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The Effects of Schema-Based Instruction on Word Problem Solving in Students with Disabilities

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Abstract

Word problem solving is a difficult portion of the math curriculum for students with disabilities. Schema-based instruction is an intervention used to help these students increase their word problem solving performance. This study involves three 9th grade students (1 female and 2 male) who attended a public high school in the southeastern part of the United States. The intervention took place in a small group setting. A single subject multiple baseline across participants design was used to implement schema-based instruction. Results indicate growth in word problem solving among these students at the secondary level. Diagram generation and quality was fair (diagram was somewhat related to problem and some parts are labeled) and played a role in increasing word problem solving ability in the study. This intervention needs further research to include more high school aged students with disabilities to determine its effectiveness within this population.

Keywords: word problem solving interventions, math difficulties, concrete representational abstract, disabilities

Effects of Schema-Based Instruction on Word Problem
Solving in Students with Disabilities

Math curriculum and requirements for graduation are rapidly changing in each state. These rapid changes and increasing expectations for academic achievement make it difficult to meet the education needs of students with disabilities (Alter, Brown & Pyle, 2011). The current math Common Core Georgia Performance Standards, (CCGPS) and curriculum require students to apply mathematical thinking to real world situations. Common Core Standards provide a reliable structure to prepare students to be successful in college and/or the global workplace (georgiastandards.org, n.d). Math is a subject that is difficult for most students, especially students with disabilities.

Due to changes in math curriculum and the adoption of national standards such as Common Core, math problem solving is an essential skill, and is a struggle for many students. According to Alter (2012), "Math problem solving is defined as the presentation of a novel problem that requires the student to determine an appropriate course of action for attaining a goal before implementing a strategy to address the problem (p. 55)." Word problems are challenging for students because reaching correct answers involve processes and skills beyond basic arithmetic (Zheng, Flynn, & Swanson, 2013).

In order to solve a word problem, students must apply previous knowledge of a concept to the word problem. Calculation is one of the many steps to reach the correct answer. Solving math word problems involves several processes. According to Montague (2009), there are seven cognitive processes that are essential to solving word problems in math: (a) reading the problem for understanding, (b) putting the problem in own words (c) drawing a diagram (d) developing a plan (e) predicting the answer, (f) calculation, and (g) checking the answer. Accomplishing success in math problem solving, leads to overall achievement in math (Krawec, Huang, Montague, Kressler, & de Alba, 2013).

Students with disabilities and math difficulties often struggle to determine the relevant information needed to solve a word problem. This struggle is due to a combination of deficits in working memory, processing speed, operation identification, calculation, higher order reasoning, and the comprehension embedded in word problems (Krawec et al., 2013). These deficits make math problem solving one of the most challenging aspects of the curriculum. This difficulty is also leading to poor performance on classroom and standardized assessments.

Items on the math portions of standardized test such as End of Course Tests (EOCT), Criterion-Referenced Competency Tests (CRCT) which is now called Georgia Milestone EOC and Georgia High School Graduation Test (GHSGT) are written as word problems. These items are written in this format because they signify the use of math skills to real world situations (Alter, Brown & Pyle, 2011). According to the Governor's Office of Student Achievement (GOSA, 2012), in the 2011-12 school years throughout the state of Georgia, a large number of students with disabilities failed EOCT's in math related courses. Sixty-three percent failed in Geometry, 72% in Math I, and 75% in Math II. In the 2012-13 school years, new standards for math were introduced and Math I curriculum became Coordinate Algebra for some districts. Failure rates continued with 90% of students failing in Coordinate Algebra, 54% in Geometry, 88% in Math I, and 72% in Math II (GOSA, 2013). This research will add to the body of literature on this intervention. This will also provided interventions to students with disabilities at the secondary level to increase their ability to solve word problems.

Review of Literature

Math Disabilities

Students struggling with math problem solving and those who fail statewide assessments often have a math related disability. Students with learning disabilities struggle due to one or more of the basic psychological processes involved in understanding or in using language, spoken, or written that may manifest itself in the inability to listen, think, speak, read, write, spell, or to do mathematical calculations including conditions such as perceptual disabilities, brain injury, minimal brain dysfunction, dyslexia, and developmental aphasia (IDEA, 2004). Dyscalculia is a specific type of learning disability related to math (Waddlington 2008). Students with dyscalculia have a severe problem with mathematics. Dyscalculia is a neurological disorder of the brain that causes a discrepancy between general cognitive level and mathematical abilities.

According to Waddlington (2008), there are three dyscalculia subtypes, (a) *Semantic memory*: difficulty recalling math facts, (b). *Procedural memory:* trouble with the comprehension and application of numerical procedures, and (c) *Visuospatial memory:* difficulty understanding spatially represented numerical information such as misalignment of columns, place value errors, or geometry. Semantic and procedural memory have the most impact math problem solving. This impact is greatest with students who have difficulty recalling math facts to simplify expressions and the steps they need to correctly solve a math problem. In order to solve a math problem, students must master the basic operations of math (addition, subtraction, multiplication and division).

Students with dyscalculia may also have co-morbid disabilities such as, learning disability (LD), emotional behavioral disorder (EBD), mild intellectual disability (MID) or attention deficit hyperactivity disorder (ADHD) that further impact math achievement and word problem solving skills (Alter, 2012). Language processing disabilities such as dyslexia or dysgraphia can hinder a person's ability to learn vocabulary and concepts as well as use symbols, signs, and operations (Wadlington, 2008). Learning vocabulary for math may be difficult for students with disabilities due several meanings of the words for different contents. Word problem solving involves a large amount of processing and reasoning which is difficult due to the deficits they possess. These processing deficits make it difficult to learn the vocabulary due to words having different meanings in different contexts. Students with auditory comprehension difficulties often struggle with oral presentation of concepts, and those students with oral language or word-retrieval deficits have trouble explaining concepts aloud.

In math, there is a requirement for work to be organized, implement the correct procedure and following a detailed course. Students with dyscalculia and dyslexia may have further challenges with organization due to processing deficits. People with language processing deficits will struggle to complete math work in an appropriate amount of time due to the number of steps and processes they have to recall to solve the problem (Wadlington, 2008).

Math Interventions

To help address these problems, there are several interventions and strategies that have been researched in the effort to increase word problem solving in students with disabilities and math difficulties. Some of these interventions were very successful and some less successful. The interventions that will be discussed in the upcoming sections have evidence that indicate effectiveness in word problem solving for students with disabilities. See Table 1 for additional details on the research articles reviewed and reported in this paper.

Concrete Representational Abstract

Concrete Representational Abstract (CRA) is a three-stage learning process where students master math concepts through the use of tangible objects *(concrete),* followed by learning through illustrative depictions of the tangible objects *(representational),* and end with solving problems using abstract representation *(abstract)* (Witzel, 2005). In the concrete stage, students use manipulatives such as Algeblocks or Algebra tiles to solve the representation of the problem. In the representation stage, a picture is used to represent the concrete objects in the problem. In the last stage, abstract, the problem is written with the use of symbols. This approach is useful for simplifying algebraic expressions and solving algebraic equations. CRA is successful with students in grade levels in which algebraic concepts are taught.

In one study, CRA was investigated with 231 sixth and seventh graders (Witzel, 2005). The participants included 182 students without disabilities and 49 students with a learning disability in math. A quasi-experimental design with pre-post follow up with random assignment of clusters was used to examine the effectiveness of the CRA model for solving for variables with multiple coefficients, fractions and exponents. CRA was implemented in four steps for each stage, (a) introduce the lesson, (b) model the new procedure, (c) guide students through procedures, and (d) begin students working at the independent level. Concrete lessons were taught through the use of manipulatives, pictures were used for the representational lessons, and symbols were used for abstract lessons.

Strengths of the study include the description of the participants, the instructional techniques that were used in the treatment and comparison groups, and how both groups followed the same implementation procedures to ensure the results of the study were valid. A major limitation of the study is high standard deviations in the treatment group’s scores show that the model does not have an immediate effect for all sixth and seventh grade students with this content.

The results of the study indicate that the treatment and comparison group showed improvement from pretest to post test. The abstract (comparison) group out performed multisensory (treatment) group on the pretest but the multisensory group outperformed the abstract group on the post test. The multisensory (treatment) group received CRA instruction, while the abstract (comparison) group received traditional instruction. The multisensory approach benefited students with high math achievement. Overall, this intervention was somewhat successful in addressing the problem.

Computer-based math intervention

Another approach to address math problem solving is *GO Solve Word Problems* (Leh & Jitendra, 2013). *Go Solve* is computer software grounded in schema principles with lessons that focus on the structure of problems that is effective in successful student learning. This software includes error correction measures using a text box that provides a hint regarding the type of error whenever students enter labels, number tiles to represent quantities, or answers that are inaccurate. Students were taught various types of word problems in a sequence such as addition and subtraction one-step and two-step problems involving Group or Parts and Total, Change, and Compare or Comparison problems. To guide the problem-solving process, the program includes a three-step process of (a) reading the problem to understand the problem, (b) identifying problem features associated with the problem type to map onto the schematic diagram, and (c) computing the answer based on information in the diagram to guide the problem-solving process.

Leh and Jitendra (2013) investigate the use of *GO Solve*, with 25 third grade students, 20 of whom were general education student with math difficulties and 5 of whom were students with disabilities. These students scored at or below the 50^{th} percentile and were selected to participate in the study based on their total math score of the Stanford -10 Achievement Test. An experimental pretest/posttest design was used to examine the effectiveness of the *Go Solve* program for word problem solving compared to teacher mediated instruction (TMI). Teacher mediated instruction used schema- based instruction as an intervention. A strength of the software is its provision of immediate feedback to students and the level of engagement it promoted through the use of engaging programming. The results of the study did not indicate sustained benefits for computer- mediated instruction (CMI) over TMI when controlling for significant instructional variables. The results of the study indicate that *GO Solve* is not beneficial for students with disabilities. TMI did result in higher mean scores than CMI although the result was not statistically significant.

Problem solving sequence

Another intervention to address word problem solving is an 8-step problem solving process (Alter, 2012). The problem solving process is used to help provide step by step instructions or guidelines for students to follow when applying a particular approach. See Table 2 for a list of the steps and sub steps in the problem solving process. The steps in this problem solving approach are general in nature can be utilized in solving multiple levels of multistep problems. This approach could be successful with students from elementary to high school.

Alter (2012) investigates the use of an 8-step problem solving process with 4 fourth and fifth grade males with EBD and an IQ range of 68-88. Three were African American and one was Caucasian. A single subject multiple baseline design was used to examine the effectiveness of the 8 step problem solving process in conjunction with a token economy system. The token economy system was used as a tool to intervene with on task behavior and to provide reinforcement of on task behavior during the intervention. Student tokens were index cards with verbal praise prompts and reminders. Token cards were also used to provide the students with points as a reward for the use of items within the classroom (Alter, 2012). There are multiple strengths of this study. First, is that students learned a process that they could use to solve any type of problem. Second, this study provided a detailed description of the target intervention that supports teacher use in practice. Third, in the study, the researcher described the thought process of each step in the problem solving process. Students were trained via modeling how to implement the problem solving process when given word problems. Despite the strengths, limitations of the study include lack of generalization to the population due to the research design, a limited number of participants, and collection of only two data points in the intervention phase for one of the participants. Results showed that during the intervention phase, problem solving precision and on task behavior improved in relation to the baseline data, the percentage of problems finished correctly improved for all 4 participants from baseline to intervention, from pretest to post test, 3 students improved (S1 from 10% to 60%, S2 from 20% to 30%, and S3, 10% to 60%) and one student decreased (from 30% to 10%) and that the participants utilized the problem solving strategy. Overall, this strategy does improve word problem solving (percentage of problems completed correctly) but its use has not been evaluated with students with various disabilities. This intervention was used specifically with students with EBD.

General Strategy Instruction

An additional intervention to improve problem solving is General Strategy Instruction (GSI). GSI involves a four- step problem solving technique which requires students to (a) read to understand, (b) develop a plan, (c) solve, and (d) look back (Xin, Jitendra & Deatline-

Buchman, 2005). The researcher of this strategy has developed a problem- solving think along sheet that asks questions that prompt action for each step. In the first step (understand), students are asked to state the problem in their own words. In the second step (plan), students were asked to draw a picture, make a table or make a model or write a math equation. In the third step (solve), student have to show their plan and explain what steps they took to solve the problem and write the answer in sentence form. In the last step (look back), students are asked if they solve the problem in a different way and rationalize if their answer was reasonable. Research on this strategy has evaluated its use with varied concepts including multiplication and proportions.

In this study, 22 students in grades 6-8 with difficulty learning (18 with LD, 1 serious emotional disturbance, 3 not labeled) were participants. There were 11 males and 11 females participating in the study. Seven participants were Caucasian, 12, Hispanic and 3 African American. A pretest-posttest comparison group design with random assignment of subjects was used to examine and compare the effects of schema- based instruction (SBI) and general strategy instruction (GSI) on word problem solving. Strengths of the study include the development and use of a guide to help facilitate group discussions. Despite the strengths, researchers did not control for student reading levels, and there was a limited use of problems that applied to real world situations. The lack of use of real world situations could have impacted the outcomes due to students not knowing how to apply the intervention to those types of problems. The results of the study indicate that SBI group performed better than GSI group and the SBI students were able to transfer learned skills to new tasks.

Schema-based Instruction

Although there are several interventions to address the problem of increasing word problem solving, one intervention, schema- based instruction has shown to be the most effective in helping students with math difficulties and disabilities. A number of studies have been conducted to examine the effectiveness of this intervention with the use of several variations of this intervention in each study (van Garderen , 2007; van Garderen, Scheuermann, & Jackson, 2013; Jitendra & DiPipi, 2002; and Fuchs et al., 2008). Schema- based instruction involves focused instruction to help students recognize and understand the composition of a word problem (Maccini, Mulcahy, & Wilson, 2007). SBI is a two phase instructional approach: problem schemata instruction and problem solution instruction (Xin, et. al., 2005). SBI is implemented via scripted lessons, checklists, schematic diagrams, and student worksheets. During the first phase, students are taught to identify the problem type or structure and represent and solve the problem using a schematic diagram. In the second phase, participants used word (story) problems with unknown information to solve problems. As a result of this intervention, students learned to recognize important problem structures and record the problem onto a diagram and review information in the problem on a finished diagram.

Studies by van Garderen (2007), van Garderen, Scheuermann, and Jackson (2013), Jitendra and DiPipi (2002) and Fuchs et al (2008) examined the effectiveness of SBI on elementary and middle school students with disabilities and math difficulties. This intervention was used to solve a variety of word problems. van Garderen (2007), conducted a study with a single subject multiple probes across participants design with 3 eighth grade students with disabilities. Students were given three phase instruction to help solve word problems. The instruction included strategies for generation of diagrams, strategy for one step word problems and two step word problems instruction. Students were given a variety of the 3 types (i.e., one step, two- step and a mixture) of problems on the assessment. All word problem tests were scored to evaluate (a) diagram use, (b) diagram form, and (c) student performance. Strengths of this study include a description of the word problem types and description of each phase of the intervention condition. The first phase (generating diagrams) focused on diagram definition and why and how to use a diagram. The second phase (single step word problems) focused on the "Visualize" strategy. See Table 2 for steps to this strategy. The final phase (multi step word problems) also focused on the "Visualize" strategy with identification of the primary goal of the problem and final answer prediction. The results did not indicate that the use or diagrams alone improved word problem solving performance of the participants and the instruction was given to the participants individually, not as a group. Results indicate that after students received instruction all students developed a diagram to solve the problem each time. Diagrams developed were primarily schematic in nature going beyond simple diagrams. Overall, from the baseline average score to the Probe 3 score, all three students improved in performance for mixed word problem solving: S1 increased by 45.8% S2 by 43.7% and S3 by 35%.

An additional study of SBI was conducted by van Garderen, Scheuermann, and Jackson (2013) exploring its use with 95 elementary and middle school students in grades 4-7. Participants were classified into 3 groups: learning disability (n= 16), typically achieving (n = 53) and high achieving (n = 26). Students with disabilities were identified and classified based on their full scale score of 80 or more on the WISC-IV. The intervention measured student use of diagrams and problem solving performance. While this study has high potential for generalization due to number of participants, the failure to include students with learning disabilities who had math difficulties limited insight into its use with students with the greatest need. Results indicated that students with disabilities did not differ from their peers in terms of the average number of diagrams they used to solve the word problems. Results also indicated that students with disabilities did not use high quality schematic diagrams when solving problems. The results also suggest the use of better quality diagrams leads to increased performance in problem solving.

In Jitendra and DiPipi (2002), 4 eighth grade students with disabilities with a full scale IQ range from 89-103 were given schema-based word problem solving instruction through scripted lessons, strategy diagram sheets and practice problems. Students utilized the process to identify the problem type by drawing a picture (problem schemata) developing a plan (action), and setting up math sentences for single and multi-step problems prior to solving (strategy knowledge). Strengths of this study include description of the participants, description of the types of problems used in the intervention, and involving the teacher in the process of implementing the intervention. Despite the strengths, this study also had some limitations that include lack of generalization due to number of participants, use of only specific types of problems in the study, and instruction was individual instead of group. Results indicate that scores increased 25-60 points from pretreatment to post treatment for single and multistep problems and that students were able to maintain the skills they had been taught during the intervention.

In the study conducted by Fuchs et al. (2008), group tutoring was used to implement varying math interventions to 120 third grade classes of students at risk and not at risk for math failure. A combination of four instructional approaches known as schema broadening instruction (SBI) was used. Participants in the study were randomly assigned to one of two groups: (a) classroom control with 3 weeks researcher-designed general problem-solving strategies plus 13 weeks of teacher-designed conventional instruction or (b) classroom SBI with 3 weeks researcher-designed general problem-solving strategies plus 13 weeks of researcher-designed SBI. Students in each group, control and SBI, who were at risk for math failure were then randomly assigned to either a no tutoring or an SBI tutoring condition. Strengths of this study include generalization due to the number of participants, description of the intervention phases and description of participants. Despite the strengths this study also had some limitations which include the results do not report separately for students with disabilities and the classroom teachers were not involved in the implementation. The results indicated that teacher lead instruction was less effective than tutoring with validated classroom instruction. Results also indicated that preventive tutoring is necessary for at risk students.

Discussion

SBI studies have been conducted to examine its effectiveness with the use of several variations in each study. SBI is used with a multitude of concepts such as addition, subtraction, multiplication, division, fractions and algebra. Schema-based instruction has shown encouraging effects for low-achieving students and students with disabilities. Schematic diagrams are an essential component of this intervention. Students must understand how and why they should be used to help solve a problem. Each study conducted using SBI as an intervention yielded positive results making it an evidence- based practice.

Each intervention reviewed is useful to educators in providing students with strategies to become more successful at solving word problems. Students must learn to identify the link between problems modeled during instruction and those on an assessment (standardized or classroom) that may have additional distinctive parts. This link will assist them in applying knowledge to any situation given to them as a word problem. Teachers need to provide step by step instructions or guidelines for students to follow when applying a specific approach. Cueing and verbal prompts are helpful, but does not provide the same results as guided steps (i.e., strategy instruction). Computation is a small part in completing the multiple steps necessary to produce the final correct answer to a math problem.

Method

Setting and Participants

Setting. The study took place in a suburban high school (grades 9-12) with a population of 1,237 students. The school was located in a small city (N < 25,000) in the southeastern region of the United States. Demographics of the community consisted of 73.9% of residents being high school graduates or higher compared to 84.4% of the state (USCB, 2010). Seventy-six percent to the students receive free or reduced lunch which makes this school a Title I school. The demographic summary of the participating school is 35.4% Caucasian, 53.6% African American, 6.6% Hispanic, 1.2% Asian, .32% American Indian or Alaska Native and 2.8% of students are 2 or more races. Special education services are provided to 10% percent of the student population.

Participants. Four 9th grade students participated in this study. Students were chosen to receive the intervention based on the criteria (a) receiving special education services, (b) poor performance on the math section of state standardized test (i.e. -EOCT and CRCT) and (c) math deficits (i.e. math computation, math reasoning, application, number operations, and fluency) based on Wechsler Individual Achievement Test (WIAT) or Wechsler Intelligence Scale for Children (WISC) results.

“Brian”, a Caucasian boy who is 15 years old in the 9th grade, received special education services for Autism. He is served in co-teach classes for four classes in the general education setting (Math, Science, Social Studies, and English). “Brian” has a full scale IQ of 84 according to Wechsler Intelligence Scale for Children- Third Edition (WISC-III).

“Jessica”, a 15- year -old Caucasian girl also in the 9th grade received special education services for Specific Learning Disability for deficits in math calculations. She is served in co-teach classes for four classes in the general education setting (Math, Science, Social Studies, and English). “Jessica” has a full scale IQ of 102 according to Wechsler Intelligence Scale for Children- Third Edition (WISC-III).

“Kameron”, a 14- year- old African American boy also in the 9th grade received special education services for Autism. He is served in co-teach classes for four classes in the general education setting (Math, Science, Social Studies, and English). Kameron has a full scale IQ of 86 according to Wechsler Individual Achievement Test (WIAT).

“Rodney”, a 14- year- old African American boy also in the 9th grade received special education services for Other Health Impairment for Attention Deficit Hyperactivity Disorder (ADHD). He is served in co-teach classes for four classes in the general education setting (Math, Science, Social Studies, and English). Rodney has a full scale IQ of 81 according to Wechsler Intelligence Scale for Children- Third Edition (WISC-III).

Interventionist

The researcher in this study collected analyzed and maintained all data. The researcher held a Bachelor’s degree, a Master’s degree and is currently enrolled in an educational specialist degree program in special education. She had 8 years of teaching experience in the areas of other health impairments, emotional behavior disorder, intellectual disabilities, specific learning disabilities and autism.

Design

To observe the effects of Schema-based Instruction (SBI) on math word problem solving performance, the present study employed a single subject multiple baseline across participants design. The study was conducted during a 12 week period which began in August and concluded in November. This design was most appropriate for the number of participants and was used in similar studies of the intervention. To establish internal validity, baselines were established for each participant and intervention start times were staggered.

Intervention Description

Schema-based instruction involves focused instruction to help students recognize and understand the composition of a word problem (Maccini, Mulcahy, & Wilson, 2007). SBI is a two phase instructional approach: problem schemata instruction and problem solution instruction (Xin, et. al., 2005). SBI is implemented via scripted lessons, checklists, schematic diagrams, and student worksheets. During the first phase, students are taught to identify the problem type or structure and represent and solve the problem using a schematic diagram. In the second phase, participants used word (story) problems with unknown information to solve problems.

Implementation

The materials included practice problems and assessments for each phase of instruction, and note sheets with a problem solving strategy (see table 2 and 3). Participants in the study received the intervention 2 times a week for 40 minutes.

Baseline

For each baseline session, students were given one step and two- step word problems related to the content presented in their general education math class. For each baseline session, a different version of a word problem assessment was used (Jitendra, DiPipi & Jones 2002). Baseline data was collected for each student until stability was established. According to Alberto and Troutman (2003), baseline stability is obtained when data points vary not more than 50% from the mean for each participant in the study.

Intervention and Procedures

Parents of students who met the participant criteria were sent a packet of information (See Appendices A, B, C, and E) regarding the study to be conducted. After parental consent was received, the researcher reviewed the minor assent forms with participants and obtained signatures.

The procedures and measures in this study were modeled after word problem solving research the study conducted by Van Garderen (2007). For this study, a phase approach was used for intervention implementation. Phase 1: diagram generating instruction, in this phase of instruction the focus was the (a) purpose of a diagram, (b) why a diagram should be used to solve problems, (c) how to develop a diagram to solve problems, (d) how to use signs and codes to symbolize people or things (e) how to use a symbol or variable such as a question mark or x to specify what is unknown, and (f) the types of diagrams that can be created and when to use them for specific word problems. Phase 2: instruction for one step equations, in this phase students were introduced to a problem solving strategy. Phase 3: two step word problems solving instruction, in this phase students used the problem solving strategy to solve multiple step word problems. Students were also taught to determine the main goal of the problem. This information allowed students to determine vital parts of the final answer to the problem (van Garderen, 2007).

Measures and Data Collection

Data was collected based on the number of word problems solved correctly (problem solution) and the use of a quality schematic diagram to assist students in solving the problem (problem schemata). A quality schematic diagram would include a diagram that is a picture representing key parts of the problem with all parts labeled based on information given in the problem. Diagram quality criteria were *Excellent*- diagram is clearly related to problem and all parts are labeled, *Good*- diagram is related to problem and most parts are labeled, *Fair*- diagram is somewhat related to problem and some parts are labeled, and *Poor*- diagram is not related to problem and no parts are labeled.

During baseline and intervention, students received instruction for two types of word problems single step, and two-step problems. Each student worksheet had 5 of each type of problem. The problems were randomly selected from EOCT released test questions, study guides, math problem generating software, and other supplemental instruction resources. During baseline and intervention, worksheets and assessments were collected at the end of each 40 minute session. A word problem solving data collection checklist (See Appendix D) was completed for each participant after each session. This checklist indicated the number of word problems solved correctly and the quality of the diagram (% schematic) used to solve the problem. This allowed time for monitoring progress for each student.

Results

Figure 1 shows the percentage of word problems solved correctly for each participant across each phase of the intervention. After diagram generation instruction, participants still had difficulty understanding why and how to use a diagram. Once they had a better understanding of why to use a diagram they were able to generate them easily. During the intervention phase for one and two step equations, each participant created diagrams to assist in solving the word problem. Overall the quality of the diagrams created was fair, each diagram was related to the problem but participants did not label the parts of the diagram.

During baseline, “Jessica” averaged 30% correct for one and two-step equation word problems. During intervention, she averaged 70% correct for one step equation word problems and 60% correct for two step equation word problems giving her an increase of 40% for one step and 30% for two step equation word problems from baseline to intervention. For the second baseline, “Jessica” was able to maintain 70% for both one and two-step equation word problems.

During baseline, “Kameron” averaged 50% correct for one and two step equation word problems. During intervention, he averaged 20% correct for one step equation word problems and 50% correct for two step equation word problems giving him an decrease of 30% for one step and remained at 50% for two step equation word problems from baseline to intervention. For the second baseline, “Kameron” was able to maintain 50% for both one and two step equation word problems.

During baseline, “Rodney” averaged 50% correct for one step word problems and 27% correct for two-step equation word problems. During intervention, he averaged 50% correct for one step equations giving him no increase for one step equations and remaining at 50% and an increase of 23% for two step equation word problems from baseline to intervention. For the second baseline, “Rodney” was able to maintain 50% for both one and two step equation word problems.

Discussion

The purpose of this study was to determine if Schema-based instruction would increase math word problem solving performance in high school students with disabilities. This instruction allowed improvement in solving one and two-step equation word problems. Prior to this study, participants had never used a diagram to assist in solving a word problem. Participants reported that solving word problems was where they had the most difficulty in math class.

During baseline and intervention, participants received word problem solving instruction 1-2 times a week for 50 minutes. The results of this study provided evidence that Schema-based Instruction was effective in students with disabilities at the secondary level. Results also indicate that there was growth among each student in solving word problems. Overall, diagram generation and quality was fair and played a role in increasing word problem solving ability. “Jessica” seemed to benefit the most from the intervention. She had the largest growth and maintenance rate of all participants. “Kameron” and “Rodney” both generated diagrams to help them solve word problems during each phase, but they did not generate them at the same level as “Jessica.” When “Kameron” and “Rodney” generated diagrams, they did not label certain parts of the diagram that would have helped them solve the problem correctly. This indicates that diagram generation and quality is important in solving word problems. Each participant in the study demonstrated an increase in the ability to solve word problems using a diagram from baseline to intervention.

Limitations

Although there were positive results during the study, there were limitations that possibly affected the study. During the intervention, “Brian” withdrew from the study after the second phase (one step word problems) of the intervention due to a transfer to another school district. During this phase, he did not generate any diagrams to assist him in solving word problems.

Time was a major limitation during the course of this study. First, there were delays in choosing a group of students utilize as participants. The researcher’s teaching schedule did not allow for a resource class, which meant that students in a co-teach class had to be chosen for participation in the study. The researcher wanted to choose a class that would be receptive to participating in the study. Students did not return their consent forms in a timely manner despite follow up contact with parents. This caused additional delays at the beginning of the study.

During the study, other time constraints included the pace in which new material was being presented in the general education class. This caused sessions to be reduced due to participants in the study not understanding concepts being taught in class. The researcher tried to ensure that participants completely understood the concepts being taught in class and their grades would not be affected by participating in the study.

District, state, and unit testing also played a role in the number of sessions that were held. During the course of the study there were several district, state and national tests given such as benchmarks, GHSGT, and PSAT. Some of these testing sessions caused extended periods and the schedule did not allow for the researcher to meet with participants. Although the results of this study cannot be generalized to the population, Schema-based instruction can be utilized with a small group of students who struggle to solve one or two-step equation word problems.

Implications for Practice

There were suggestions that could be made for future teacher researchers that may attempt using this intervention. Although at the secondary level math resource rooms are limited, future studies with this population should be conducted in a resource class. Conducting a similar study in a resource room would allow the researcher more flexibility when collecting data for this intervention. Another suggestion would be to start as early as possible in the school year. This would possible reduce the interruption of sessions by district, state and national testing.

Future Research

High school aged students have often been excluded from this type of research. It is important that students with disabilities have interventions to address their needs and help them to become successful with curriculum in which they often have the most difficulty. The small sample size of this study contributes to the body of literature on this subject, but it is recommended that experimental research be conducted for generalization. Experimental research with this group would assist in developing successful interventions for students with math disabilities and difficulties at the secondary level.

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Table 1. Literature Review Matrix

Date/ Authors	Purpose	Students	Setting	Independent Variable	Dependent Variable	Data Collection	Design	Results
Alter (2012)	Used guiding questions	4 4th and 5th grade males w/EBD (MMD, ADHD, ODD and PTSD) (1 caucasian and 3 AA) IQ range 68-88	Alt. school for students with severe and profound emotional and behavioral disabilities	8 step problem solving process Token economy system for feedback and reinforcement Baseline 30 mins Intervention 60 mins 4 times per week	Percentage of problems completed correctly on daily work sheets Percentage of problems completed correctly on pretest-posttest measure Percentage of time on task	Completed math worksheets	Single subject multiple baseline	percentage of problems completed correctly increased for all 4 participants from baseline to intervention, The stability of performance in baseline data and the clear differentiation between baseline and intervention are suggestive of the effect of the intervention;

								however, there are only two data points in the intervention phase.
Alter, Brown & Pyle (2011)	Used guiding questions	3 AA 4th grade EBD students 2 Male and 1 female IQ range 67-101	Special ed resource room	strategies: Draw a picture, Guess and check and Make a Table or Chart problem structures are: (1) join, (2) separate, (3) part-part whole (4) compare problems. 15 min independent work sessions 5 problems	Percentage of mathematics word problems solved correctly The four criterion items were: (1) evidence of a clearly written problem-solving strategy (e.g. a picture drawn, a table or chart) (2) correctly found and labeled solution to	Percentage of time on-task was measured using real time observation and momentary time sampling in 30-second intervals for each participant across the 15-minute work session.	Single subject multiple baseline across participants	Baseline range 14-23% Intervention range 48-52%

					the problem (3) correct use or retrieval of basic facts or operation chosen (participant still gets a point if there is a computation error) (4) underlining the key mathematic vocabulary in the problem. On-task behavior. Students ‘on-task behavior’ was defined as each student having their eyes oriented toward their paper, and working			

					on the assigned mathematics word problems.			
Fuchs et al (2008)	examine students' mathematics problem-solving learning and to explore the prevalence of mathematics difficulty as a function of validated classroom prevention, as a function of small-group tutoring, and as a function of whether tutoring occurs with or without validated classroom	120 3rd grade classrooms at risk and non at risk students	General ed classroom	SBI Hot Math Classroom control with 3 weeks researcher-designed general problem-solving strategies + 13 weeks teacher-designed conventional instruction Classroom SBI with 3 weeks researcher-designed general problem-solving strategies + 13 weeks researcher-designed SBI	Math problem solving Math applications. The 60-item WJ III Applied Problems (Woodcock et al., 2001) measures skill in analyzing and solving	WJ III Applied Problems	Experimental random assignment Control and no control	scored higher on far than on near transfer at pretreatment because far transfer incorporated a greater variety of problem types, some of which were simpler than the problem types on near transfer. Of importance, tutoring was significantly and substantially more effective when it occurred in

	instruction								combination with validated classroom instruction than when the tutoring occurred with conventional classroom instruction
Jitendra, DiPipi & Jones 2002	Examine the effectiveness of schema strategy on solving mult and div word problems	4 8th graders with disabilities 2 boys 2 girls Full scale range from 89-103	General ed clsssroom with learning support for math	Schema strategy Id problem type by drawing a pic(problem schemata) Dev a plan (action) by setting up math sentences for single and multi step prior to solving (strategy knowledge) Used scripted lessons, strategy diagram sheets and practice problems 35-40 mins	Word problem tests Counted the # of problems answered correctly	Check lists Scored tests	Single subject multiple probe across participants	Baseline- mean # of correct problems was 41% Scores increased from ptrmt to potrmt for single and multistep 25-60pts 2 scores increased 30-70 pts for vary and 2 stayed the same. Scores increased for

								mult. Comparison 70 pts and multistep 70-90 pts
Krawec, J, (2013)	Determine the effects Student process knowledge after Solve it instruction 2 research questions: effects of Solve it instruction on middle school students' knowledge of math problem solving strategies Differential effects of Solve it instruction on students' knowledge	154 middle school students (7th and 8th grade) 77 swd 77 av. ach	General ed classroom	Solve it instruction Scripted lessons, 3 days of intensive instruction and 30 minute problem solving practice sessions once a week	Math problem solving assessment (mpsa)	Pretest/ postposttest	Experimental Treatement and comparison groups	Treatment students outperformed comparison students from pretest to posttest Students who received the intervention used more strategies on the MPSA than students who didn't.

	of math problem solving strategies as a function of ability							
Leh & Jitendra (2013)	Evaluate the effectiveness of CMI and TMI on word problem solving performance on students struggling in math.	25 3rd grade students (5 swd) scoring at or below the 50th percentile Selected based on total math score of the standford - 10 achievement test	General ed classroom	50 mins daily of supplemental TMI from Solving math word problems: teaching students with learning disabilities using schema based instruction curriculum 50 mins daily of CMI via Go Solve word problems computer program 3 review lessons and 4 lessons each of group or parts and total, change and compare/comparison Taught in the same sequence.	Researcher developed word problem solving test 16 problems represented the 3 taught types Correct number sentence Correct computations and labels in answers	pretest/posttest student scores from Pennsylvania System of School Assessment (PSSA)	Experimental with random assignment pretest/posttest	Comparable performance from both groups CMI is favored for SWD

Van Garderen (2007)	Examine the effectiveness of instruction focused on teaching SWD to solve 1 and 2 step word problems of varying types	3 8th grade SWD 2 male. 1 female Full Scale score 89-95	Resource room	3 phase instruction Generating diagrams Strategy for 1 step word problems 2 step word problems instruction	1. a mixture of eight one- and two step word problems (for baseline, probe, and maintenance conditions), 2. eight one-step word problems (for Phase 2), 3. eight two-step word problems (for Phase 3), and 4. five one-step word problems (for pretest—posttest; the same test was used both times). 5. eight "nonroutine" or complex,	All word problem tests were scored to evaluate (a) diagram use, (b) diagram form, and (c) student performance	Single subject multiple probe across participants	Use of diagrams to represent word problems After instruction 100% diagram generation Ability Primarily schematic after instruction Performance for solving word problems Baseline solving one- and two-step word problems was 37.6The average performance for the word

					authentic real-world word problems			problem tests ranged from 29-44%. Following strategy instruction for one-step word problems, on average, the students correctly answered 78.6%. Individual student ranges were 75-83%. Following strategy instruction for two-step word problems, on average, the students correctly answered 79.2%. Individual student ranges were

								75-83%. Overall, from the baseline average score to the Probe 3 score, all three students improved in performance: S1 increased by 45.8% S2 by 43.7% and S3 by 35%
Van Garderen, Scheuermann & Jackson (2013)	examine what both students with and without LD understand regarding diagrams and how they use diagrams as tools to solve mathematics word problems.	95 students in grade 4-7 Classified as learning disabled (LD), typically achieving (TA) and high achieving (HA) LD 16 TA 53	Gen ed classroom	Key Math 3 40-60 min sessions	Student use of diagrams and problem-solving performance was examined through a researcher-developed measure: Nonroutine Word Problem Assessment (NWPA).	Performance score # of times a diagram was used to solve problem Total # of pictorial and schematic diagrams generated by each student Ways diagrams were	Quasi experimental	students with LD did not differ from their peers in terms of the average number of diagrams they used to solve the word problems students with LD consistently lagged behind

		HA 26 SWD full scale score 80 or more on WISC-IV				used to solve word problems		their peers in both the frequency of the ways in which they used diagrams as a strategy and, more important, in the quality of their diagram use when solving mathematical word problems LD group had a poorer definition of what a diagram is when compared with their peers. Even more disconcerting, however, were the low scores across all students

								for their reasons to use a diagram.
Witzel (2005)	Compare student achievement in solving linear algebraic functions across two procedural approaches: multisensory algebra model and usa CRA instructional model.	231 6th and 7th graders 182 general ed students 49 SLD students in math.	General ed classroom	CRA model for solving for variables with multiple coefficients, fractions and exponents. (linear functions) Treatment group received instruction through multi sensory approach	# of correct answers out of 27 possible on an algebra assessment	Pre test Post test Follow up	Quasi-experimental Pre-post follow up with random assignment of clusters	Treatment and comparison group showed improvement from pretest to post test Abstract group out performed multisensory group on the pretest but the multisensory group outperformed the abstract group on the post test. Multisensory benefited students w high math achmnt

Xin, Jitendra & Buchman (2005)	Examine the effects of schema based instruction and general strategy instruction	22 Students with learning problems (18 LD , 1 Serious Emotional Disturbed, 3 not labeled) Grades 6-8 11 males 11 females 7 Caucasian 12 Hispanic 3 African American	General ed classroom	Schema based instruction 3-4 times a week 12 sessions 2 phase instruction problem schemata(id problem type/structure and represent problem using schematic diagram) and problem solution (story problems w/unknown info) GSI 3-4 times a week for 12 sessions Read to understand, develop a plan, solve and look back	Percentage correct on word problem solving performance	4 parallel word problems containing 16 one step multiplication and division word problems Proportion problems	Pretest-posttest comparison group design with random assignment of subjects Pretest posttest follow-up	SBI group performed better than GSI group SBI students were able to transfer learned skills to new tasks

Table 2. Problem Solving Steps

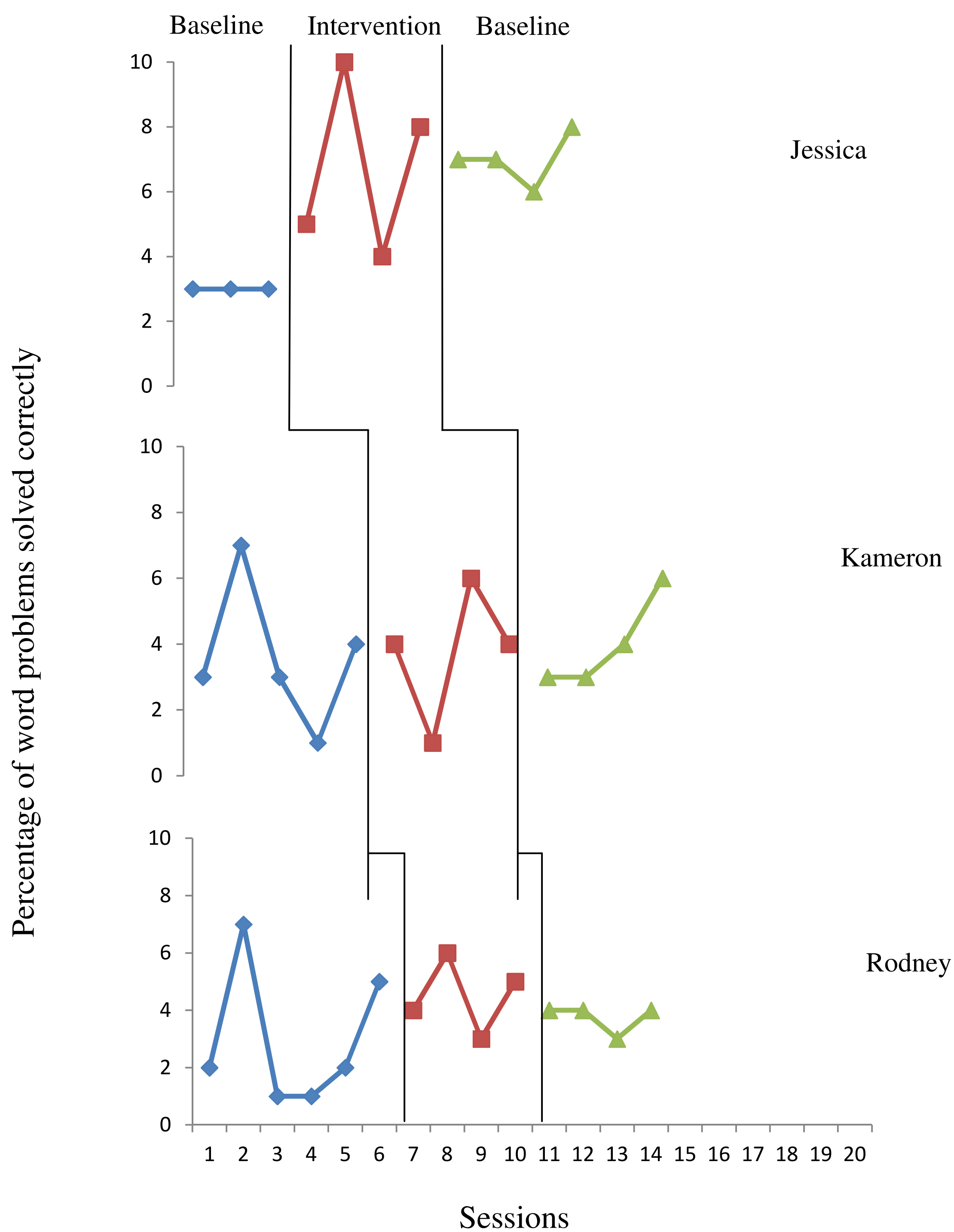
1. Read the problem aloud
2. Rephrase
   a. Give important information
   b. Repeat question aloud
   c. What is being asked? What am I looking for?
3. Think
   a. Draw a diagram
4. State the problem
   a. I have… I want to find….
5. Hypothesize
   a. If I ….then….
   b. How many steps will be needed?
6. Approximate
   a. Round the Numbers
7. Calculate
   a. Label
   b. Circle
8. Self- Check
   a. Check each step
   b. Check answer
   c. Does the answer make sense?

Table 3. Visualize strategy steps

SAY:		READ to understand the problem.
ASK:		"Do I understand the problem?" If not, reread the problem.
CHECK:		For understanding as I solve the problem.
SAY:		VISUALIZE the problem.
	STEP 1:	DRAW: Ask: "What type of diagram should I draw?"
		Draw a diagram of what I know and a symbol for what I do not know.
		Check to see if the diagram is drawn correct.
	STEP 2:	ARRANGE: Ask: "Does my diagram show how the parts of the problem are related?"
		Re-Arrange the diagram if needed.
		Check to make sure that the diagram is a match for what is being asked in the problem.
SAY:		PLAN how will the problem get solved.
ASK:		"What operations and how many steps are needed to solve the problem?"
CHECK:		Using my diagram, that my plan makes sense.
SAY:		CALCULATE the answer.
ASK:		"Did I calculate the correct answer?"
CHECK:		That all the operations were completed in the right order.
SAY:		CHECK the solution.
ASK:		"Does my solution make sense?"
CHECK:		That everything is right. If not, go back. Then ask for help if I need it.

Figure 1

Graphed Participant Data



Appendix A

August, 2014

Dear Parent/Guardian:

Your child ______________________________________ is a student in my _____ period __________________________class. I am currently enrolled at Georgia College and State University as an Education Specialist student. As part of my degree requirements I have to conduct research on an intervention. The intervention I chose to research is Schema-based Instruction (SBI). Schema based instruction involves focused instruction to help students recognize and understand the composition or make up of a word problem. I chose to research this intervention due to items on the math portions of standardized test such as the EOCT, (now Georgia Milestone Assessment) being written as a word problem. Students with disabilities are often the lowest performing students on these types of test. SBI has been proven to increase word problem solving in students with disabilities. As part of the study your child will potentially participate in, he/she will be asked to solve content related word problems using strategies and techniques learned in the intervention stage of the study.

Enclosed you will find 2 copies of a Parent Consent Form requiring your signature, 1 copy of the Minor Assent Form which is what your child will sign upon receiving consent from you and a copy of the Principal Consent Form so that you know I have permission to conduct this study at Griffin High School. If you grant your child permission to participate, please review, sign, and return one copy of the Parent Consent Form. Please keep the other copy for your records. If you require additional information regarding this study, please contact me by phone at (770) 229-3752 between the hours of 11:45am to 1:15 pm or by email at tamika.james@gscs.org.

Respectfully,

Tamika C. James, MPA
Teacher, Griffin High School

Appendix B

Parent/Guardian Consent Form

I give permission for my child, _________________________, to be a participant in the research titled **The Effects of Schema-based Instruction on Word Problem Solving in Students with Disabilities**, which is being conducted by Tamika James, who can be reached at 770-229-3752. I understand this participation is entirely voluntary; I can withdraw my consent at any time and have the results of the participation returned to me, removed from the research records, or destroyed.

The following points have been explained to me:

1. The purpose of this study is to determine if integrating Schema-based Instruction in the math curriculum will improve math achievement and if there is an impact on solving word problems.
2. The procedures are as follows: My child will be asked to participate in integrated lessons and complete/solve word problems three times per week. My child will also participate in a weekly assessment. My child's name will not appear on the data sheet; therefore the information gathered will be completely confidential. I will be asked to sign two of these consent forms. One form will be returned to the investigator and the other consent form will be kept for my record.
3. No physical, psychological, social or legal risks exist in this study.
4. The results of this participation will be anonymous and will not be released in any individually identifiable form without my prior consent unless required by law.
5. The investigator will answer any further questions about the research (see above phone numbers).
6. In addition to the above, further information, including a full explanation of the purpose of this research, will be provided at the completion of the research, if you request it.

____

Signature of Investigator   Date

____

Signature of Parent or Guardian   Date
(If participant is less than 18 years of age)

****

Research at Georgia College & State University involving human participants is carried out under the oversight of the Institutional Review Board. Questions or problems regarding these activities should be addressed to Mr. Marc Cardinalli, Director of Legal Affairs,
CBX 041, GCSU, (478) 445-2037.

Appendix C

IRB Minor Assent Form

I, ____, agree to participate in the research “Effects of Schema-based Instruction on Word Problem Solving of Students with Disabilities” which is being conducted by Tamika James, who can be reached at 770-229-3752. I understand that my participation is voluntary; I can stop at any time. If I withdraw my consent, my data will not be used as part of the study and will be destroyed.

The following points have been explained to me:

1. I will be asked to solve word problems before and after the intervention starts and finishes and three times a week during math instruction. I will also be asked to participate in Schema-based instruction 3 times a week.
2. My name will not be on the data collection sheet.
3. I will be asked to sign two identical consent forms. One form must be returned to my teacher before the study begins, and I can keep the other consent form.
4. If I become uncomfortable answering any questions, I can stop participating at that time.
5. I am not putting myself in any more physical, psychological, social, or legal danger than I would ordinarily encounter in daily life or during the performance of routine examinations or tests.
6. My information will be kept secret, and no one will know that the answers or results are mine, unless I tell them.
7. If I have any questions about this research, I can ask my teacher at any time.
8. If I want to know more about the research, I can ask my teacher for more information.

____

Signature of Investigator   Date

____

Signature of Minor Participant   Date

Research at Georgia College & State University involving human participants is carried out under the oversight of the Institutional Review Board. Address questions or problems regarding these activities to Mr. Marc Cardinalli, Director of Legal Affairs, CBX 041, GCSU, (478) 445-2037

Appendix D

Schema – based Instruction
Word Problem Solving Data Collection Check List

Student # ______

Problem #	# Correct		Diagram Quality			
	Full	Partial	Excellent	Good	Fair	Poor

% Correct (# correct/total) _____________

% Schematic (# exc + good/total) ____________

Diagram Quality

Excellent- diagram is clearly related to problem and all parts are labeled
Good- diagram is related to problem and most parts are labeled
Fair- diagram is somewhat related to problem and some parts are labeled
Poor- diagram is not related to problem and no parts are labeled

Appendix E

Griffin High School

1617 West Poplar Street • Griffin, Georgia 30224
Phone: (770) 229-3752 • Fax: (770) 467-4644
website: www.griffinhighschool.org

Est. 1953

Keith Simmons
Principal

The Academies of Griffin High School

Consumer Science Academy
Fine Arts Academy
Freshman Academy
STEM Academy

June 10, 2014

Keith Simmons, Principal
Griffin High School
1617 West Poplar Street
Griffin, GA 30224

To Whom It May Concern:

It is my understanding that Tamika James will be conducting a research study at Griffin High School on "The Effects of Schema-based Instruction on Word Problem Solving in High School Students with Disabilities."

Ms. James has informed me of the design of this study, as well as the target population. I further understand the purpose of this study is to provide students with disabilities a proven strategy to increase word problem solving performance and math achievement.

I understand the data obtained during the course of this study will be utilized for classroom purposes only and will not be disseminated publicly in any form. I further understand that all student participant information will be kept confidential. As a result, I fully support this effort and will provide any assistance necessary to ensure the successful implementation of this study.

If you have any questions, please do not hesitate to contact me. I may be reached at (770) 227-3752 or at keith.simmons@gscs.org

Sincerely,

Keith Simmons, Principal
Griffin High School

Thematic Academies at Griffin High School will prepare students to compete globally at post-secondary options.

Appendix F

Name _________________________________ Date____________________

Schema-based Instruction Assessment

1. Last Friday Adam had $22.33. Over the weekend he received some money for cleaning the attic. He now has $32. How much money did he receive?

2. ¼ of the total bird population in your town is 200 birds. How many birds are there in your town?

3. A used book costs $17 less than the same book new. The used book costs $9. How much is the cost of a new book?

4. Lone Star Supply company bought a computer system with a color monitor for $1,598. If the color monitor cost $699, how much did the rest of the system cost?

5. Jennifer made a deposit of $150 for soccer camp. Her unpaid balance was $300. What was the fee for soccer camp?

6. On Tuesday Shanice bought five hats. On Wednesday half of all the hats that she had were destroyed. On Thursday there were only 17 left. How many did she have on Monday?

7. Jill sold half of her comic books and then bought sixteen more. She now has 36. With how many did she begin?

8. Aliyah had some candy to give to her four children. She first took ten pieces for herself and then evenly divided the rest among her children. Each child received two pieces. With how many pieces did she start?

9. Chelsea was going to sell all of her stamp collection to buy a video game. After selling half of them she changed her mind. She then bought seven more. How many did she start with if she now has 24?

10. Oceanside Bike Rental Shop charges a 14 dollar fixed fee plus 8 dollars an hour for renting a bike. Keith paid 54 dollars to rent a bike. How many hours did he pay to have the bike checked out ?

Appendix G

Name__________________________________ Date_______________ Period _______

Algebra Word Problems

1. Moe Tell starts washing dishes at the Greasy Spoon Café. Fifteen minutes later Fran Tick joins Moe, and both wash until all the dishes are done. Moe washes 9 dishes per minute and Fran washes 16 dishes per minute. How long did it take Moe and Fran to finish the dishes?

2. Jamal is decorating a ballroom ceiling with garland. If the rectangular ceiling is 15 meters by 8 meters, how much garland will Jamal need to reach from one corner of the ceiling to the opposite corner?

3. Clara bought 0.9 pounds of peanuts and 0.87 pounds of raisins. How many pounds of snacks did she buy in all?

4. A group of 3 children and 3 adults are going to the zoo. Child tickets cost $8, and adult tickets cost $10. How much will the zoo tickets cost in all?

5. Jason sold half of his comic books and then bought 7 more. He now has 18. How many did he begin with ?

6. Melanie spent half of her allowance going to the movies. She washed the family car and earned 7 dollars. What is her weekly allowance if she ended with 18 dollars ?

7. Enrico paid $4.75 for a sandwich, a drink, and frozen yogurt. He remembered that the drink and the yogurt were each $1.15 and that the sandwich had too much mustard, but he forgot the price of the sandwich. How much did the sandwich cost?

8. The Audio Outlet purchased 60 cassette recorders, gave away three in a contest, and sold the rest at twice their purchase price. If the store's total profit was $1188, how much did the store sell each recorder for?

9. Aliyah had $24 to spend on seven pencils. After buying them she had $10. How much did each pencil cost?

10. Maria bought seven boxes. A week later half of all her boxes were destroyed in a fire. There are now only 22 boxes left. With how many did she start?