real life situations (Problem Solving, 2007). Students need to become problem solvers to determine how to use the given information to reach the goal of the problem. Strategies are necessary in identifying ways to solve problems and become critical skills in mathematics curriculum today. Student success in mathematics classes as well as in their careers after school is highly correlated to developing a proficient level of mathematics problem solving (Krawec, Huang, Montague, Kressler, & Melia de Alba, 2012). Problem-solving skills are also utilized in all five curricular content standards and represent a great deal of workplace success.

The Common Core State Standards Initiative (2010) describes the standards for mathematical practice, which include making sense of problems and persevering in solving them, reasoning abstractly and quantitatively, constructing viable arguments and critiquing the reasoning of others, modeling with mathematics, using appropriate tools strategically, attending to precision, looking for and making use of structure, and looking for and expressing regularity in repeated reasoning. At the high school level, the Common Core standards focus on number and quantity, algebra, functions, modeling, geometry, statistics, and probability in order for students to be prepared for college and careers. All of these standards show that there is a strong emphasis on problem solving and mathematical reasoning, which is a main focus of the high school mathematics curriculum.

The basis for solving mathematical word problems involves translating a verbal statement into numerical representations and applying mathematical operations to determine the solution to the problem (Zheng, Flynn, & Swanson, 2012). Problems involving concrete and familiar situations can help students to bridge the gap between the more abstract mathematical concepts and the basic math facts that they already know. These contextual problems can help students expand on what they understand about quantities, how to operate on quantities, and the relationships between different quantities (Walkington, Sherman, & Petrosino, 2012). The

Common Core State Standards Initiative (2010) emphasize that students who can explain the rules and processes of a mathematical problem will have a better chance of succeeding in future problem-solving tasks. This knowledge can assist students with making the transition from arithmetic to algebraic word problems.

In problem solving, arithmetic problems generally require the use of addition, subtraction, multiplication, or division to solve the problem in one step. According to Kotsopoulos and Lee (2012), algebraic problems often involve one or more unknown quantities and could require multiple steps in order to find a solution. These algebraic problems require students to utilize higher order thinking, knowledge of multiple mathematical processes, application of knowledge of given situations, involvement in several mathematical strands, and identification of extraneous information. Word problems are also built on linguistic information that require students to construct their own mathematical model based on what is known and what is missing from the problem (Fuchs et al., 2008).

Students can become successful problem solvers when they understand the similarities and differences among solutions to problems. Common mathematical vocabulary can assist students with moving from arithmetic to higher order algebraic problems. However, mistakes are often made involving letters in algebraic problems. Reed, Stebick, Comey, and Carroll (2012) emphasize that letters in algebraic problems are used to represent unknown quantities, but they can also be used to express generalized numbers, labels, constants, parameters, and varying quantities.

Without knowledge and understanding of mathematical concepts and vocabulary, many students, especially those receiving special education services, continue to be challenged with the notions of problem solving (Miller & Hudson, 2006). Whitby (2012) states, “As the number of steps required in solving word problems increases, problem solving requires working memory, organization, and mental flexibility for task completions" (p. 79). When mathematical situations become more complex, all students at the high school level require more strategies in problem solving in order to be successful with the curriculum.

Special Education Students and Their Challenges in Problem Solving

Special education services are provided to millions of students throughout the United States. However, it has only been within the past forty years that federal legislature has allowed special education services to evolve into what they are today. In 1973, the Rehabilitation Act stated that any public or private school that received federal funds could not discriminate against students with handicapping conditions. The Education for All Handicapped Children Act of 1975 provided funding for both direct and indirect support for students with disabilities. Schuelt, Osborne, and Erchul (1998) emphasized the key features of this law, which mandated that an individualized education plan (IEP) would determine a free and appropriate public education in the least restrictive environment for all students with disabilities.

Some of the most recent changes to special education services were developed in the Individuals with Disabilities Education Act (IDEA), which was reauthorized in 2004. IDEA states that student IEPs must create performance goals and achievement indicators that can be more closely aligned to the educational goals of students without classified disabilities. These goals and objectives should be measureable and assessed regularly to review progress towards annual goals. The IEP will explain how a student's disability affects their participation in the general education setting and curriculum. Students with disabilities are also now required to participate in state and district-wide assessments with the use of accommodations or alternative testing methods (Schuelt et al., 1998). IDEA was again reauthorized in 2004 to include Response to Intervention (RTI), which helps identify students with specific learning disabilities (SLD) by providing an alternative to traditional intelligence achievement testing (Fuchs et al., 2008).

In order to provide special education services to students, the IEP team must consider placement in the least restrictive environment. The first line of placement should be the general education classroom where the regular educator will provide modifications and accommodations during general instruction. If additional services are still required in order to help the student meet the curriculum requirements, pull-out services can be utilized to provide more assistance in a resource room or in a self-contained classroom for specific content needs. Students can also be removed from the general education classroom setting to receive services in the adaptive self-contained classroom with the resources of a special education teacher and often additional adult support. If all of these in-school classroom supports do not prove to be effective, students may require placement outside of the student's home school in residential facilities, hospitals, or home instruction (Schuelt et al., 1998).

Students receiving special education services may be labeled as having a specific learning disability (SLD) related to reading, writing, or mathematics. Often times, students who have difficulties with reading comprehension or written expression will also have difficulties with mathematics. This makes problem solving extremely difficult for SLD students who demonstrate challenges with comprehending math problems, as well as determining the appropriate mathematical operations necessary to solve the problems (Mastropieri, Scruggs, & Shiah, 1997). Specifically, students with a mathematics disability (MD) are considered to be performing below their expected grade level requirements in mathematics (Fuchs, Fuchs, &

Prentice, 2004). These students need additional modifications to help them meet the requirements of their curriculum.

Many students categorized with learning disabilities experience difficulties in working memory, processing speed, determining the appropriate mathematical operation, performing computations, problem solving, and higher order thinking (Krawec et al., 2012). These students face challenges with solving word problems because they are unaware of the necessary strategies needed to find a solution. Self-regulation strategies, including questioning, instruction, monitoring, evaluating, and reinforcing are lacking in many students with learning disabilities (Montague, 2008). These skills and strategies are essential in order to apply mathematical processes across curricular areas and problem-solving applications.

Language deficits are seen in students who are categorized as having both reading and math disabilities. This causes word problems to be a major difficulty due to a lack of initial comprehension necessary to determine what the problem is asking (Fuchs et al., 2008). Math problem solving requires students to perform calculations as well as comprehend, decode, and integrate written information about the problem. According to Krawec et al. (2012), higher-level thinking and use of strategic approaches are needed when developing a plan to solve mathematical problems. The learning disability population consistently shows an inability to problem solve using cognitive and metacognitive skills, such as decision making and self-monitoring of progress.

Poor organization, difficulty with attention, motivational issues, and difficulties with completing assignments are often seen in students with learning disabilities, attention deficit disorder, attention deficit hyperactivity disorder, emotional disabilities, behavioral disorders, and autism spectrum disorders. These executive functioning deficits affect memory, planning, mental flexibility, and impulse control (Whitby, 2012). Working memory, inhibition, and shifting are the sub processes of executive functioning. The ability to store information is one of the main aspects of working memory. Inhibition involves suppressing tendencies in order to achieve a goal, and shifting is a person's ability to multitask while problem solving (Jansen et al., 2013). The abstract and applied concepts that are seen at the high school level in mathematical problem solving create a challenge in thinking for students with executive functioning problems.

Teachers need to utilize various methods of instruction when teaching mathematical word problems. The special education population is often faced with reading, writing, and mathematical deficiencies, which are all necessary in problem solving. Strategies must be utilized to assist these students with determining what a problem is asking, what mathematical operations can be used, and what they need to do to determine the solution (Problem Solving, 2007). Today, many students are being diagnosed with learning disabilities, autism spectrum disorders, emotional disorders, behavioral disorders, and other health impairments and will face the same academic requirements and standards of their non-disabled peers (Whitby, 2012). These students must also take and pass the standardized state assessments in order to receive a high school diploma. Teachers need to provide effective instruction in mathematics and problem solving in order for their students to meet with success during high school and beyond as 21st-century learners.

Methods and Interventions to Improve Problem Solving

Students with learning disabilities, specifically in math, have struggled with solving word problems. Unfortunately, there is not one method of intervention that every teacher can use to help improve mathematical problem solving because of the differences in disabilities that special education students exhibit (Schuelt et al., 1998). A variety of methods, such as problem-solving models, self-regulation strategies, computer programs, tutoring, and personalized instruction have been the topics of several research studies and can be excellent tools for daily classroom instruction.

Many studies involving the *Solve It!* Problem-Solving Routine have been conducted to determine whether this was an effective form of teaching mathematical word problems to students with disabilities. Research has shown that *Solve It!* has been an effective method for students with learning disabilities, intellectual disabilities, and spina bifida. Whitby (2012) studied the effect of *Solve It!* on three middle school students who were classified with autism spectrum disorders. *Solve It!* guides and encourages students to read and paraphrase the problem to demonstrate understanding, visualize the problem and draw a picture or diagram when necessary, hypothesize and estimate solutions for the problem, and finally, solve and check the solution for accuracy. This study found that when given mathematical word problems, all of the participants increased the percentage of correct answers after receiving *Solve It!* instruction.

There are numerous self-regulation strategies utilized to help improve the mathematical problem-solving ability of students with learning disabilities. Montague (2008) reviewed multiple studies on self-regulation approaches and determined that they all followed similar steps in cognitive strategy instruction. Deficits in problem-solving strategies are common in students with learning disabilities but can be enhanced through explicit instruction, structured modeling, prompting, guided practice, immediate feedback, and positive reinforcement. Results of studies conducted with students categorized with learning disabilities have shown substantial improvement from pre- to posttests, as well as improvement in strategy use and maintenance when given mathematical word problems.

Another study focused on how executive functioning deficits affect students during problem solving. Instruction was based on a four-step problem-solving plan that included understanding, devising a plan, carrying out the plan, and looking back. It was found that shifting, inhibiting, and updating working memory were all issues during the various different phases of instruction (Kotsopoulos & Lee, 2012). This emphasized how students, especially those with disabilities, need more guidance during each phase of problem solving as well as instruction in improving executive functioning processes.

Computer instruction in problem solving is becoming increasingly popular with the rise of technology in schools. A study of students with mild intellectual disabilities was conducted to determine whether a computer tutorial program could teach problem-solving strategies. The computer program involved basic instruction, guided and independent practice, and word problem tests. All of the computer instruction provided onscreen written directions as well as digital voice instruction (Mastropieri et al., 1997). The results of using this computer program indicated that all students scored significantly higher from the pretest to the online computer posttest after receiving instruction in word problem strategies using the computer program.

Similar computer programs have been utilized to improve basic math skills for students receiving special education services. Jansen et al. (2013) believe that knowledge of basic math facts is necessary in order to move on to higher-order mathematical problems. A study was conducted involving a web-based adaptive computer platform called Math Garden. This program was designed to focus on the four basic mathematical operations (addition, subtraction, multiplication, and division) and allowed students to solve problems in a game-like format that awarded digital rewards for correct responses. Results of this study involving students with mild to borderline intellectual disabilities showed that students both improved the number of problems that they were able to correctly answer for each operation and the amount of time in which it took them to correctly reach an answer. Thus, computer programs could provide additional assistance when students are struggling with mathematical concepts.

Tutoring is another option that can provide secondary instruction to students who have difficulties with mathematical problem solving. Fuchs et al. (2008) conducted a study that focused on providing after school tutoring three times a week for 12 weeks to students classified as having both math and reading disabilities. The students were given instruction on identifying the structure of word problems, solving the problems, and transferring solution methods to other problems. The results of this study showed that students in the tutoring program performed better than non-tutored students in the areas of computation, concepts, and problem solving, thus emphasizing the benefits of additional mathematics instruction through tutoring.

Many students need to feel as though they are invested in the material that they are being taught at school. The idea of solving mathematical word problems often does not appeal to students because they do not feel a connection to the content of the problem. Walkington et al. (2012) conducted a study of low-performing high school students to determine whether placing mathematics problems in context would affect their ability to solve the given problems. The students in this study participated in an interview that asked a series of questions relating to their interests and how they perceived to use mathematics in their daily lives. Students then received instruction based on situational word problems that were expressed by the students during their interviews. These problems proved to capture the interest of the students and helped them to feel more invested in wanting to find solutions.

Instructional methods, such as *Solve It!*, self-regulation strategies, computer assistance, tutoring, and personalized instruction, are frequently utilized in order to improve the problem-solving abilities of all students, including special education students. These methods also tend to have similarities in that they all break down the problems through detailed examples in order to help students assess each step necessary for solving (Miller & Hudson, 2006). Some of the most effective instructional interventions include mnemonic strategy, curriculum-based measurements, direct instruction on strategies, and early intervention (Schuelt et al., 1998). No matter what method of problem-solving instruction is used, it is critical to improve students' critical thinking abilities in order to provide them with the skills needed to problem-solve in real life situations.

Summary

The Common Core standards for mathematics provide a strong emphasis on problem solving in all areas of the high school math curriculum. With these high standards, students are now required to utilize more problem-solving strategies in order to comprehend, solve, analyze, and question the solutions to mathematical situations. This becomes a challenge for the special education population which often lacks the skills necessary to determine solutions for such complex multi-step problems. Students with learning disabilities involving reading and math experience a great deal of difficulty because they lack the initial comprehension skills that are essential to understanding what the problem is seeking.

Numerous instructional methods have been reviewed in order to determine their effectiveness on improving mathematical problem solving of students with disabilities. These studies have shown that there is not one single method that can demonstrate full effectiveness for every student. However, when teaching the special education population, it is extremely important to provide guided instruction, visual examples, and step-by-step strategies for working through the problems. At the high school level, mathematical problems should continue to be focused on real-world applications that the students can relate to. No matter what method of instruction is utilized, it is imperative for schools to implement problem-solving instruction in math classes on a daily basis in order to help special education students develop the critical thinking skills that are necessary to become successful lifelong problem solvers.

CHAPTER III

METHODS

This study examined the impact of daily mathematical problem-solving skills instruction on the mathematical understanding and written expression of mathematical logic of special education students in high school. Additionally, the impact of personalizing the math problems was assessed.

Design

A quasi-experimental pretest/posttest design was used in this study. All students were given a 12 item pretest containing two items reflecting each of six major types of algebraic word problems. These six areas of instruction were determined based on the areas of instruction that are tested on the Maryland High School Assessment for Algebra. The intervention (treatment) included daily word problem instruction using the 5-Step Problem Solving Plan during warm-up drills. Two groups were formed which each contained students enrolled in one of two Algebra/Data Analysis classes and one of two Algebraic Functions classes. Both groups received the same daily instructional content. However, the treatment group (Algebra/Data Analysis (period 9/10) and Algebraic Functions (period 3)) reviewed the problem types with items which included information that was of interest to the participants, such as shopping and part-time jobs. These interests were determined by completion of a survey of their interests (see Appendix A). In contrast, the control group (Algebra/Data Analysis (period 7/8) and Algebraic Functions (period 2)) received treatment on the same problem types, but the information in their problems was based on generic mathematical situations from the curriculum. After the intervention was completed, all participants in both groups were given a posttest on the six major types of algebraic word problems. The differences between the students' pre- and posttest intervention scores were calculated to reflect the students' improvement in mathematical problem solving during the study.

Participants

The participants for this research study included special education students in grades 9 through 11 from a high-performing high school in Baltimore County, Maryland. Participants were students enrolled in two self-contained Algebra/Data Analysis courses and two self-contained Algebraic Functions courses at the school. Forty-four students total (25 ninth-grade students, 17 tenth-grade students, and two eleventh-grade students) participated in the daily word problem instruction, with 24 of them using personalized problems and 20 of them not. The sample included 29 males and 15 females. The treatment group ADA class contained seven males and six females, and the treatment group AF class contained seven males and four females. The control group ADA class contained 10 males and 3 females, and the control group AF class contained five males and two females.

A convenience sample was used for this study. All of the participants were students with individual education plans (IEP) and were enrolled in the school's special education self-contained math program. Class sizes ranged from 7 to 13 students. Each class was taught by the same teacher (the researcher) who was certified in mathematics and special education. There was also an assistant teacher in every class and additional adult support personnel in the two Algebra/Data Analysis classes. The students in the sample will be taking the Algebra High School Assessment in May 2014 and will also be taking the PARCC assessment for mathematics for the first time in the 2014–2015 school year.

Instruments

The instruments used for this study were parallel pre- and posttests created by the researcher, which included algebraic word problems taken from previously released Algebra HSA exams. The assessments were designed to test students' problem solving abilities and included 12 questions, two of which reflected each of the following six algebraic problem types: (1) manipulating and analyzing statistics, (2) writing and solving equations with one unknown quantity, (3) analyzing tables, graphs, diagrams, and matrices, (4) writing and solving equations with two unknown quantities, (5) proportional reasoning, and (6) identifying patterns and sequences. These six algebraic problem areas were aligned with the Baltimore County algebra curriculum and the Common Core standards.

On the pre- and posttests, students were required to read each situation and show the mathematical steps necessary to find an answer. An additional element was added to the tests which asked the students to explain in written form how they determined their solutions. This new element will be required on the upcoming PARCC assessment in the 2014–2015 school year. Each question on the pre- and posttests was worth two points. One point was awarded for the correct mathematical answer and one point was given for the correct written explanation of the mathematical process that was used to solve the problem. This made it possible to earn a total of 24 points for each pre- and posttest.

In order to determine student interests, a survey was provided to the students in the treatment condition group prior to treatment intervention that included ten multiple choice questions relating to personal interests, such as music, food, television, sports, school, etc. A copy of the survey is located in Appendix A. This survey was administered to students as a warm-up drill at the beginning of their class period before the intervention. Students were given as much time as they needed to complete the survey. They were asked to respond honestly based on their likes and dislikes. The researcher answered any questions that students had about the items on the survey or how to complete it. The results of the surveys were used as the topics for real-life problem solving situations that were of interest to the participants and were utilized with the treatment group.

Procedure

The researcher began by giving the pretests to all 44 students in the Algebra/Data Analysis and Algebraic Functions classes. The treatment and control groups were divided into two sections based on class period. The period 3 Algebraic Functions class (treatment group) was given Form A as a pretest and the period 9/10 Algebra/Data Analysis class (treatment group) was given Form B as a pretest. The period 2 Algebraic Functions class (control group) was given Form B as a pretest and the period 7/8 Algebra/Data Analysis class (control group) was given Form A as a pretest. All of the pre- and posttests contained parallel generic questions of equal difficulty. Students who were absent on the day of the pretest or posttest were given the opportunity to take the assessments when they returned to school. Each question on the pre- and posttests was worth two points. After grading the pretests, the researcher recorded how every student performed in each of the six key algebraic areas of the assessment.

Treatment was then provided for six weeks and included review of the key algebraic areas that were assessed on the pretest. Each week was spent on a single mathematical problem type. Students received instruction for 10 to 15 minutes daily during warm-up drills. A different word problem was given every day. The problems were all similar in nature to the types that were utilized on the pretest. The control group received generic problem situations taken from previously released Algebra HSA test items, while the treatment group was given problem situations based on their interests as determined from the surveys.

All students also received instruction on the 5-Step Problem Solving Plan. This is a method that was developed as part of the Baltimore County Algebraic Functions curriculum and was modified by the researcher to fit the needs of the participants. Modifications included altering the choices in Step 3 to include only mathematical options that relate to the six key algebraic types of instruction, as compared to the original curriculum model which included more generic mathematical options such as guessing, drawing a picture, working backwards, or making a list. In order to assist this group of special education students with comprehending the complex nature of algebraic word problems, they were given graphic organizers that separated each of the five steps of this plan because it allowed the students to visually organize the mathematical information in each problem. A copy of the 5-Step plan is located in Appendix B.

During instruction, the researcher instructed students to begin by reading through each problem and underlining or highlighting key information. Next, they utilized the 5-Step Problem Solving Plan's graphic organizer to write down the question in box one. In the second box, students were told to list the key information, such as numerical values including price, distance, time, etc. In the third box on the graphic organizer, students were to select a plan for how to solve the problem based on list of mathematical strategies provided. Box four required students to show all work necessary to mathematically solve the problem. Finally, in box five, students were to explain in sentence form how they solved the given problem and analyze whether their answers were reasonable.

After the six weeks of instruction covering each algebraic problem type using the 5-Step Problem Solving Plan, all participants were given a posttest, which was the alternate form of the pretest they had taken. Results from the pre- and posttests were then compared to determine whether, overall, students in each group showed improvement in mathematical understanding and written expression given daily practice. The scores from the control group and treatment group were also compared to determine whether students demonstrated greater improvements when given problem situations that were of interest to them.

CHAPTER IV

RESULTS

The purpose of this study was to determine the impact of using two variations of instruction to improve word problem-solving skills of high school special education students who received daily algebraic problem-solving instruction. The independent variable was the provision of two variations of daily word problem instruction. To assess the impact of using personalized versus generic problems to practice word problem skills, two groups practiced similar word problems. One group worked on problems which contained personalized content derived from a survey of their interests, and the other group was assigned problems that were more generic and came from curricular materials not specifically chosen for their relevance to the students' interests. After this instruction, students' improvement in mathematical understanding and written expression were assessed.

It was hypothesized that there would be no difference in the two groups' mathematical understanding and written expression skills before or after a daily word problem instructional intervention or in the two groups' gain scores. This was tested by comparing the mean pre- and posttest scores for the control (generic problems) and treatment (personally relevant problems) groups and by comparing their gain scores to zero and each other. Table 1 below presents the descriptive statistics for both groups' pre- and posttest data.

Table 1

Descriptive Statistics for Pre- and Posttest Data for Control and Treatment Groups

Test	Group	N	Mean	Std. Deviation	Std. Error Mean	Range
Pretest	Control	20	2.0500	2.16370	.48382	0-7
	Treatment	24	3.0000	2.93406	.59891	0-10
Posttest	Control	20	11.4500	6.29515	1.40764	2-22
	Treatment	24	12.1667	5.42672	1.10772	2-21

The differences in the pretest and posttest scores of the control and treatment groups were compared using t-tests for independent samples. The results follow in Table 2.

Table 2

Results of t-tests for Independent Samples Comparing the Treatment and Control Groups' Pre- and Posttest Scores

	t	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
						Lower	Upper
Pretest	-1.200	42	.237	-.9500	.79138	-2.54707	.64707
Posttest	-.406	42	.687	-.7167	1.76682	-4.28225	2.84892

Equal variances assumed

The results in Table 2 indicate that neither the mean differences between the control and treatment groups' pretest scores (-.95) nor posttest scores (-.7167) were statistically significant. (The probability of finding a difference this large due to chance in each case was .237 and .687, respectively). Thus, the null hypotheses that the pre- and posttest scores for the two groups were equal were retained.

Additionally, it was hypothesized that the gains in mathematical understanding and written expression for the students who received real life/personally relevant examples would not differ significantly from the gains of those who received generic problems. To calculate the gains, each student's pretest score was subtracted from his or her posttest score to yield the change (in points) in test scores exhibited over the intervention period for each student. Then, the mean gain scores for both the control and treatment groups were computed and compared to zero (to see if any were significant), using a one-sample t-test. The two groups' gains were also compared to each other using a t-test for independent samples to see if one group made significantly larger gains than the other. Table 3 lists the descriptive statistics for the gain scores, disaggregated by group.

Table 3

Descriptive Statistics: Gain Scores Disaggregated by Group

Group	**N**	**Mean**	**Standard Deviation**	**Standard Error Mean**
Control	20	9.40	5.134	1.148
Treatment	24	9.17	3.975	.811

Table 4 lists the results of one-sample t-tests comparing the mean gains for both groups to zero. These results indicate that the mean gains for both groups were statistically significant ($p < .000$), so the hypotheses that there would not be a difference in the two group's pre- and posttest scores (or that the gains made by either or both groups would be statistically insignificant) were rejected.

Table 4

Results of One-Sample t-tests Comparing Mean Gains of the Control and Treatment Groups to Zero

Group		Test Value = 0					
		t	**df**	**Sig. (2-tailed)**	**Mean Difference**	**95% Confidence Interval of the Difference**	
						Lower	Upper
Control	Gains	8.188	19	.000	9.400	6.997	11.803
Treatment	Gains	11.299	23	.000	9.167	7.488	10.845

Finally, Table 5 contains the results of a t-test for independent samples which compared the control and treatment groups' mean gain scores to each other. The results indicated that the mean gains for the groups (9.4 for the control group and 9.167 for the treatment group), which differed by .233 points, did not differ statistically significantly ($t = .170$, $p < .866$). Thus, the hypothesis that the gains in mathematical understanding and written expression for the students who received real life and personal examples would not differ significantly from the gains of those who receive generic problems was retained.

Table 5

Results of an Independent t-test Comparing Mean Gains of the Control and Treatment Groups

	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Gains	.170	42	.866	.233	1.373	-2.538	3.005

Equal variances assumed

As attendance rates could have impacted the results of either intervention, the number of absences for the word problem sessions was tracked for each student in both the control and treatment groups. Descriptive statistics for the absences of the students in the control and treatment groups and results of a t-test for independent samples comparing them follow in Tables 6 and 7.

Table 6

Descriptive Statistics for Attendance Data by Group

Group	N	Mean	Standard Deviation	Standard Error Mean
Control	20	3.10	3.417	.764
Treatment	24	2.08	2.518	.514

Table 7

Results of an Independent t-test Comparing Mean Absences for Students in the Control and Treatment Groups

t	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
					Lower	Upper
1.135	42	.263	1.02	.896	-.791	2.824

Equal variances assumed

These results show that the mean difference of 1.02 between the mean absence frequencies of 3.1 for the control group students and 2.08 for the treatment group students was not statistically significant ($t = 1.135$, $p < .263$).

CHAPTER V

DISCUSSION

This study was conducted to determine the impact of using two variations of word problem instruction to improve the mathematical skills of high school special education students who received daily problem-solving instruction. The results indicated that both the control and treatment groups showed improvement in scores from the pre- to posttest. Additionally, the study compared the pre- and posttest scores of students receiving personalized word problems versus generic problem solving instruction. Results indicated that there was not a significant difference in the size of the gains of the two groups.

Implications

The findings of this study indicate that high school special education students can show improvement in mathematical problem solving and written expression when given daily word problem instruction using guided practice. The difference in gains shown between those students who received personalized word problems and those who received generic word problem instruction was not significant. Student attendance did not vary much between the two groups, and did not appear to be a significant factor in determining the gains in mathematical problem-solving made by either group.

Threats to Validity

Throughout an experimental study, there may be threats to internal or external validity based on uncontrolled variables (Gay, Mills, & Airasian, 2011). In this study, internal validity would be affected if the level of student improvement of mathematical understanding and written expression was affected by the provision of daily word problem instruction. The main threat of internal validity in this study was the use of a non-random sample because the participants were selected based on being classified as special education students who were enrolled in the self-contained algebra classes. The researcher intended for all students to receive instruction in mathematical problem solving, so there was no control group that did not receive the intervention to which to compare the gains of those who did receive the two variations of the intervention.

Threats to external validity affect how the results of the study can be generalized to broader group(s) outside of the experimental setting. This study utilized a small sample of special education students enrolled in a self-contained algebra classes. The results from this population would most likely differ from the results of a parallel study conducted with a different group, for example, a group of gifted and talented students enrolled in Algebra I classes. Due to the nature of disabilities of the students in the given self-contained classes, improving mathematical understanding and written expression on word problems was the focus area of this study. The strategies that were implemented were designed around six key areas of algebra instruction, so it would be difficult to determine whether this study would impact other subject areas. Another external threat involved was the length of time for the study. The intervention was conducted over only six weeks. If more instructional time was provided, the outcomes may have been different.

Connections to Previous Studies

There have been a variety of studies conducted to analyze the effects of problem-solving strategies and interventions for students with special needs. *Solve It!* is an instructional strategy used to teach mathematical word problems using the cognitive processes of reading, paraphrasing, visualizing, hypothesizing, estimating, computing, and checking. Whitby (2012) conducted a study using this *Solve It!* method on students with autism spectrum disorders and found that all of the participants improved in the percentage of correct word problem answers after receiving treatment. The current study used a similar method that required students to use the 5-Step Problem Solving Plan of restating, listing, planning, showing work, and justifying the answer to develop and understand the solutions of mathematical word problems. The current research showed comparable findings to those of Whitby in that both groups demonstrated improvement from pre- to posttests.

Another study on *Solve It!* conducted by Krawec et al. (2012) differed from the current study because it utilized a random sample of participants using an experimental model with a treatment and control group. The students in the treatment group received mathematical problem-solving instruction using *Solve It!* once a week for an entire school year, while the control group received regular instruction based on the district curriculum. The results of Krawec et al.'s research indicated that students in the treatment group showed significant improvement from pre- to posttest, but the students in the control group did not show significant improvement. Unlike Krawec et al.'s study, the current study did not have a control group which did not receive treatment to use as a comparison to those which received the word problem instruction. All of the participants in the current study received one of the two treatments in order to provide instructional strategies that could benefit their mathematical understanding.

A study of executive function and problem solving conducted by Kotsopoulos and Lee (2012), using a four-step problem solving strategy, was very similar to the 5-Step Problem Solving Plan used in the current research. Kotsopoulos and Lee conducted their study over an entire school year and required students to talk aloud using video diaries as they worked through mathematical word problems. This study differed from the current research in that students completed problems on laptops both in school and at home and recorded themselves throughout the process. Computer problems were not used at all during the current study due to a lack of availability of laptops for all participants.

Implications for Future Research

Various improvements could be made to future research on this topic. The given study utilized a convenience sample which included a small group of 44 students enrolled in self-contained algebra classes. A larger sample could provide more generalizable results. An option for future studies would be to include a variety of students, as opposed to just those in self-contained classes. Researchers could examine special education students in inclusion classes, as well as the general education population, in order to determine which interventions are most or least beneficial to which types of students.

Additional time for the length of the study could also be helpful to analyze student benefits. The current intervention lasted for six weeks. If the research could be conducted over an entire school year, the results could be used to analyze how a variety of factors relate to the instruction, such as the students' pass/fail rate on the standardized algebra high school assessment. It would also be interesting to see how special education students develop mathematical problem-solving skills throughout all four years of high school. The study could begin in ninth grade and continue with the same group of students until graduation to analyze a wider variety of factors during different mathematical courses.

Conclusions/Summary

This study demonstrated that special education high school students can show improvements in mathematical understanding and written expression when given daily word problem instruction. The results from the six-week intervention supported the null hypothesis that there would be no significant difference in the gains in mathematical understanding and written expression for the students who received real life personalized problems and those who received generic problems, suggesting that modifying the problems to reflect interests may not be directly important in terms of math skill acquisition. However, it was noted by the researcher that during intervention, the students in the treatment group showed more interest in the problem types which they could relate to. Specific problems designed around sports, music, video games, and technology were of particular interest to the participants. During intervention, these students often compared the mathematical results to real life situations. A longer period of intervention may have shown more detailed statistical findings between the achievement of the students who received personalized instruction and those who did not.

It should also be noted that written expression continued to be a challenge for both groups of participants throughout the intervention. Students frequently developed the correct mathematical response, but were unable to explain their answers in sentence form. One student questioned, "Why do we have to write sentences? This is math class." Such comments were not uncommon during the intervention. Each student in the sample had an IEP with specific goals and objectives, many of which related to mathematics and writing. Students with writing goals often had objectives associated with spelling and grammar. Due to these goals, the researcher did not take off points for spelling or grammatical mistakes on the written explanations on the pre- or posttests. The researcher would be interested to see if additional time and studies in collaboration with the self-contained English teacher would help students continue to improve their written expression in mathematics.

Overall, the study did not support the null hypothesis that there will be no difference in mathematical understanding and written expression for special education high school students before and after a daily word problem instructional intervention, because the results indicated that participants did show statistically significant improvement from pre- to posttests. The second null hypothesis, that there would be no significant difference in the gains in mathematical understanding and written expression for the students who received personalized problems and those who received generic problems, was supported as results showed that there was no significant statistical difference between the mean gains made by both groups of students.

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Appendix A

Student Interest Survey

Please choose the response that best fits your preference.

1.) Which social networking site do you use the most?
(a) Facebook (b) Twitter
(c) Instagram (d) SnapChat (e) Other

2.) What is your favorite type of electronic device?
(a) Cell Phone (b) iPod
(c) Computer (d) Tablet (e) Other

3.) What is your favorite subject in school?
(a) Math (b) English (c) Science
(d) Social Studies (e) Physical Education (f) Tech Ed
(g) The Arts (Band, Chorus, Theater, Orchestra, etc) (h) Other

4.) What is your favorite type of video game system?
(a) X-Box (b) Wii (c) Playstation (e) Other

5.) Which type of pet do you prefer?
(a) Cats (b) Dogs (c) Birds
(d) Fish (e) Insects (f) Other

6.) What would you like to do after high school?
(a) 4-year College (b) 2-year College (c) Trade School
(d) Armed Forces (e) Get a job (f) Other

7.) What is your favorite snack food?
(a) Pizza (b) Chips (c) Candy
(d) Ice Cream (e) Cookies (f) Fruit (g) Other

8.) What is your favorite type of television show?
(a) Sitcoms (b) Drama
(c) Action (d) Reality (e) Other

9.) What is your favorite type of music?
(a) Rap (b) Rock (c) Pop
(d) Country (e) RnB (f) Techno (e) Other

10.) What is your favorite sport?
(a) Baseball (b) Football (c) Basketball
(d) Lacrosse (e) Track & Field (g) Soccer (e) Other

5-Step Problem Solving Plan

1. Restate what needs to be solved.
2. List the information that you need.
3. Plan how to solve. Circle the best method. Find a pattern — Make/Use a table / graph / list / diagram Use a formula — Write an equation using: $y = mx + b$ Set up a ratio / proportion — Write an equation using: $Ax + By = C$
4. Show all work to find the answer.
5. Check & justify your answer. Is your answer reasonable? Explain in sentence form.