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Implementing Schema-Based Instruction in the Elementary Classroom (Project)

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in the Elementary Classroom
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Abstract

Solving mathematical word problems is an ongoing problem for students with both reading and math learning disabilities (Powell, 2011). As more and more students with learning disabilities are included in the general education classroom, teachers must differentiate instruction to benefit all learners. The current strategies emphasized in textbooks are misleading and too general for students who struggle (Jitendra, 2008). Schema-based instruction is an alternative problem solving strategy, which requires students to identify the underlying structure (schema) which each word problem belongs, to translate important information to a diagram, and then to solve the problem. This project uses cognitive theory as a theoretical framework and analyzes the effects of schema-based instruction on students with learning disabilities and their general education peers. Enhancement materials for implementing schema-based instruction were created so that teachers in a small, urban, parochial school could meet the mathematical needs of a diverse population of students. The key features of the enhancement materials include descriptions of each schema, directions for delivering explicit instruction, example and practice word problems, and student reference materials/manipulatives.

Keywords: learning disabilities, schema-based instruction, word problem solving

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Chapter One: Introduction

Problem Statement

Students with both reading and math learning disabilities struggle to solve word problems in mathematics. In order to accurately solve word problems, a student must employ a multitude of cognitive skills, ranging from decoding the words and understanding the question, to creating a number sentence and accurately completing the necessary computation. According to Powell (2011), "Many students with LD struggle with mathematics and reading difficulty; therefore, embedding mathematics within a linguistic context may challenge students who also have reading deficits" (p. 95). Currently, most textbooks teach word problem solving through general strategy instruction (GSI), which instructs students to utilize the steps "Understand, Plan, Solve, and Check". However, the steps in this model are too general for students who struggle with mathematics (Jitendra & Starr, 2011). Many students, both with LD and without, will not even attempt to understand the problem. Instead, they skip directly to computing the numbers without checking their answers for meaning (Kajamies, Vauras, & Kinnunen, 2010).

Importance and Rationale of the Project

Students' ability to solve word problems accurately is important both for school success as well as functioning in society. Since the No Child Left Behind Act of 2001, schools have placed a major emphasis on state standardized assessments. The National Council of Teachers of Mathematics Research Committee (2013) announced that the Smarter Balance Assessment is projected to be released in the 2014-2015 school year, and is aiming to assess students' ability to solve complex problems and use critical thinking. These assessments will be based on The *Common Core State Standards for Mathematics,* which include standards for mathematical practice. In order to do well on these assessments, students must be able to make sense of problems and persevere in solving them, reason abstractly and quantitatively, model with mathematics, and use appropriate tools strategically (National Council of Teachers of Mathematics Research Committee, 2013). According to the National Governors Association for Best Practices and Council of Chief State School Officers (2010), teachers will need to adjust the traditional problem solving techniques they are using in the classroom to accommodate an increase in expectations for *all* students.

More and more schools have begun adopting an inclusion model, which ensures that students with LD are instructed in the general education classroom. As a result, classroom teachers must meet the needs of a more diverse group of learners (Kunsch, Jitendra, & Sood, 2007). Van de Walle, Karp, Lovin, and Bay-Williams (2014) reminded teachers that “each student has specific learning needs, and strategies that worked for one student may not work for another” (p. 74). Encouraging students to use different strategies or take different “roads” in problem solving is important to increase their ability to access the essential information within a lesson (Van de Walle et al., 2014). While all students need to be exposed to multiple ways to solve word problems, studies indicate that students with LD benefit from explicit instruction, visual representation, and a sequence of examples (Zheng, Flynn, & Swanson, 2012). Schema-based instruction (SBI) uses all three of these strategies to help improve mathematical problem-solving (Jitendra & Star, 2011).

Meeting the needs of diverse learners is not an easy task and can easily make teachers feel overwhelmed. Ross-Hill (2009) acknowledged that the lack of hands-on training and practice “has brought on stress, tension, and strain for both teachers and students alike in inclusive settings” (p.189). If they feel overwhelmed, the classroom teachers may look to the special education teacher or aide to be able to supplement the curriculum with pull-out resources.

While students benefit from small group tutoring, they will be more likely to retain the information if they are presented with it during whole class instruction as well. According to Powell (2011), “Students who received two tiers of schema-broadening instruction (whole class and small group tutoring) significantly outperformed students who received schema-broadening tutoring without whole class schema-broadening instruction” (p.104). Teachers will need resources to envision how to incorporate schema-based intervention in conjunction with their current curriculum.

Background of the Project

Students’ difficulty solving mathematical word problems has been an ongoing issue; however, interventions focused on solving word problems continue to change over time. Historically, strategies for teaching problem solving have included identifying key words, drawing a diagram, using a mnemonic device, utilizing computer assisted instruction, and learning metacognitive strategies to self-monitor the problem solving process (Powell, 2011). According to Van de Walle (2001), “Problem solving has been the focus of school mathematics for more than two decades” (p. 7). Over the past twenty years, Jitendra and colleagues have developed a strategy for problem solving called schema-based instruction. Unlike the other instructional methods, while using schema-based instruction, students must first identify a word problem as belonging to a problem type, and then use a specific problem type schema to solve the problem (Powell, 2011). Schema-broadening instruction was also developed in response to schema-based instruction. It uses all of the same principles, but emphasizes transferring knowledge to novel problems (Fuchs et al., 2010).

Statement of Purpose

The purpose of this project is to increase students' ability to solve word problems, by creating enrichment materials to implement schema-based instruction in the general education classroom. These enrichment materials include: (a) a scope and sequence, (b) schema descriptions and example problems, (c) directions for explicit instruction, (d) overhead cue cards for teacher presentation, (e) several practice problems for modeling and student practice, and (f) sorting activities. Each of these resources will focus on using teacher scaffolding, along with questioning, visual representations and strategy cues.

Students who struggle to understand word problems, especially those with LD, will be given an alternative strategy to solve them. By providing schema-based instruction to the whole class, the teacher will ensure that every student has received research validated core instruction. After using these enrichment materials with the whole class, the teacher will be better equipped to provide schema-based instruction as an intervention, more intensively, to small-groups of students. This project will be focused on students in second through fifth-grade and will address addition, subtraction, multiplication, and division problems.

Objectives of the Project:

- Teachers will be able to meet the mathematical learning needs of a diverse population of students in the general education setting.
- Students will increase their ability to accurately solve word problems. CCSS.MATH.PRACTICE.MP1
- Teachers will have enrichment materials and detailed instructions for implementing schema-based instruction, in conjunction with the current curriculum.
- Students will understand the underlying structure of word problems and sort them into types (schemas). CCSS.MATH.PRACTICE.MP4

- Students will be able to solve novel word problems, given real life situations.

  CCSS.MATH.PRACTICE.MP2

Definition of Terms

Explicit Instruction: "A structured systematic, and effective methodology for teaching academic skills" (Archer & Hughes, 2011, p. 1)

General Strategy Instruction (GSI): Based on Polya's four-step problem-solving model and involves the use of multiple strategies (Griffin & Jitendra, 2008).

Learning Disabilities (LD): Children with specific learning disabilities have average or above average intelligence, but one or more of their information processing systems do not work efficiently, making academic work challenging (Deiner, 2013, p.180).

Manipulatives: Concrete objects that are used to help make concepts visual, concrete, and connected to other ideas that students have learned (Van de Walle, 2014, p.24).

Scaffolding: "Providing support, structure, and guidance during instruction promotes academic success and systematic fading of this support encourages students to become more independent learners" (Archer & Hughes, 2011, p. 5)

Schema: "refers to a generalized description of a word-problem type that requires similar solution methods"(Fuchs et al., 2010, p. 441). The schema is the framework, or outline of the problem. Students can use schema's to organize and solve word problems (Powell, 2011).

Schema-Based Instruction (SBI): Teaches students to use schematic diagrams to solve word problems (Powell, 2011). The four steps are identification of the problem schema, representation of the problem using a schematic diagram, planning and writing the math sentence equation, and finding the solution by carrying out the plan (Griffin & Jitendra, 2008).

Schema-Broadening Instruction: Differs from schema-based instruction because students are taught to transfer their knowledge of problem types to recognize problems with novel features (Powell, 2011).

Scope of the Project

This project will systematically and explicitly expose students in second through fifth-grade to schema-based instruction, in order to improve their word problem solving accuracy. Teachers will be provided with the materials necessary to successfully implement schema-based instruction without changing their school-wide curriculum. The scope and sequence of these enrichment materials will align with Saxon Math Curriculum, although will be able to be adapted to fit others if needed.

This project is intended to increase students' exposure to an alternative approach to solving problems in the second through fifth-grades in the general education classroom. Students with LD as well as others who struggle with math or reading, will most likely require additional, more intensive, schema-based interventions, to allow for more practice and corrective feedback. This project will not replace the current curriculum, and students will not be required to implement one problem solving approach over another.

Chapter Two: Literature Review

Introduction

Students with LD continue to struggle with mathematical word problems. In order to successfully complete a word problem, a student must engage multiple cognitive skills. Attention, active memory, reading decoding, and reading comprehension are necessary along with math problem solving and computation skills. The general strategy instruction that is utilized in most text books for solving word problems is too general for students who have Learning Disabilities. The textbook suggests that the student complete four steps, including: (a) understand the problem, (b) devise a plan, (c) solve the problem, and (d) go back to check your answer for meaning (Griffin & Jitendra, 2008). Rather than trying to understand the problem, many students simply look for two numbers, complete the computation, and do not check back for meaning (Kajamies et al., 2010). Students need to be able to solve word problems in order to do well on standardized tests and function in their day-to-day life (Jitendra, Hoff, & Beck, 1999).

To address the difficulty that students with LD have when solving mathematical word problems, this literature review looks closely at Piaget's cognitive theory, specifically schema theory. Many researchers have used Piaget's schema theory to inform their development of strategies for word problem solving. This literature review will critically analyze meta-analyses, which survey current word problem solving strategies, as well as research studies focused on schema-based instruction with students with LD, schema-based instruction in inclusive settings, and schema-broadening instruction.

Theory/Rationale

In order for a strategy to be effective for helping students solve word problems, it must be based on what we know about how a child learns. Jean Piaget, one of the first and leading psychologists in the study of cognitive development, came up with a cognitive theory that has greatly shaped education. Piaget's cognitive theory involves the use of schemata, which are the basic building blocks of intelligent behavior used to organize knowledge (McLeod, 2009). Piaget (1952) defined a schema as "a cohesive, repeatable action sequence possessing component actions that are tightly interconnected and governed by a core meaning" (p. 7). These mental representations of the world are stored in a child's memory and can be applied to a new situation when needed. Piaget's word for using an existing schema to deal with a new object or situation is called "assimilation" (McLeod, 2009).

Piaget's schema theory can also be applied to word problem solving strategies in mathematics. Understanding that word problems have different underlying structures, or types, is an important step towards understanding how to solve them. If students are able to develop schemata for the different types of word problems, then they will be able to recognize the underlying structure of the problem and will know how to attempt to solve it (Powell, 2011). Without using a schema to organize the word problems, students will approach every word problem as if it is novel.

Research/Evaluation

Many strategies have been developed to aid students in their attempt to solve mathematical word problems. When trying to understand word problems, many teachers instruct their students to look for key words. However, according to Van de Walle (2007), keywords can be very misleading and "send a terribly wrong message about doing math" (p. 152). Most textbooks which use General Strategy Instruction provide suggestions for what students should do when devising a plan, such as, draw a picture, create a diagram, guess and check, or make a list (Griffin & Jitendra, 2008). Despite the prevalence of these strategies, students with LD continue to struggle solving word problems. The literature referenced below highlights schema-based instruction as a means for teaching students to use schemata as a guide to solving word problems. First, a framework for using schema-based problem solving strategies will be shared using the meta-analyses by Kroesbergen and Van Luit (2003), Zheng, Flynn, and Swanson (2012), and Powell (2011).

Meta analyses. In typical classrooms, students who struggle with mathematics, especially those with special needs, are offered extra support through specific math interventions. There has been much debate about the effectiveness of the various interventions available for these students. According to Kroesbergen and Van Luit (2003), students with difficulties learning math, share a set of general characteristics. This list includes memory deficits as well as, "inadequate use of strategies for solving math tasks, caused by problems with the acquisition and the application of both cognitive and metacognitive strategies" (p. 97).

In their meta-analysis, Kroesbergen and Van Luit (2003) investigated what makes a particular mathematics intervention effective for students with all types of math difficulties. They only included empirical studies that were published between 1985 and 2000. The studies had to be concerned with elementary mathematics. They were also required to report on an intervention, on children with mathematical difficulties, and on the systematic use of instructional strategies. The last criterion was that they had to have used a between-subjects or within-subjects control condition. Total they analyzed 58 studies. The results of their meta-analysis indicated that problem solving interventions aimed at students with mild mental retardation were more effective than those for children with learning disabilities. Interventions for those with mixed difficulties were the least effective of all. Interventions involving peer-tutoring and computer-assisted instruction were less effective than other intervention methods for problem solving. Although computers can be used to motivate students, it is vital that a teacher is conducting the intervention, to provide instruction and feedback. While it is generally considered a good strategy to let students work together, Kroesbergen and Van Luit (2003) suggest that this is not an effective strategy with students with special needs.

Zheng, Flynn, and Swanson (2012) also analyzed the intervention studies related to math problem solving. Their meta-analysis focused on intervention studies from 1986 to 2009. In order to be included in the meta-analysis, studies had to be pretest-posttest control group studies that included school-age participants with math disabilities (identified with a norm referenced test). Studies were also required to include interventions focused on mathematical word problem solving, to provide enough quantitative information to allow for the calculation of effect sizes, and to be written in English and published in peer-reviewed journals. Zheng and colleagues (2012), acknowledged the fact that reading is an integral part of solving word problems. Thus, they focused on the specific characteristics of students with math disabilities, which include the students' IQ and reading levels, and whether or not they had comorbid disabilities (math + reading problems vs. math-only problems). The results from their analysis indicated that the outcomes for students with math disabilities only, vary greatly compared to those with math disabilities and reading disabilities, favoring the math-only group. According to Zheng et al. (2012), "studies yielding high effect scores used the following components: sequencing, explicit practice, task reduction, advanced organizers, questioning, task difficulty control, elaboration, skill modeling, strategy cues, and small-group instruction" (p. 105).

While both of the above mentioned analyses look at all problem-solving interventions in general, Powell (2011) explored studies related only to schema-based instruction. To be used in her analysis, Powell required that studies incorporate explicit instruction on solving a word problem through a schema, have participants in the second or third grade, include students at-risk for or with LD, and be published in a peer reviewed journal. According to Powell (2011), "instruction using schemas differs from typical word-problem instruction (e.g. key words, checklist of steps) because students first identify a word problem as belonging to a problem *type* and then use a specific problem-type *schema* to solve the problem" (p. 95). The two approaches to schema instruction that Powell identified in the literature, were *schema-based instruction* and *schema-broadening instruction*. In schema-based instruction, students are taught to read the word problem and then select a schema diagram that it reflects. The student then uses the diagram to solve the word problem. According to Jitendra (2008), "Schema-based instruction integrates mathematical problem solving and reading comprehension strategies to improve students' problem-solving performance" (p. 24). Schema-broadening instruction also integrates mathematical problem solving and reading comprehension, but in addition explicitly teaches students to transfer their knowledge to novel problems which may include different formats, irrelevant information, or information presented in charts (Powell, 2011). Powell (2011) found that both sets of studies validated using schemas to solve word problems if the teaching is explicit, organized (using diagrams or equations), and focused on one word-problem schema at a time. Students must be given several opportunities to practice both sorting and solving equations, and the practice sessions should occur multiple times each week. Powell (2011) also emphasized that students with LD benefited from schema instruction offered as whole-class instruction, small-group tutoring, and individual tutoring. However, the combination of both whole-class and small-group tutoring seemed to benefit students with LD the most.

Schema-based instruction with students with LD. For the past two decades, Asha K. Jitendra has been leading the research on schema-based instruction with students with learning disabilities. In 1996, she, along with Kathryn Hoff, conducted a study on three students with learning disabilities from a northeastern private elementary school (Jitendra & Hoff 1996). The students were taught how to solve *change, group,* and *compare* one-step addition and subtraction word problems. A *change* problem involve situations where the initial quantity is usually given and then an action causes either an increase or a decrease in that quantity. A *group* problem involves several smaller groups combining to form a larger group (part-part-whole problems). A *compare* problem emphasizes the relationship between two distinct sets (Jitendra & Star, 2011). These word problem schemata were taught in 40 to 45 minute sessions, in which students read the story problems, mapped them onto appropriate schemata diagrams, and then solved them. Instruction included demonstration, modeling, and frequent student exchanges. Students continued to work on one schema until they proved mastery. The students also completed a maintenance probe at the end of two weeks to see how well they had retained their knowledge of schemas.

The results of this study indicated that all three students improved in their ability to solve word problems Subject One yielded a score of 73% correct on the first maintenance probe and 62% on the second one. Subject Two scored 80% on the first and 93% on the second. Subject Three scored 73% on the first and 87% on the second. All three students said that they would recommend this strategy to a friend. On a scale of one to five, with five indicating the most useful strategy, they scored it 4.5, 4.5, and 4.6 (Jitendra & Hoff 1996).

This study by Jitendra, Hoff, and Beck (1996), demonstrated that using schema-based instruction can help students with learning disabilities solve word problems. Many students with learning disabilities struggle with poor memory. This strategy provides a framework for them to organize information without depending on their memory so much.

In 1999, Jitendra, Hoff, and Beck conducted a similar study of four sixth- and seventh-grade students with learning disabilities, in a public school. Students were instructed in both one-step and two-step word problems. Along with the 4 students with learning disabilities, Jitendra and colleagues (1999) included 21 normally achieving third-grade students, for testing only. This group of students served as a normative reference because the majority of instruction in addition and subtraction word problems occurs at the third grade level. The same procedures utilized in the 1996 study, were used for implementing this intervention. Students were first taught to distinguish the unique features of each story problem, and then schemata diagrams were provided. Once students displayed their knowledge of the schemata, they advanced to being able to recognize them within word problems. The instruction for two-step word problems focused on using backward chaining procedure. Students were taught to identify the overall problem schema and then work backward.

Consistent with the findings of the 1996 study of third-graders, Jitendra et al. (1999) discovered that all four students improved in their ability solve word problems. The average correctly answered one-step and two-step word problems for the four middle school students with learning disabilities was 58%, with an increase of 26% from the baseline. For the third graders, their average was 60%, with an increase of 24% from the baseline. All four students with learning disabilities proved that they maintained their gains. These findings support Jitendra and Hoff’s 1996 research conducted on elementary students.

Jitendra (2008) explained that several important features are needed in order to implement schema-based instruction effectively. Teachers must scaffold their directions, the presentation of problems from story situations to word problems, and the amount of visual cues they provide. Teachers must also model how to use schematic diagrams and common rules, and how to analyzing solutions. Students will need a strategy checklist in order to anchor their learning, as well as opportunity to use think-alouds to reflect on their understanding of the problem. Lastly, adequate practice is necessary, with a mixed review of problem types. According to Jitendra (2008), the primary goals of schema-based instruction (SBI) are “problem comprehension development and the integration of concepts and procedures” (p.21).

Yan Ping Xin, a professor at Purdue University, also conducted research about implementing schema-based instruction. Xin (2008) sought to examine the effects of using “a schema-based instructional strategy that emphasized prealgebraic conceptualization of multiplicative relations on solving arithmetic word problems with elementary students with learning disabilities” (p. 526). Xin argued that prealgebraic thinking is important for all elementary students, including those with learning disabilities.

Xin’s (2008) research study included four fifth-grade students with LD or at risk for failure in mathematics. The intervention focused on *equal group* problems and *multiplicative compare* problems. Students were taught to transfer the information presented in the word problem to a mathematical sentence/equation. During assessments, students could receive a point for getting the correct answer, as well as a point for setting up the number sentence correctly. This study used the same steps that are involved in schema-based instruction, but after the students organized the information using a diagram, they transferred that information into an equation. During the initial phase of Xin’s intervention, there were no unknown quantities in the story situations, students were simply required to focus on setting up the appropriate equation. In phase two, the students used the letter “a” to signify the unknown quantity.

Xin (2008) found that all the participants increased in their ability to solve word problems. On the *equal group* problems, three participants scored 100% and one scored 83% correct. On the *multiplicative compare* problems, all participants scored 83%. The maintenance test results indicated average scores of 72%, 67%, 67%, and 78% correct. Xin argued that this data supports other studies that show that students with learning difficulties benefit from direct, explicit, instruction despite the fact that this type of instruction “may seem at odds with constructivism or learner-centered classrooms, which are at the heart of mathematics education reform” (p. 544).

Schema-based instruction in inclusive settings. Many children with learning disabilities are included in general education classrooms. Classroom teachers are constantly looking for ways to reach all children and to make the content accessible to all the students in their classrooms. While much of the research on schema-based instruction has been focused on students with learning disabilities in pull-out or exclusive settings, Griffin and Jitendra (2008) sought to expand the research to include students in an inclusive third-grade class.

Rather than only looking at the improvements with students with learning disability, Griffin and Jitendra (2008) investigated the effect of SBI, as compared to GSI, for all of the students. Sixty third grade students in an elementary school in the southeastern United States participated in the experiment. Students in the SBI group used worksheets, schematic diagrams, posters, and word problem-solving checklists. During the SBI intervention, students completed the problem schema and problem-solution phases. They used a four-step instructional procedure called FOPS (Find the problem type, Organize the information in the problem using the diagram, Plan to solve the problem, Solve the problem), to anchor their learning (Griffin & Jitendra, 2008). According to the researchers, supports were gradually faded. The SBI instruction focused on one and two-step word problems including the schemata *change*, *group*, and *compare*.

During the GSI intervention, students used worksheets, posters of the problem-solving steps, and manipulatives. According to Griffin and Jitendra (2008), these students solved word problems using Polya's model: "(a) read and understand the problem, (b) plan to solve the problem, (c)solve the problem, and (d) look back or check" (p. 195). Teachers asked students questions to help them understand. Then the teachers taught the students strategies designed to help plan and solve the problem, such as, use objects, act it out, or draw a diagram.

Griffin and Jitendra (2008) found that there was not a significant difference between the benefits of the SBI and GSI group. Students in both groups improved their word problem-solving from pretest to posttest, and maintained these results 12 weeks later. These findings indicate that direct word problem-solving strategies are beneficial for all students. Griffin and Jitendra (2008) suggested that "As public schools move from traditional service delivery models to more inclusive education in which students of varying abilities are taught in one classroom, it is important for educators and researchers to ascertain whether all students are benefiting from instruction" (p. 198).

More recently, Jitendra and Star (2011) wrote an article in which they addressed the role of schema-based instruction in inclusive mathematics classrooms. Based on their previous research with students with learning disabilities, they argue that schema-based instruction should serve as an "alternative to traditional instruction for enhancing the mathematical problem solving" (p. 12).

The authors claim that students with learning disabilities need interventions that address the deficits that these students experience (Jitendra & Star, 2011). Schema-based instruction provides visual representation, explicit instruction, student think-alouds, and consistent feedback, which benefit students with challenges in the areas of attention, memory, language processes, and self-regulation, among other things. Whereas other strategies may be too general for students with learning disabilities, schema-based instruction "teaches a small but adequate number of strategies to scaffold student learning" (Jitendra & Star, 2011, p. 15).

Schema-broadening instruction. Piaget's schema theory has also influenced other variations of schema-based instruction for word problem-solving. Schema-broadening instruction, was developed by Fuchs et al. (2008), and uses many of the same important features as Jitendra et al. (2007). Schema-broadening instruction adds a fourth step to schema-based instruction, in which students are explicitly taught to transfer their problem-solving skills. Fuches et al. (2008) identified that students were having trouble transferring their knowledge of the different schemata to word problems that included irrelevant information, an extra step, or information in charts and graphs.

Fuchs et al. (2008) designed an experiment to investigate whether schema-broadening instruction was a good strategy for a secondary (e.g., tier two, or more intense intervention with a smaller teacher-to-student ratio) preventative tutoring protocol. This experiment included 42 third-grade students with math and reading difficulties. The tutoring sessions were 20 to 30 minutes in duration and included two weeks of teaching prerequisite foundational skills, three weeks of teaching for each problem type, with cumulative review of the previous problem types, and one week of reviewing all three problem types (Fuchs et al., 2008).

According to Fuchs et al. (2008), "Students were explicitly taught to be aware of, find, and cross out irrelevant information" (p. 166). They were also taught to be aware of situations that could make the problem appear unfamiliar. These tutoring sessions included practice sorting problems, daily review, and reinforcement with a token system.

After the 12-week intervention period, the results of the experiment were examined. Fuchs et al. (2008) found that the third-grade students who received the preventative tutoring, improved significantly more than their peers that remained in the general education program. The findings of this experiment support earlier findings that schema-based strategy instruction is useful with all students, rather than only students with math disabilities (Jitendra et al., 1998).

More recently, Fuchs et al. (2010), conducted a study to explore the effects of schema-broadening instruction on second graders' word problem solving performance and their ability to represent word problems with algebraic equations. Similar to Xin's (2008) findings with four fifth-graders, Fuchs et al. (2010) recognized the importance of teaching algebraic reasoning in conjunction with arithmetic reasoning.

For their experiment, Fuchs et al. (2010) included 270 second-grade students in southeastern urban school districts in the United States. The control group was given general strategy instruction, while the intervention group was given schema-broadening instruction. Students in the intervention group also learned the overarching equation for the three problem types and the RUN strategy "Read the problem, Underline the question, Name the problem type" (Fuchs et al., 2010, p. 447). Students were also taught to identify and circle the relevant information. The results from this study indicated that the students who received schema-broadening instruction performed reliably better than the control students (Fuchs, et al., 2010).

Summary

Word problem-solving is an ongoing challenge for students with learning disabilities. Rather than setting up the problem for computation, word-problems imbed the mathematical concepts in a literary context (Fuchs et al., 2008)**.** This makes solving word problems a challenge for students with both reading and math difficulties. Being able to solve word problems requires a student to retrieve information from their long term memory and hold information in their active working memory. In order to alleviate the load of the memory, typical word problem-solving strategies have focused on finding keywords, or using Polya's four-step model (Understand, Plan, Solve, Check). Previous research indicates that keywords can be misleading and the four-step model is too general for students that struggle (Jitendra, 2008).

Piaget studied the origin of intelligence in children and developed a cognitive theory to explain how they learn new information. He believed that children function using basic building blocks of intelligence called schema (McLeod, 2009). These schemata guide a child's behaviors as they come across new information. *Assimilation* occurs when a child uses their current schema to understand a new situation. When the new information requires that the child change their existing schema, *accommodation* is needed.

In the past two decades, Jitendra et al. (1996; 1998; 1999; 2007; 2011) have developed an instructional method for word problem solving, called schema-based instruction. Students are taught to identify word problems as belonging to a particular type, or schema. After identifying the type of problem, students translate the important information into a diagram. Students then use the diagram to solve the problem. Several studies have proved that schema-based instruction is an effective intervention for students with both reading and math difficulties (Powell, 2011). Griffin and Jitendra (2008), and more recently, Jitendra and Star (2011), studied the effects of schema-based instruction in an inclusive setting. The results from both studies indicated that schema-based instruction should serve as an “alternative to traditional instruction for enhancing the mathematical problem solving” (Jitendra & Star, 2011, p. 12). Other researchers have added important elements to schema-based instruction. According to Xin (2008), schema-based instruction can also be used effectively to increase students’ prealgebraic thinking. In his study, students were taught to translate the important information into an equation before solving. Schema-broadening instruction is another strategy that utilizes all three steps of schema-based instruction. Fuchs et al. (2008) contributed an additional step of explicitly teaching students to transfer their knowledge of schemas to novel word problems. The studies on schema-broadening instruction also prove to be effective for improving students’ ability to solve word problems. According to Fuchs et al. (2008), schema broadening instruction was most effective when implemented during whole class instruction as well as small group tutoring.

Conclusions

Word problems present a challenge for many students, especially those who have learning disabilities. According to Piaget’s cognitive theory, children organize their knowledge around schemata, the “basic building blocks of intelligent behavior” (McLeod, 2009). Using Piaget’s cognitive theory, Jitendra et al. (1998) developed schema-based instruction. Schema-based instruction is different than other word problem solving strategies in that it requires students to identify the type, or schema, each problem belongs to before solving the problems.

This literature review has examined the research on schema-based instruction both exclusively with students with learning disabilities and in inclusive settings. The positive results from these studies indicate that utilizing schema-based instruction in a whole class setting as well as a small group setting will greatly benefit students (Fuchs et al., 2008). As education reform continues to push inclusion, teachers need to have access to strategies that work with a diverse population of learners. The project description that follows will outline schema-based enhancement materials that teachers can use alongside their current classroom curriculum.

Chapter 3: The Project Description

Introduction

Students with both reading and math learning disabilities struggle to solve word problems in mathematics. Solving word problems requires many cognitive skills including memory, attention, decoding, reading comprehension, and math computation. The problem solving strategies described in textbooks do not break down the process specifically enough for students who have learning disabilities (Jitendra & Star, 2011). Many students, both with LD and without, will not even attempt to understand the problem. Instead, they skip directly to computing the numbers without checking their answers for meaning (Kajamies et al., 2010). As teachers prepare their classrooms to include more students with diverse learning needs, they must teach multiple strategies. According to Van de Walle et al. (2014), “each student has specific learning needs and strategies that worked for one student may not work for another” (p. 74).

The purpose of this project is to enable teachers in the general education setting to meet the mathematical learning needs of an academically diverse population of students. By providing enrichment materials and detailed instructions to teachers, which they will be able to implement schema-based instruction in conjunction with the current curriculum. Schema-based instruction will increase students’ ability to solve word problems by helping them understand the underlying structure (schema) of each word problem (Jitendra & Star, 2011). Students will also learn to solve novel word problems, given real life situations.

The enrichment materials will be described in this section starting with the components of the created materials. An explanation for how to implement this project will follow. The implementation explanation will cover how the materials will be used, necessary procedures, and practical suggestions. Following that, an evaluation tool will be offered, and a conclusion presented.

Project Components

The enrichment materials, designed for second through fifth-grade teachers to implement schema-based instruction in their classrooms include schema descriptions, example and practice problems, sorting activities, directions for explicit instruction, and cue cards. These enrichment materials were created specifically for teachers in a small, urban, parochial school, with the purpose of providing an alternative word problem strategy that benefits students with LD in the general education setting. The scope and sequence of these enrichment materials aligns with Saxon Math curriculum (Hake, 2008), but can be adapted to fit others if needed.

The components of the enrichment materials were designed with an understanding of effective teaching strategies for students with LD. The materials are schema-based and emphasize explicit instruction, visual displays, repeated practice, and corrective feedback. Fortunately, students who do not struggle with LD also benefit from this type of instruction and enrichment (Fuchs et al., 2010). Therefore, this more specific strategy instruction can be an alternative to general strategies presently found in textbooks. The descriptions, directions for explicit instruction, and practice problems clearly explain how to implement schema-based instruction alongside Saxon Math curriculum. The student manipulatives and reference materials allow teachers to scaffold students' learning.

To develop the enrichment materials, educational research and theory were explored to determine which math word problem solving strategies are effective for students with learning disabilities. The literature, previously cited in this paper, strongly supports the use of schema-based instruction with students with LD, both exclusively and in inclusive settings. The research also indicates that schema-based instruction is most effective when implemented both in a whole class *and* in a small group setting (Powell, 2011). Based on these findings, the enrichment materials were created to be used in the whole-class setting, but also as a resource to provide further practice in a small group setting.

The first component of the enrichment materials is the teacher packet (see Appendix A), which includes a description of each schema, a sorting activity, a scope and sequence, directions for explicit instruction, and cue cards. The descriptions of the schemata will provide teachers with the foundational knowledge necessary to teach schema-based instruction. Descriptions include example word problems and demonstrate how specific types of problems belong to each schema. Following these descriptions, teachers will be provided with a sorting exercise to practice identifying each schema themselves. In order for teachers to see *when* they will teach each new schema in conjunction with Saxon Math curriculum, a scope and sequence is included. The last component of the teacher packet is instruction for how to explicitly instruct students using cue cards for presentation. Although teachers may not be comfortable with explicitly teaching *all* math concepts, it is important that each schema is introduced and reinforced in an explicit way.

In addition to the teacher packet are the student materials (see Appendix B), which include practice problems for each schema type, sorting activities, and mixed-review practice problems. It is vital that students practice each schema, one at a time, until mastery is achieved. Each new schema that is taught includes a cumulative review of the previously learned schemata. Students also will receive blank diagrams that coordinate with each schema. They will practice filling in these diagrams before creating their own. Finally, students will be provided with posters that highlight the problem solving steps to serve as an anchor to their learning.

Project Evaluation

To evaluate the effectiveness of these enrichment materials, students' test scores will be compared to the scores of students who attended the school in the previous year and did not receive schema-based instruction alongside the Saxon Math curriculum. The school, in which this project will be implemented, currently administers AIMSweb assessments three times a year. The Math Concepts and Applications test includes many word problems. This test is given in the Fall, Winter, and Spring.

For the purpose of evaluating the effectiveness of the enrichment materials, the students' average growth from Fall to Spring on the Math Concepts and Applications test will be compared to the average growth of students who attended the school during the previous academic year and were taught without the enrichment materials. Both groups of students being compared include students with LD. The student scores will be accessible online in order to make the comparison. The materials will be considered effective if the average growth is higher for those who were taught with the materials than for those who were not.

Additionally, the teachers will take a survey (see Appendix C), to gain their perception of the materials and their experience implementing them. The teachers' perception regarding the materials' convenience, completeness, and effectiveness will be taken into account as edits are made in following years.

Project Conclusions

Solving mathematical word problems is an ongoing problem for students with both reading and math learning disabilities. Many students lack the necessary cognitive skills to be able to accurately solve a word problem. According to Kroesbergen and Van Luit (2003), students with difficulties learning math, share a set of general characteristics. This list includes memory deficits as well as "inadequate use of strategies for solving math tasks, caused by problems with the acquisition and the application of both cognitive and metacognitive strategies" (p. 97). Currently, most textbooks teach word problem solving through general strategy instruction, which instructs students to utilize the steps "Understand, Plan, Solve, and Check". However, the steps in this model are too general for students who struggle with mathematics (Jitendra & Star, 2011). Many students, both with LD and without, will not even attempt to understand the problem. Instead, they skip directly to computing the numbers without checking their answers for meaning (Kajamies et al., 2010).

There has been much research done on word problem solving strategies for students with LD and those without. While other strategies have been found effective, the research overwhelmingly supports schema-based instruction. Jitendra and Hoff (1996) found that schema-based instruction as a small group intervention was an effective strategy for three elementary students with LD. Schema-based instruction as a small group intervention was also found effective for sixth- and seventh-grade students with LD (Jitendra, Hoff, & Beck, 1999). Jitendra and Griffin (2008) expanded the research to include students in an inclusive setting. Their results indicated that schema-based instruction and general strategy instruction contributed to students' improvement in word problem solving. Fuchs et al. (2008) studied the effect of using schema-broadening instruction (i.e., schema-based instruction including explicitly teaching students to transfer). They found that schema-broadening instruction was effective as preventative tutoring for students with math and reading difficulties. Schema-based instruction was also found to improve students' prealgebraic understanding (Xin, 2008; Fuches et al. 2010).

Based on the research results, schema-based instruction offered to the whole class and in small groups, is an effective strategy for students who struggle with word problem solving. For this project, enrichment materials were compiled that implement schema-based instruction alongside the current curriculum, in general education classrooms. These materials include both teacher and student materials that facilitate mastery of the schema-based approach to problem solving. Based on previously cited research, it is expected that by implementing these enrichment materials, both students with learning disabilities and their peers will be able to solve word problems with greater accuracy.

Plans for Implementation

The enrichment materials will be implemented in the first- through fifth-grade classrooms at a small, urban, parochial school. The teachers of these grades will receive the teacher packet at a staff in-service in the Fall of 2016. The packet will be discussed and any misconceptions regarding each schema will be addressed. Teachers will be given the sorting activity while they are in the in-service, to ensure that they are able to identify each schema. A short presentation which reviews necessary elements of explicit instruction will be given after the sorting activity. During the in-service, a model schema-based lesson will be demonstrated so that teachers can visualize what it will look like in their classrooms. After the teachers are provided professional development, they will begin implementing schema-based instruction in accordance with the scope and sequence provided. During periodic staff meetings throughout the year, the teachers will share which things have been effective and how the implementation process is going.

When the school year has ended, teachers will analyze student scores and the project will be evaluated. After evaluation, the materials will be revised for use for the next school year. If these materials are proven effective for increasing students' ability to solve word problems, the will be shared with other parochial schools in the area. Additionally, the results will be documented and shared with Christian Schools International.

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Appendix A:

Teacher Packet

Includes:

Schema descriptions, diagrams, and examples problems

Sorting Activity

Scope and Sequence

Explicit Instruction Description

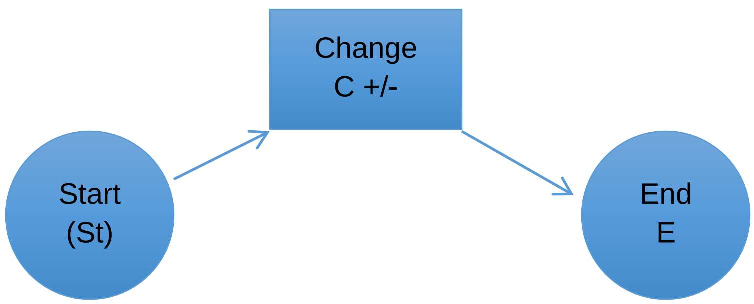
Cue Cards for Instruction

Schema Descriptions

Each word problem has an underlying structure that describes the relationship between its quantities. That structure is referred to as a schema. Below you will find a list of the 5 most frequently used schema in addition, subtraction, multiplication, and division word problems. Familiarize yourself with each structure so that you can sort word problems into the schema when you come across them in your textbook. A diagram for equations and example problems are included to deepen your understanding. Remember in each schema one or more of the quantities can be the unknown.

Change Word Problems

Change word problems involve a starting quantity that undergoes a direct or implied action, causing either an increase or decrease of a starting quantity to result in a new quantity. The three pieces of information in a change problem are the beginning, change, and ending quantity. "Some, Some More" and "Some, Some Went Away" problems both fit in this schema.



End Unknown:

1. Phillip had 15 baseball cards. Carlos gave him 5 more. How many baseball cards does Phillip have altogether?
2. Cali had 20 lollipops. She gave 5 of them to Maria. How many lollipops does Cali have now?

Change Unknown:

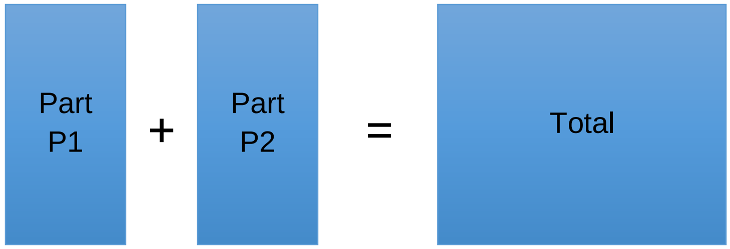
1. Phillip had 15 baseball cards. Carlos gave him some more. Now Phillip has 20 baseball cards. How many baseball cards did Carlos give to Phillip?
2. Cali had 20 lollipops. She gave some of her lollipops to Maria. Now Cali has 15 lollipops. How many baseball cards did Cali give to Maria?

Start Unknown:

1. Phillip had some baseball cards. Carlos gave him 5 more and now he has 20 baseball cards. How many baseball cards did Phillip begin with?
2. Cali had some lollipops. She gave 5 of them to Maria. Now Cali has 15 lollipops. How many lollipops did she begin with?

Total Word Problems

Total problems involve a number of distinct smaller groups that combine to form a new larger group. You may have heard these "Part-Part-Whole" problems in your textbook. The pieces of information in a total problem are each of the distinct parts and the total.



Total Unknown:

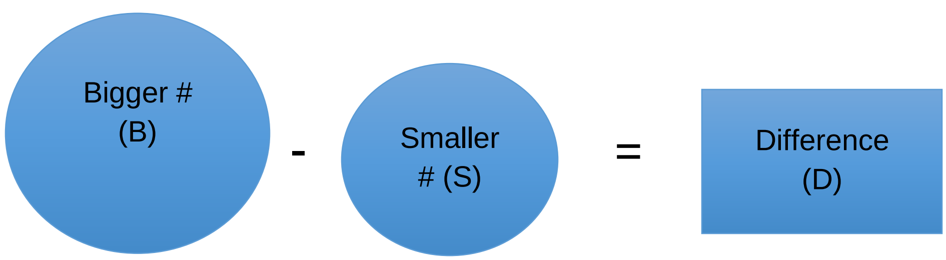
1. Phillip has 15 pencils and Cali has 5 pencils. They put their pencils in one bag to share. How many pencils did they put in the bag?
2. Phillip has 15 pencils and 5 pens. How many writing utensils does Phillip have?

Part Unknown:

1. Phillip and Cali put 20 pencils in a bag. Phillip put in 15 pencils. How many pencils did Cali put in?
2. Phillip has 20 writing utensils (pens and pencils). 15 of the writing utensils are pencils. How many are pens?

Compare Word Problems

Compare problems involve the comparison of two separate sets and emphasize the relationship between them. This type of problem has also been referred to as a "difference" problem. The three pieces of information in a compare problem are the compared, referent, and difference sets.



Difference Unknown:

1. Phillip has 20 stickers and Cali has 15 stickers. How many more stickers does Phillip have than Cali?
2. Phillip has 20 stickers and Cali has 15 stickers. How many fewer stickers does Cali have than Philip?

Bigger Quantity Unknown:

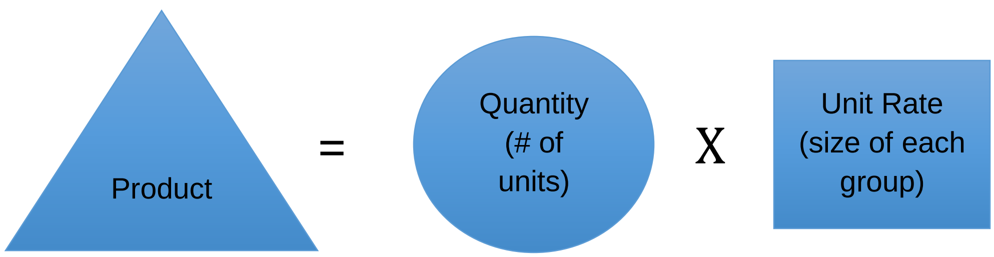
1. Phillip has 5 more stickers than Cali. Cali has 15 stickers. How many stickers does Phillip have?
2. Cali has 5 fewer stickers than Phillip. Cali has 15 stickers. How many stickers does Phillip have?

Smaller Quantity Unknown:

1. Cali has 5 fewer stickers than Phillip. Phillip has 20 stickers. How many stickers does Cali have?
2. Phillip has 5 more stickers than Cali. Phillip has 20 stickers. How many stickers does Cali have?

Equal Groups Word Problems:

Equal Groups problems describe a number of equal sets or units. The three pieces of information in an equal groups problem are the unit rate, number of units, and the product.



Product Unknown:

1. Phillip has 5 bags of cookies. There are 3 cookies in each bag. How many cookies does Phillip have altogether?
2. Each cookie cost 2 dollars. How much money did Phillip pay for 15 cookies?
3. Phillip walked to the store to buy the cookies. It took him 3 hours. If he walked at 5 miles per hour, how far did Phillip walk?

Unit Rate Unknown:

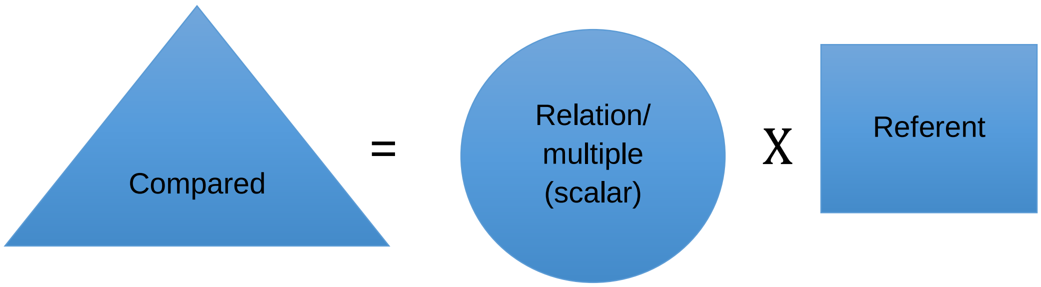
1. Phillip wants to give his 15 cookies to 5 friends. How many cookies will each friend get?
2. Phillip paid 30 dollars for the 15 cookies. How much did each cookie cost?
3. Phillip walked 15 miles in 3 hours. How many miles per hour did he walk?

Number of Units Unknown:

1. Phillip had 15 cookies. He put them into bags of 3 cookies each. How many bags did Phillip use?
2. Phillip spent 30 dollars at the store. He used his money to buy cookies that were 2 dollars each. How many cookies did Phillip buy?
3. Phillip walked 15 miles at a rate of 5 miles per hour. How many hours did Phillip walk?

Multiplicative Compare Word Problems

Multiplicative Compare problems compare two quantities. This problem type is similar to the additive compare problem, except that it describes one quantity as a multiple or part (the scalar) of the other quantity. The three pieces of information in a Multiplicative Compare problem are the compared set, referent set, and the scalar.



Compared Unknown:

1. Phillip ate 3 pieces of candy. Cali ate 4 times as much candy as Phillip ate. How much candy did Cali eat?
2. This week Phillip walked 3 times as far as he walked last week. Last week Phillip walked 4 miles. How far did Phillip walk this week?

Referent Unknown:

1. Cali ate 12 pieces of candy. She ate 4 times as much candy as Phillip. How many pieces of candy did Phillip eat?
2. This week Phillip walked 3 times as far as he walked last week. This week Phillip walked 12 miles. How many miles did Phillip walk last week?

Scalar Unknown:

1. Phillip ate 3 pieces of candy and Cali at 12 pieces of candy. How many times as much candy did Cali eat than Phillip?
2. This week Phillip walked 12 miles. Last week he only walked 4 miles. How many times more miles did he walk this week than last?

Sorting Activity

Label each word problem as a Change, Total, Compare, Equal Groups, or Multiplicative Compare problem.

1. Jamal left his house and ran for 20 minutes before he took a break. After his break he ran for another 15 minutes before he got home. How many minutes did Jamal run? __________

2. Charlotte and her two best friends decided to have a lemonade sale. They made $10 selling cups of lemonade for 25 cents each. How many cups of lemonade did they sell _________

3. Tasha bet that she could eat 5 times as many Hot Cheetos as Montrel. If Montrel ate 5 ounces of Hot Cheetos, How many ounces would Tasha need to eat in order to win the bet? ________

4. Christopher and his sister were collecting seashells at the beach. Christopher collected 15 and his sister collected 6 more than he did. How many shells did Christopher's sister collect? _________

5. Anya was practicing shooting free throws in her back yard. She took 50 shots and made 35 of them. How many free throws did Anya miss? ________

6. Felix was bird watching for his first time while he was at camp. He noticed a tree with several birds in it. At first glance Felix counted 10 birds in the tree. While he was watching 6 of the birds flew away. How many birds remained in the tree? __________

7. Shandra was preparing for her 8th birthday party. She knew she wanted to invite 20 guests and that she wanted to give them each a goody bag at the end of the party. If Shandra's mom bought her 100 pieces of candy to go in the bags, how many pieces should Shandra put in each bag? ________

8. In the garden there were 15 tomato plants and 12 pepper plants. How many more tomato plants are there than pepper plants?

9. Carl counted his Halloween candy and he had 25 tootsie rolls. Donte gave Carl all of his tootsie rolls as well. Now Carl has 40 tootsie rolls. How many tootsie rolls did Carl give Donte?

10. At the beginning of the year Michel was only able to complete 10 subtraction problems in a minute on his fact test. Now he is able to complete 50. How many times more problems is Michel able to complete now than he was able to at the beginning of the year?

Answers: 1:Total, 2:Equal Groups, 3: Multiplicative Compare, 4: Compare, 5: Total, 6: Change, 7: Equal Groups, 8: Compare, 9: Change, 10: Multiplicative Compare

Scope and Sequence

Grade	Saxon	Schema	Timeframe
2nd	Begin around Lesson 22 *(Draws pictures and to model and solve addition and subtraction problems)*	-Introduce *"Change"* schema by modeling diagram. -Teach problem-solving: ending unknown, beginning unknown, change unknown, mixed-review -Test for mastery of *"Change"* schema and provide remediation -Introduce *"Total"* schema and model using diagram -Teach problem-solving: Total unknown, part unknown, mixed-review -Test for mastery of *"Total"* schema and provide remediation. -Practice sorting problems into *"Total"* and *"Change"* problems. Practice problem solving, mixed-review -Teach problems with extraneous information (charts, tables, graphs, and non-relevant info) -Comprehensive assessment.	2 weeks 5 weeks 2 weeks 2 weeks 4 weeks 1 week 2 weeks 2 weeks 1 week
3rd	Begin around Lesson 6 + 7 *(Solves addition and subtraction equations using concrete and pictorial models)*	-Pre-assessment on "Change" and "Total" word problems. Identify students who will need remediation during review. -Review "Change" schema -Review Total schema -Practice sorting and solving mixed review problems, and dealing with extraneous information -Test for mastery of "Total" and "Change" problems -Introduce Compare schema and model using diagram. -Teach problem solving: Difference unknown, Compared set unknown, Referent set unknown, mixed review	1 week 1 week 1 weeks 2 weeks 1 week 1 weeks 3 weeks

	         Begin “Equal Groups” around Lesson 84 *(Solves multiplication and division equations using concrete and pictorial models)*	-Test for mastery of “Compare” problems and provide remediation. -Sort problems into all 3 schemas. Solve mixed review problems. -Test for mastery of all 3 addition/subtraction schema (Change, Total, and Compare) and provide remediation. -Introduce Equal Groups Schema and model using the diagram. -Teach problem solving: Product unknown -Test for mastery of Equal Groups Schema and provide remediation -Practice sorting problems into all previously learned schema -Comprehensive assessment of mixed review word problems	1 week 2 weeks 1 week 2 weeks 4 weeks 2 weeks 2 weeks 1 week
4th	Begin at Lesson 1 + 25 *(Solves addition and subtraction equations using concrete and pictorial models)* Begin around Lesson 52 *(solves multiplication and division equations using concrete and pictorial models)*	-Pre-assessment (Total, Change, Compare, Equal Groups) identify students for remediation during review -Review Total, Change, & Compare schema -Mixed addition and subtraction problem solving practice. -Review “Equal Groups” schema model and solving problems with the product unknown -Teach how to solve problems with the unit rate and number of units unknown. Provide mixed practice. -Teach “Equal Groups” problems with extraneous information (charts, graphs, tables, irrelevant info) -Test for mastery of “Equal Groups” schema and provide remediation.	1 week 3 weeks 1 week 3 weeks 3 weeks 3 weeks 2 weeks
5th	Begin around Lesson 10	-Pre-assessment on Total, Compare, Change, and Equal Groups schema. Identify students for remediation.	1 week

	(Writes and solves equations to solve word problems)	-Review Equal Groups schema, mixed practice -Introduce Multiplicative Compare schema and model using the diagram. -Teach problem solving: Compared unknown, Referent Unknown, Scalar unknown, Mixed Review -Teach Multiplicative Compare problems with extraneous information (charts, graphs, tables, irrelevant info) -Test mastery of Multiplicative Compare schema and provide remediation. -Sort problems into Equal Groups and Multiplicative Compare, provide mixed review practice -Comprehensive assessment -Continue remediation throughout the course until mastery is indicated.	2 weeks 2 weeks 4 weeks 3 weeks 2 weeks 3 weeks 1 week
6th	Begin around Lesson 23 *(Applies proportional relationships such as similarity, scaling, and rates)*	-Pre-assessment (Change, Total, Compare, Equal Groups, Multiplicative Compare) identify students for remediation throughout review. -Review Equal Groups and Multiplicative Compare schema, provide mixed practice -Continue remediation as necessary; introduce multi-step word problems for advanced students.	1 week 4 weeks 3 weeks

Explicit Instruction

Schema-based instruction for word problem solving must be explicit. As each new schema is introduced, teachers should follow the guidelines below:

1. Opening:
    a. Gain the students attention:
    b. Preview
        i. State the goal of the lesson:
        ii. Discuss the relevance of the schema:
    c. Review
        i. Review critical prerequisite skills
2. Body:
    a. Modeling (I do it.)
        i. Describe the schema and demonstrate how to use the diagram
        ii. Be Clear, Consistent, and Concise
        iii. Require frequent responses from students
    b. Prompted or guided practice (We do it.)
        i. Tell the students what to do, then Ask them what to do, then Remind them what to do.
        ii. Provide physical, verbal, and visual prompts and gradually fade them.
    c. Unprompted practice (You do it.)
        i. Check for high levels of understanding
        ii. Provide immediate affirmative and corrective feedback
3. Closing:
    a. Review the schema
    b. Assign independent work
    c. Monitor initial practice attempts

Archer, A., & Hughes, C.A. (2011). *Explicit instruction: Effective and efficient teaching.* New York, NY: The Guilford Press.

Cue Cards

Use the cue cards below to introduce each new schema and for student reference.

Cue Card 1

<u>Word Problem Types</u>

There are many types of word problems.

The first step to solving a word problem is to decide which type of word problem it is.

Cue Card 2

“Change” Problems

A change problem has a starting number, a change that takes place, and an ending number.

The change in some problems is an **increase:**

Ex: John had 6 apples and picked 3 more. Now John has 9 apples.

In other problems the change is a **decrease:**

Ex: John had 6 apples and he ate 3 of them. Now John has 3 apples.

Cue Card 3

“Total” Problems

A total problem has two or more parts that make up a whole or larger part.

Ex: Carly has 5 best friends that are girls and 3 best friends that are boys. Carly has 8 best friends.

Cue Card 4

“Compare” Problems

A compare problem has a bigger and a smaller number that are being compared to find the difference between them.

Sometimes we want to know “how many more”

Ex: Jose has 7 stickers and Chris has 4. Jose has 3 more stickers than Chris.

Sometimes we want to know “how many fewer”

Ex: Jose has 7 stickers and Chris has 4. Chris has 3 fewer stickers than Jose.

Cue Card 5

“Equal Group” Problems

An equal group problem has a total number of items split equally between a set number of groups.

Ex: Taren had 20 pieces of candy, which she put into 4 bags. She put 5 pieces of candy in each bag.

Cue Card 6

“Multiplicative Compare” Problems

In a multiplicative compare problem there is a larger and a smaller number that are being compared. The larger number is a multiple of the smaller number.

Ex: Brenda is 4 years old and Rob is 12 years old. Rob is 3 times older than Brenda.

Appendix B:

Student Materials

Includes:

Diagrams of each schema

Practice Problems

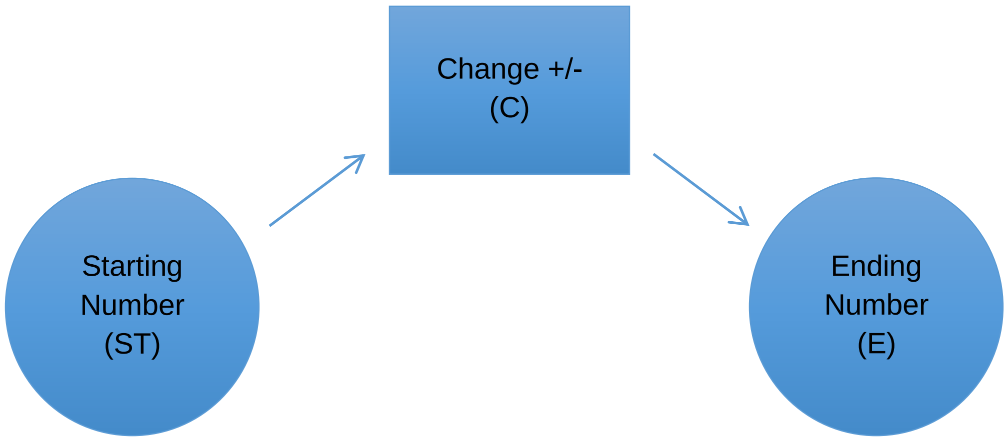
Review Quizzes

Sorting Activities

Blank Diagram Sheets

"Change" Problems

Diagram



Example: Johanna's dog had 8 puppies. Johanna sold 5 of the puppies. She has 3 puppies left to sell.

Practice Problems

Directions - Label each part of the problem (St, C, and E). Write a number sentence. Solve.

Ending Unknown

1. There were 7 students eating lunch at the table. After awhile 4 more students joined them. How many students are eating lunch at the table now?

2. Cali went running on Sunday. She ran 5 miles, took a short break, and then ran 3 more miles. How far did Cali run on Sunday?

3. George and Jose were running a lemonade stand. It was a very hot day, so they made 5 gallons of lemonade. By 3:00 pm they had used 3 gallons of lemonade. How much lemonade do they still have to sell?

4. Teresa loved to collect cooking magazines. She had 15 last week and this week she bought 5 more. How many magazines does Teresa have now?

5. Montrell and Davion were writing a rap together. The boys worked on the rap for 30 minutes in the morning and then another 45 minutes in the afternoon. How much time did they spend working on their rap?

Beginning Unknown

1. Christopher collected a lot of candy at the 4th of July parade. When he got home he quickly at 6 pieces of candy. After eating the candy he counted and had 15 pieces of candy left. How many pieces of candy did Christopher collect at the parade?

2. There were several birds sitting in a tree. 9 of the birds flew away and 4 were left. How many birds were sitting in the tree to begin with?

3. Karen lost 3 pencils today at school. She checked her backpack and only counted that she had 4 pencils left. How many pencils did Karen have before she went to school today?

4. Some kids were swinging on the swing set during recess. Four of the students jumped off and went to the jungle gym. Now only 5 kids are swinging. How many kids were singing to begin with?

5. Justine gave Alisha 5 stickers. Now Alisha has 12 stickers. How many stickers did Alisha have before Justine gave her some?

Change Unknown

1. Mike got 6 sets of Legos for his birthday. On Monday he worked on completing some sets. Now he only has 2 sets left to complete. How many Lego sets did Mike complete on Monday?

2. Each half of the soccer game was 25 minutes long. Mayah looked at the clock and saw that there was only 10 minutes left in the first half. How many minutes had she been playing soccer for?

3. The oven needed to preheat to 450 degrees. When Paul first checked the oven he saw that it was up to 250 degrees. How many more degrees does the temperature need to increase in order to be ready?

4. Terima and Tanya were decorating cupcakes for their friend's birthday party. They had baked 48 cupcakes and already decorated 12 of them. How many more cupcakes do Terima and Tanya need to decorate?

5. Ryan read 14 pages of his book and then read some more after lunch. Now he is on page 30. How many more pages did Ryan read after lunch?

Mastery Quiz

Directions - Label each part of the problem (St, C, and E). Write a number sentence. Solve.

1. At basketball practice Jack practiced for 2 hours. When he got home Jack had some friends over and played basketball some more. At the end of the day Jack had played basketball for 5 hours. How long were Jack and his friends playing basketball?

2. Felicity roasted 5 marshmallows the first night she was camping and then roasted 3 more the second night she was camping. How many marshmallows did Felicity roast while camping?

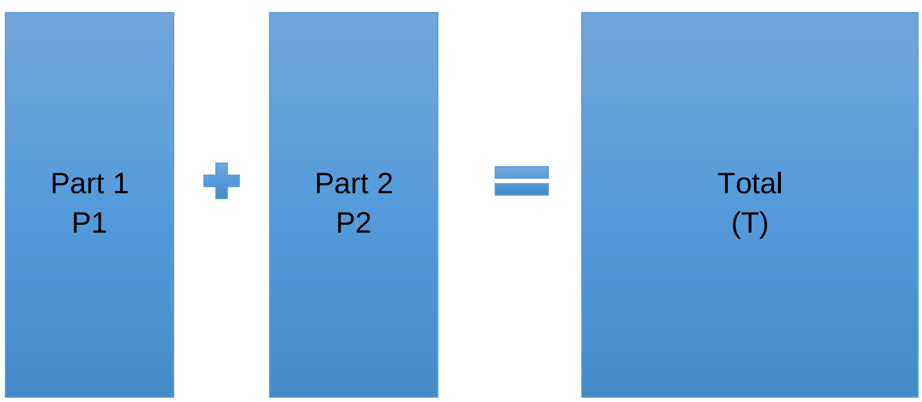
3. Five of the boys in Mrs. Sherman's class went home sick today. There were only four boys left in the classroom! How many boys were in Mrs. Sherman's class at the beginning of the day?

4. Senita's mom packed 7 empanadas in her lunch, but Senita was only hungry enough to eat 3 of them. How many empanadas did Senita have to take back home?

5. Drew loved to draw cartoons. He had already created 3 cartoon books and was planning to draw some more. By the end of the summer he wanted to have drawn 7 cartoon books. How many more cartoon books will Drew need to draw in order to reach his goal?

"Total" Word Problems

Diagram



Example: <u>Jan has 4 pets</u> and <u>Carlos has 3 pets</u>. <u>Together they have 7 pets</u>.
P1 P2 T

Number Sentence: 4+3=7

Practice Problems

Directions - Label each part of the problem (P1, P2, and T). Write a number sentence. Solve.

Total Unknown

1. Mark had 2 tennis balls and his cousin had 5 tennis balls. How many tennis balls did they have altogether?
2. Mr. Harrison had a container of pencils and pens for his students to use. There were 14 pencils and 25 pens in the container. How many writing utensils did he have in the container?
3. Jimmy's school uniforms only came in blue or white. Jimmy had 3 of the white uniform shirts and 7 of the blue ones. How many uniform shirts did Jimmy have?
4. There were 8 girls on the soccer team and 6 boys. How many students played on the soccer team?
5. The pet store sold two types of fish food. One of the types cost $3.50 and the other cost $2.50. Mrs. Thomas decided to buy them both to see which her fish liked better. How much money did Mrs. Thomas spend on fish food?

Part Unknown

1. The 2nd grade class had 25 students. They split up into two teams in order to play a game. One team had 15 students on it. How many students were on the other team?
2. Marcos ate 1 banana, 1 mango, and some strawberries today. If he ate 8 pieces of fruit, how many strawberries did Marcos eat?
3. At the T-shirt sale Mrs. Mendez sold 24 shirts. The shirts only came in size small or large. If she sold 14 small T-shirts, how many large ones did she sell?
4. The baseball team was for 7 or 8 year olds. There were 20 kids on the team and 8 of them were 8 years old. How many of them were 7 years old?
5. Treshon went fishing with his dad. They caught 5 fish. Treshon was happy he caught 3 of them. How many fish did Treshon's dad catch?

Mastery Quiz

Directions - Label each part of the problem (P1, P2, and T). Write a number sentence. Solve.

1. Jonathan and his sister each got some stuffed animals from their parents. Jonathan got 3 of them and his sister got 5. How many stuffed animals did they receive altogether?

2. There were 9 flowers in bloom in Carla's front yard. 3 of them were pink and the rest of them were yellow. How many yellow flowers were blooming in Carla's front yard?

3. The candy store sold jawbreakers in small, medium, or large. 5 boys walked into the store and each bought a jawbreaker. 2 of the boys bought small jawbreakers and 1 of the boys bought a medium jawbreaker. How many boys bought a large jawbreaker?

4. Denise and Monique were having a garage sale. Denise sold 7 items and Monique sold 15. How many items did they sell in all?

5. The swimming team held its swim meets on Saturdays or Sundays. 4 of the 15 meets were on Sunday. How many of the meets were on Saturday?

Sorting Activity

Directions - Fill in the blank with either "Change" or "Total".

1. Kyle played on his iPad for 15 minutes in the morning. Later he played for another 25 minutes. Altogether Kyle was playing on his iPad for 40 minutes. ____________________

2. There were 25 boats on the lake. 10 of them were sailboats and the rest were motorboats. There were 15 motorboats on the lake. ___________________________

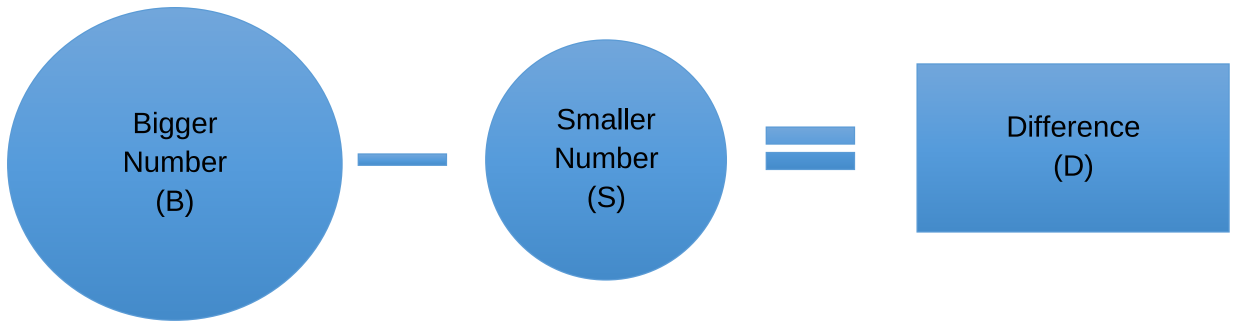
3. Tasha checked out 10 books from the library. She returned 7 of the books. Now she only has 3 books checked out from the library. _______________________

4. Jonah and Josiah found a slug on the playground. They measured how far the slug traveled. During the first recess the slug only traveled 5 centimeters. However, when they came back to check again the slug had traveled 7 more centimeters. The slug traveled 12 centimeters in all. _________________________

5. Tim planted tomatoes and cucumbers in his garden. By the end of the summer he had grown 20 tomatoes and 15 cucumbers. Altogether his garden produced 35 vegetables. ____________________________________

"Compare" Problems

Diagram



Example: Carson has 10 bugs. Milly has 4 bugs. Carson has 6 more bugs than Milly.
B S D

Practice Problems

Directions - Label each part of the problem (B, S, and D). Write a number sentence. Solve.

Difference Unknown

1. Chantelle can do 30 addition problems in one minute and Mindy can do 21 problems in one minute. How many more problems can Chantelle do than Mindy?

2. Janet weighs 100 pounds and her sister weighs 75 pounds. How many more pounds does Janet weigh than her sister?

3. Tammy slept for 6 hours last night. The night before she slept for 9 hours. How many fewer hours did Tammy sleep last night compared to the night before?

4. Ty and his dad were bowling. Ty scored 112 points and his dad scored 124. How many more points did Ty's dad score than Ty?

5. Kirby made 7 of his free throw shots and missed 9. How many more shots did Kirby miss than make?

Bigger Set Unknown

1. Jan found 15 more seashells than Stephanie. If Stephanie found 10 seashells, how many seashells did Jan find?
2. Ming ate 3 cookies. His sister ate 2 more cookies than Ming. How many cookies did Ming's sister eat?
3. Francis spent 5 more dollars at the store than Charles. If Charles spent $12 how much money did Francis spend?
4. Mrs. Calvin's class had 7 fewer students than Mr. Smith's class. If Mrs. Calvin's class had 19 students, how many students did Mrs. Calvin's class have?
5. Zhin got his report card back from school and had three A's. He noticed that he had two fewer A's than B's. How many B's did Zhin have on his report card?

Smaller Set Unknown

1. Lacy ran 5 more miles yesterday than she did today. If she ran 3 miles today, how many miles did she run yesterday?
2. Troy scored 120 more points on his video game than Scott did. If Troy scored 350 points. How many points did Scott score?
3. Antonio caught 5 frogs at the pond. He caught 7 fewer frogs than Ashley. How many frogs did Ashley catch?
4. Dana read 40 pages of her book last night. Tina read 12 more pages than Dana. How many pages did Tina read?
5. After trick or treating, Martin and Salvatore counted their candy. Salvatore had 20 more pieces than Martin. If Martin had 45 pieces of candy, how many did Salvatore have?

Mastery Quiz

1. Aamir is 7 years older than his brother. If his brother is 4 years old, how old is Aamir?

2. Jacklyn road her bike around the block 6 times. Latoya road her bike around the block 3 times. How many fewer times did Latoya ride around the block than Jacklyn?

3. Johanna is 7 inches taller than her friend Miguel. Johanna is 4 feet 11 inches tall. How tall is Miguel?

4. The volleyball team had a record of 9 wins and 3 losses. How many more wins did they have than losses?

5. Ms. Brown's and Mr. Lopez's were competing in the penny drive. Ms. Brown's class collected 450 pennies. They were proud of themselves for collecting 75 more pennies than Mr. Lopez's class. How many pennies did Mr. Lopez's class collect?

Sorting Activity

Directions - Fill in the blank with either "Change", "Total", or "Compare".

1. There were 7 chickens on the farm at the beginning of the year. Those chickens laid many eggs, and added 14 more chickens to the farm. Now there are 21 chickens on the farm. ____________________

2. The boss had 52 employees. 30 of the employees were women and 22 were men. ______________________________

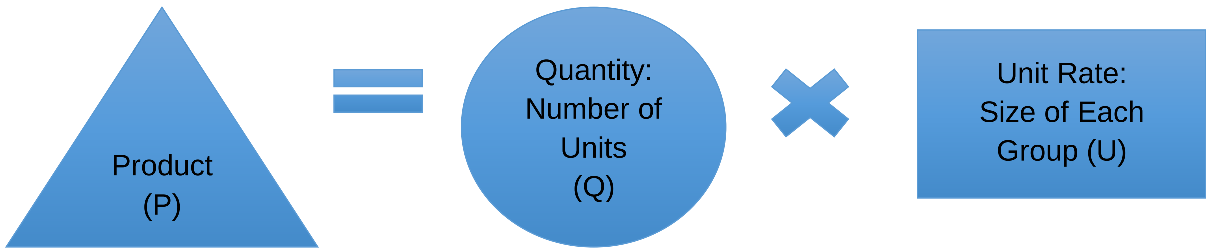
3. A principal hired 22 teachers to start a school. After a year he gave 10 of them a promotion for doing such a great job. 12 of the teachers did not receive a promotion. ________________________

4. The car ride to school took 25 minutes today. Yesterday the car ride only took 14 minutes. The car ride took 11 more minutes today than yesterday. ______________________________

5. Jaime collected fireflies one night during the summer. He counted that he collected 30 of them. When he woke up in the morning 12 of them were dead. Now Jaime only had 18 fireflies. _____________________________

"Equal Groups" Problems

Diagram



Example: Anna made 24 cookies. She put 6 of them on each of the 4 plates.
P U Q

Practice Problems

Directions - Label each part of the problem (P, Q, R). Write a number sentence. Solve.

Product Unknown

1. Samuel ran 5 miles per hour. If he ran for 2 hours. How many miles did Samuel run?

2. There were 24 students in Miss Campa's class. Each student was given 7 pencils at the beginning of the year. How many pencils did Miss Campa need to buy for her class?

3. Marcus had to take his inhaler 3 times a day for a week. How many times did Marcus need to take his inhaler in the week?

4. The 4th grade class split into 5 groups. Each group had 6 students in it. How many students were in the 4th grade class?

5. Jasmine was running a fundraiser. She asked 35 people to sell 5 tickets each to the fundraiser. How many tickets was Jasmine hoping to sell?

Unit Rate Unknown

1. Abdul's mom made him 30 cookies to take to school. He wanted to split them equally between his 6 friends. How many cookies did he give to each friend?

2. The food pantry was giving away boxes of cereal. Each person was given the same amount of boxes. If the food pantry gave away 40 boxes of cereal to 8 families. How many boxes did each family get?

3. Jan tied 45 water balloons in 9 minutes. How many water balloons could Jan tie per minute?

4. At the apple orchard there were 72 apple trees arranged in equal rows. If there were 8 rows, how many apple trees were in each row?

5. Sherry put her silverware back in the silverware drawer. She counted that she had 24 pieces of silverware, only counting the forks, knives, and spoons. If she had the same number of each, how many forks did she have?

Number of Units Unknown

1. Rashawn made 15 bracelets to give to her friends. If she gave each of them 5 bracelets, how many friends did she give bracelets to?

2. The plant had several branches with 3 leaves on each of them. If the plant had 21 leaves, how many branches did it have?

3. The train carried 100 crates. Each train car could carry 5 crates. How many train cars did the train have?

4. The monkeys at the zoo were fed 5 bananas a day. The zoo keeper knew he would need to have 40 bananas set aside for each day. How many monkeys were at the zoo?

5. Casper was shooting off fireworks for the 4th of July. Each firecracker popped 5 times. Total he heard 60 pops. How many firecrackers did Casper use?

Mastery Quiz

1. Demarius has to walk up the stairs 5 times a day at school. If he goes to school for 175 days a year, how many times does he climb the stairs in a school year?

2. Mrs. Sanchez spent $2.50 on gumballs at the candy store. If each gumball costs a quarter, how many gumballs did Mrs. Sanchez buy?

3. Jeremy had 3 fish which he kept in separate fish bowls. He fed them each 4 scoops of food a day. How many scoops of food did he have to use to feed all of his fish?

4. Amari ran the mile race in 6 minutes. If he could keep up this pace, how many minutes would it take him to run 5 miles?

5. Joey takes his dog for a 3 miles walk every time he walks the dog. If he walked the dog a total of 27 miles last month, how many times did he take his dog for a walk?

Sorting Activity

Directions - Fill in the blank with either “Change”, “Total”, “Compare”, or “Equal Groups”.

1. Amir’s mom bought him a pack of 24 bags of Hot Cheetos. Amir ate 4 bags of Hot Cheetos on the first day. Now he only has 24 bags of Hot Cheetos. ______________________

2. The class split up into 6 teams. Each team was given 7 pieces of paper. Total the class used 42 pieces of paper. ____________________________________

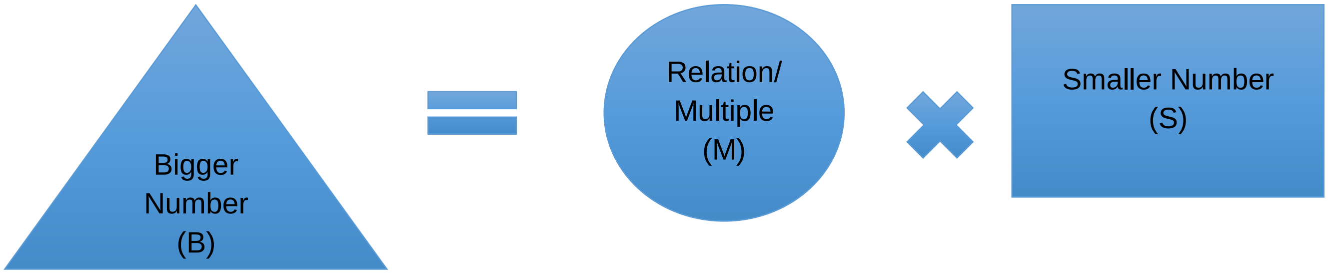
3. Courtney’s parents gave her $5 for every A she earned for the semester. At the end of this semester Courtney had 3 A’s. Her parents gave her $15. ____________________________

4. Tyler asked his class if they liked dogs or cats better. 15 of his peers said they liked dogs better. The other 7 students preferred cats. 8 more students liked dogs than cats. _________________________________.

5. Alana had $250 dollars in her bank account. She also had $16 in her wallet. Altogether, Alana has $266 dollars. ______________________________

“Multiplicative Compare” Problems

Diagram



Example: Jason is 3 times as old as his nephew. Jason is 24 and his nephew is 8.
M B S

Practice Problems

Directions - Label each part of the problem (M, B, S). Write a number sentence. Solve.

Bigger Number Unknown

1. Johnny ate 7 jellybeans. Enrique at 5 times more jellybeans than Johnny. How many jellybeans did Enrique eat?

2. Martha was training for a very long hike. The first day of training she walked 2 miles. Now she was able to walk 3 times as many miles as she was able to the first week. How many miles can Martha walk now?

3. When Shiloh was a puppy she only weighed 5 pounds. As a full grown dog she weighs 6 times as many pounds as she did when she was a puppy. How many pounds does Shiloh weigh now?

4. Raquel and her sister were collecting leaves for a class assignment. Raquel collected 4 times as many leaves as her sister. If her sister collected 5 leaves, how many leaves did Raquel collect?

5. Jonah completed is able to complete an addition worksheet 5 times faster than he was able to at the beginning of the year. If he is able to complete the worksheet in 2 minutes now, how many minutes did it take him at the beginning of the year?

Smaller Number Unknown

1. The Thompson children kept their lemonade stand open for 2 days. The first day the temperature was pretty cool outside and on the second day it was very hot. On the 2nd day the children sold 64 cups of lemonade, which was 8 times as many as the day before. How many cups of lemonade did the children sell the first day?

2. Franco made a bet that he could stand on one leg 10 times longer than his little brother. Franco was able to stand on one leg for 60 seconds. In order to win the bet, Franco hoped his brother wouldn't stand on one leg for more than how many seconds?

3. When Samuel went to the pet store he brought home a few rabbits. By the end of the month Samuel had 5 times as many rabbits as he started with. If Samuel has 35 rabbits now, how many did he start with?

4. The tree that Maribel planted as a seed has been growing rapidly. It is now 36 inches tall. That is 3 times as big as it was last week. How tall was Maribel's tree last week?

5. Cornelia split a bag of skittles between the two children she was babysitting. She gave the older child 45 skittles which was 5 times as many as she gave the younger child. How many skittles did she give the younger child?

Multiple Unknown

1. In Mrs. Marco's classroom there were 16 girls and only 4 boys. How many times more girls are there than boys?

2. Jason finished the roller blade race in 7 minutes. The last person to cross the finish line finished in 21 minutes. How many times faster was Jason than the last person?

3. The families on Benjamin Street decided to each hold a garage sale on the same day, to encourage people to attend. The Carlton's raised $20 from their garage sale and the Choi's raised $160. How many times more money did the Choi's raise than the Carlton's?

4. Rueben and Marshal were jumping on a trampoline. Rueben jumped for 15 seconds before getting sick of it. Marshal continued to jump and jumped 45 seconds. How many times longer did Marshal jump than Rueben?

5. The Marquez family decided to have a summer reading competition. Felipe read 12 pages his first day and Ana read 60 pages. How many times more pages did Ana read than Felipe?

Mastery Quiz

1. Anique's essay was 30 sentences long. Ralph's essay was only 5 sentences long. How many times longer was Anique's essay than Ralph's?

2. Abe climbed up the tree in 15 seconds. It took his brother 3 times as long to get up the tree. How long did it take Abe's brother to climb the tree?

3. On Rachel's birthday, her parents always gave her 3 times as many balloons as how old she was. This year Rachel is turning 12. How many balloons with her parents give her?

4. Jamal was shooting hoops in his backyard. He missed 5 shots, but made 30. How many times more shots did Jamal make than miss?

5. James had to practice piano for 15 minutes a day. His older sister had to practice 4 times as long as James. How many minutes a day did James' sister need to practice piano?

Sorting Activity

Directions - Fill in the blank with either "Change", "Total", "Compare", "Equal Groups", or "Multiplicative Compare".

1. There were 25 dogs in the dog park. 15 of the dogs were big enough to go in the area for big dogs and 10 of the dogs were too small. ______________________

2. Mr. Torres passed out two pencils to each of the 24 students in his class at the beginning of the year. He made sure to buy 48 pencils so that he would have enough. ________________________________

3. Jonathan had $50 in his wallet when he went to the store. He spent $15 and now only has $35 in his wallet. _____________________________

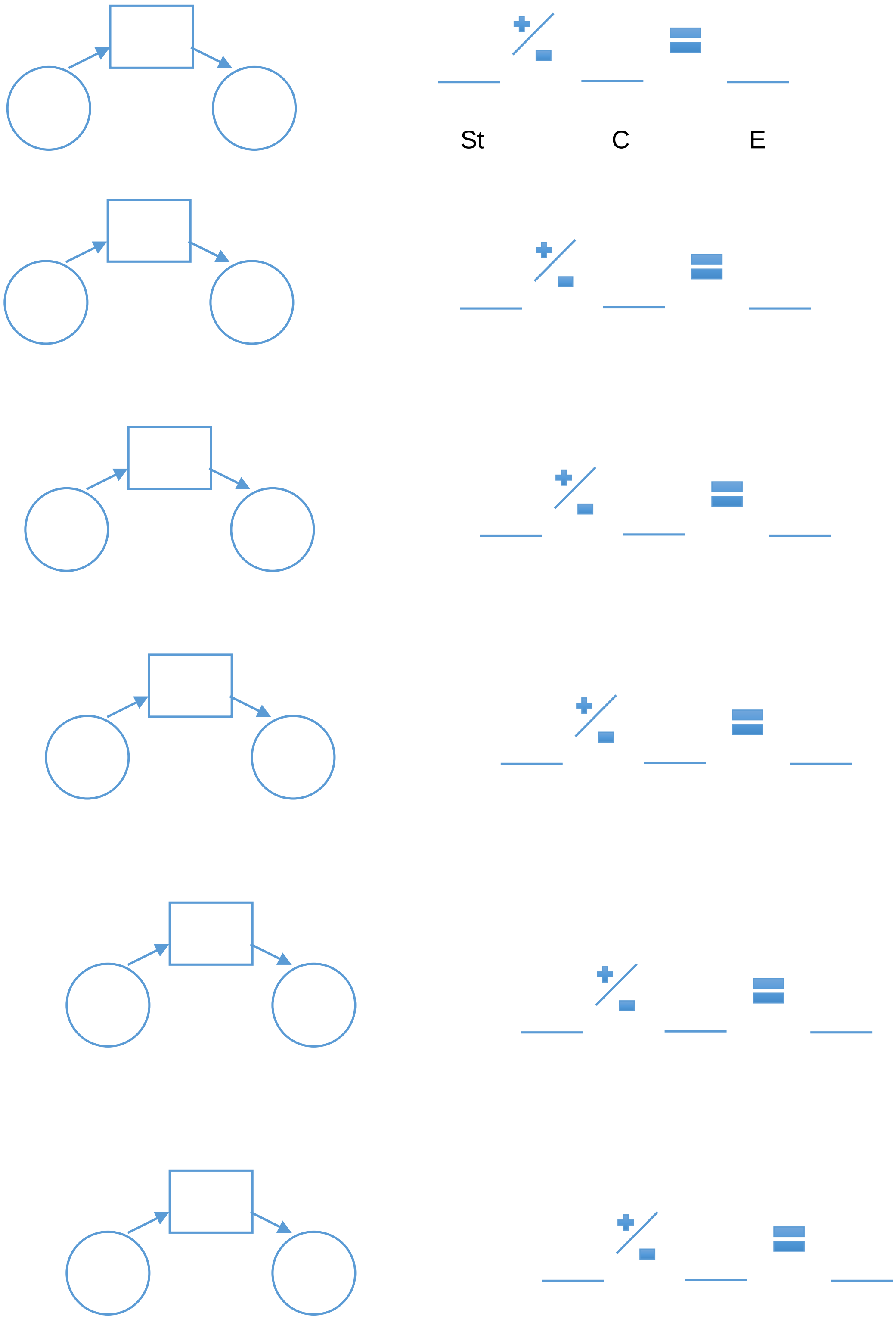
4. The 3rd grade class sold 150 magazines at the magazine sale. They sold 3 times as many magazines as the 2nd grade class. The 2nd grade class only sold 50 magazines. _____________________________

5. The uniform colors at Mount Pleasant School are blue and white. In Carissa's class today there were 4 students wearing white and 19 wearing blue. There were 15 more students wearing blue than wearing white. _______________________

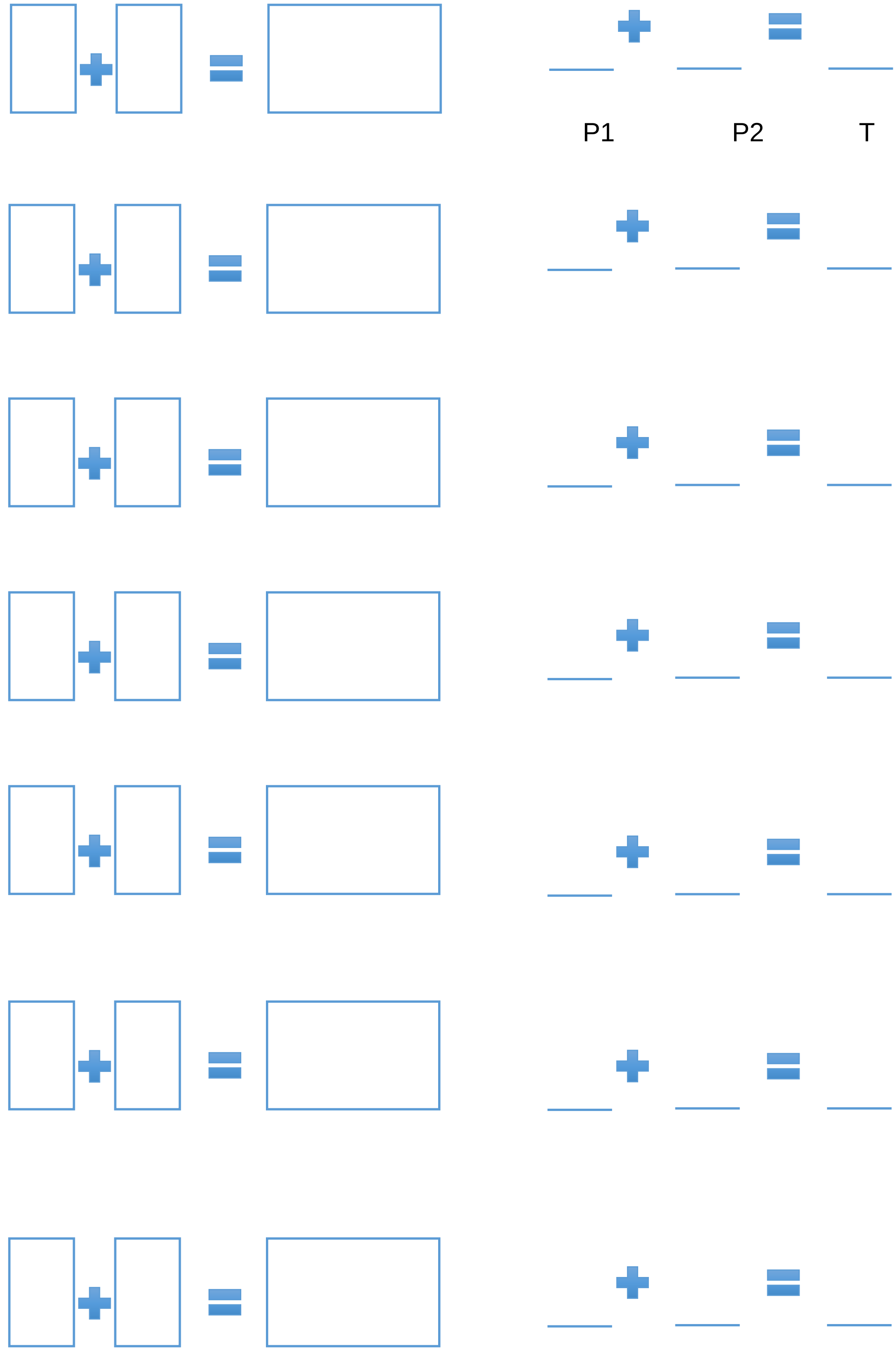
Blank Diagrams for Student Work

Students should use the following sheets to help them solve the word problems. As they become more familiar with each schema, gradually teach them to draw the diagrams themselves.

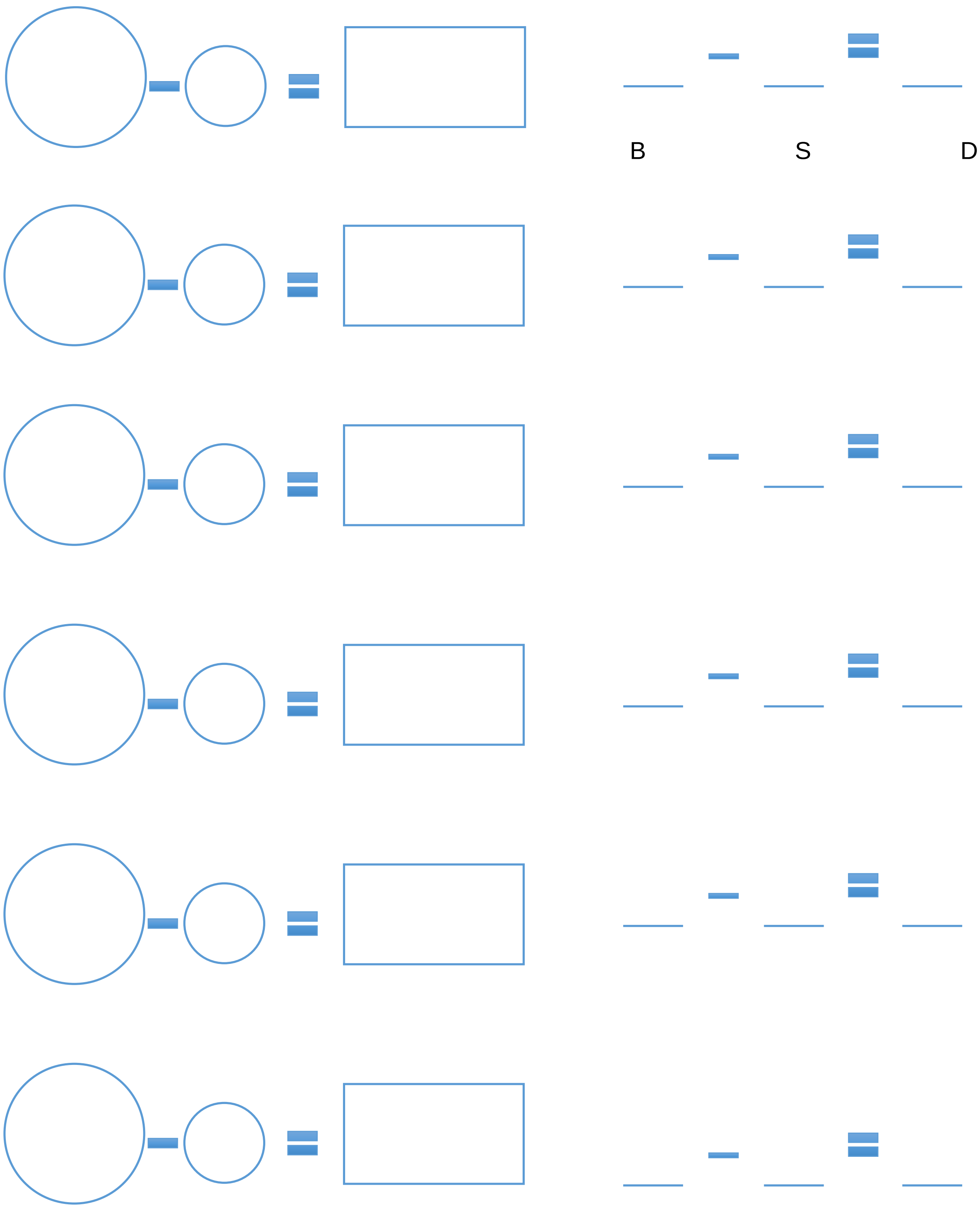
“Change” Diagrams



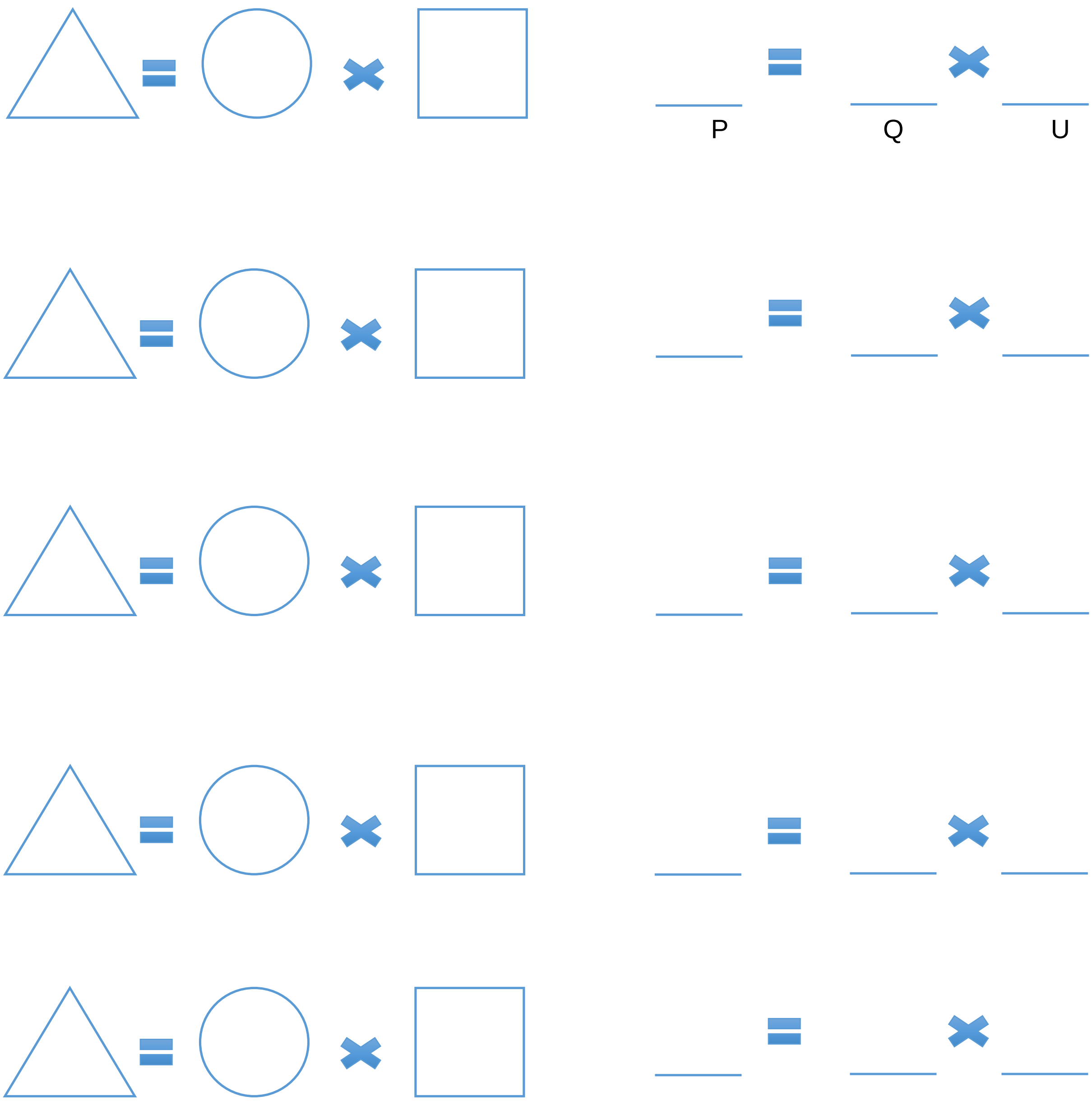
“Total” Diagrams



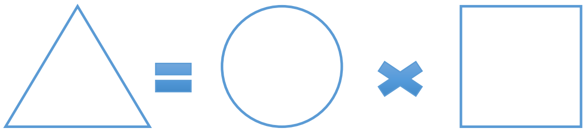
“Compare” Diagrams



“Equal Groups” Diagrams

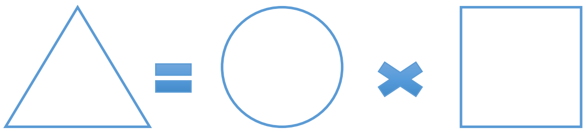


“Multiplicative Compare” Diagrams



_____ = _____ × _____

B M S



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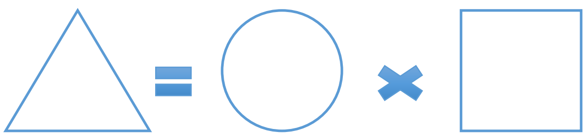

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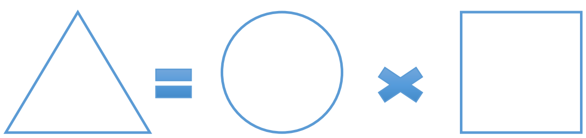

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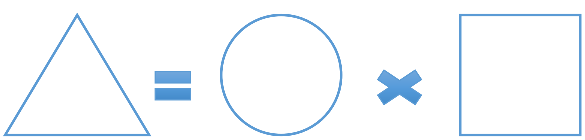

_____ = _____ × _____

Appendix C:

Teacher Survey

Name: ________________________
Date: _________________________

Teacher Perception Survey:
Schema-Based Instruction for Word Problem Solving

Directions: Read the statement on the left. Decide how much you agree with the statement and completely fill in the corresponding oval.

EFFECTIVENESS OF INSTRUCTIONAL METHOD	STRONGLY DISAGREE	DISAGREE	AGREE	STRONGLY AGREE
I saw an increase in my students' ability to solve word problems.	⬭	⬭	⬭	⬭
Schema-based instruction helped my students with learning disabilities more accurately solve word problems.	⬭	⬭	⬭	⬭
My students are able to sort word problems into their schemas.	⬭	⬭	⬭	⬭
My students are able to use their knowledge of schemas to solve novel word problems in their textbooks.	⬭	⬭	⬭	⬭
Schema-based instruction increased my students' ability to write equations before solving a word problem.	⬭	⬭	⬭	⬭
Schema-based instruction increased my students' ability to explain why they chose to compute the way they did.	⬭	⬭	⬭	⬭

FUNCTIONALITY OF MATERIALS	STRONGLY DISAGREE	DISAGREE	AGREE	STRONGLY AGREE
The schema descriptions gave me an deep enough understanding of schemas.	⬭	⬭	⬭	⬭
The examples problems in the packet helped me create some of my own word problems.	⬭	⬭	⬭	⬭
The student materials were comprehensive enough for most of my students to gain a basic level of understanding.	⬭	⬭	⬭	⬭
The scope and sequence allowed for appropriate pacing and aligned to my curriculum.	⬭	⬭	⬭	⬭
The description of explicit instruction and the cue cards helped me structure my lessons.	⬭	⬭	⬭	⬭
I would like to use these materials again next year.	⬭	⬭	⬭	⬭

Additional Comments:

GRAND VALLEY STATE UNIVERSITY

ED 693/695 Data Form

NAME: Claire Lim

MAJOR: (Choose only1)

_____ Adult & Higher Education	_____ Educational Differentiation	_____ Library Media
_____ Advanced Content Specialization	_____ Education Leadership	_____ Middle Level Education
_____ Cognitive Impairment	_____ Educational Technology	_____ Reading
_____ College Student Affairs Leadership	_____ Elementary Education	_____ School Counseling
_____ Early Childhood Education	_____ Emotional Impairment	_____ Secondary Level Education
_____ Early Childhood Developmental Delay	___X__ Learning Disabilities	_____ Special Education Administration
_____ TESOL		

TITLE: Implementing Schema-Based Instruction in the Elementary Classroom

PAPER TYPE: (Choose only 1) **SEM/YR COMPLETED:** Summer 2015

__X__ Project

_____ Thesis

SUPERVISOR'S SIGNATURE OF APPROVAL____________________________

Using key words or phrases, choose several ERIC descriptors (5 - 7 minimum) to describe the contents of your project. ERIC descriptors can be found online at: http://www.eric.ed.gov/ERICWebPortal/Home.portal?_nfpb=true&_pageLabel=Thesaurus&_nfls=false

1. Academic Achievement
2. Instructional Effectiveness
3. Curriculum Enrichment
4. Direct Instruction
5. Scaffolding
6. Remedial Instruction
7. Educational Strategies