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Effects of Fourth- and First-Grade Cross-Age Tutoring on Mathematics Anxiety

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Mathematics Anxiety

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ABSTRACT

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A mixed methodological approach was used to examine the effects of fourth- and first-grade students cross-age tutoring on mathematics anxiety. 37 Fourth-grade tutors, both trained and untrained, helped 37 first graders use multiple strategies to solve mathematical word problems for 10 weeks. A control group of 16 first-grade students completed the problems independently. Pre-test and post-test mathematics anxiety measures were used. Observations were also conducted throughout the study. The measures used for both primary and intermediate students were effective in identifying students with mathematics anxiety. However, quantitative findings showed no difference for fourth- or first-grade students on mathematics anxiety measures. Results of an ANOVA were not significant. The qualitative findings revealed the trained tutors and their partners were the most structured. They tried more strategies to solve problems and stayed on task better than other groups. Untrained tutors and their partners needed more redirection and engaged in more off-task conversations. First graders with tutors received more positive reinforcement than those who worked independently.

Keywords: mathematics anxiety, cross-age tutoring, elementary

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Introduction

Mathematics anxiety is an issue that has been identified in the United States since the 1970s. Researchers have worked to identify mathematics anxiety in young children and examine how the anxiety impacted these children (Harari, Vucovik, & Bailey, 2013). Mathematics anxiety can have a negative impact not only on students' initial learning of mathematics, but can lead to long-term consequences with avoidance and struggles in mathematics education and careers (Hembree, 1990; Krinzinger, Kaufman, & Willmes, 2009; Vukovic, Kieffer, Bailey, & Harari, 2012; Wu, Barth, Amin, Malcarne, & Menon, 2012).

Since the 1980s many attempts have been made to find ways to alleviate mathematics anxiety. Of those attempts, the research literature revealed few that have included in-class programs. The National Council of Teachers of Mathematics (NCTM) (as cited in Stuart, 2000) shared a few practices in 1995 about how to reduce math anxiety: "accommodate different learning styles, design experiences so that students feel positive about themselves, emphasize that everyone makes mistakes, allow for different social approaches, and emphasize the importance of original quality thinking rather than manipulation of formulas" (p. 334). Stuart implemented some of these practices by having her class work in small groups to complete word problems. As a result from her work, she reported that the "students learned to share and accept more than one correct answer. They began to take risks in their problem-solving endeavors, thus increasing their mathematics confidence" (p. 334)

The NCTM (2000) created principles and standards that have transitioned the focus from accuracy to understanding. These concepts include skills to help students better comprehend their mathematical thinking and feel more confident in their procedural methods than before. A few recommended skills for students include discussing and justifying student work with others, providing multiple opportunities to explore strategies, practicing with creating and using representation, and receiving prompt feedback on work. These concepts demonstrate that mathematics anxiety results from a lack of confidence in mathematics and therefore put a strong focus on identifying skills and principles to help students gain confidence in mathematics abilities and knowledge.

Statement of the Problem

One method that has yet to be explored to reduce mathematics anxiety is cross-age tutoring, during which older students mentor younger students. Studies have shown that cross-age tutoring is associated with an array of benefits including academic achievement, positive attitudes, increased use of vocabulary, and increased self-esteem (Fogarty & Wang, 1982; Gordon, Morgan, O'Malley, & Ponticell, 2007; Sharpley, Irvine, & Sharpley 1983; Topping, Campbell, Douglas, & Smith, 2003). When Stuart (2000) used small group work in her class, she found that students enjoyed working with their peers and could better communicate ideas, which in return led to higher results of mathematics confidence and lower levels of mathematics anxiety. Perhaps cross-age tutoring will have similar positive effects in lowering mathematics anxiety. Since tutoring allows students an opportunity for more conversations, direct feedback, and chances for practice and exploration, it may be an effective method for helping to alleviate mathematics anxiety in elementary schools.

One source of anxiety for many students is working with word problems. Word problems have become a major tool for introducing mathematical concepts in primary grades. Using word problems creates situations in which students must comprehend the nature of the mathematical task in order to find the solution. In the lower grades, teaching mathematics should focus on student understandings and strategies then building on from the students' knowledge. Most students learn best when they understand one concrete principle before moving to more abstract skills (Kilpatrick, Swafford, Findell, & National Research Council, 2001). Cemen (1987) referred to learning one principle before moving onto the next as concepts built from prerequisites. Word problems are a source of frustration for young students, because they involve coordinating multiple ideas to determine the solution. In a study by Fuchs, Seethaler, Powell, Fuchs, Hamlett, and Fletcher (2008), tutoring was shown to help students increase their performance when solving mathematics word problems. If tutoring helps students' academic skills, it's associated benefits of better communication and higher confidence may also assist in reducing students' mathematics anxiety when working on word problems. Currently no published studies have explored the effects of cross-age tutoring on mathematics anxiety using word problems.

Statement of the Purpose

The purpose of this study was to determine how the implementation of cross-age tutoring might impact mathematics anxiety in selected fourth- and first-grade students. Furthermore, this study examined the social interactions between tutors and tutees during cross-age tutoring sessions to determine the differences in relationships between groups (trained tutors, untrained tutors, and no tutors).

Research Questions

This research was patterned after a study by Mitchell, Morrison, Feinauer, Wilcox, and Black (2016) in which older students helped younger students focus on spelling accuracy and writing fluency. The current study focused on mathematics anxiety levels in students and interactions between tutors and tutees. This study was guided by the following questions:

1. Do tutors' or tutees' mathematics anxiety change as measured by pre- and post-test scores during a 10-week cross-age tutoring instructional period?
2. Are there significant differences in mathematics anxiety as measured by pre- and post-test scores according to assigned group (trained tutors, untrained tutors, and no tutors)?
3. Is there an interaction over time in mathematics anxiety according to group membership?
4. How do trained and untrained tutors interact with tutees?

Definition of Terms

Several terms that were used in this paper are defined below. While some of the terms are widely accepted, others have been specifically defined for the purpose of this study.

Cognitively Guided Instruction (CGI). A professional development program for elementary school teachers focused on problem solving with understanding.

Cross-age tutoring. When an older student tutors a younger student (Cairo, Craig, & Appalachia, 2005).

Mathematics anxiety. "Feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (Richard & Suinn, 1972, p. 551).

Problem solving. "Engaging in a task for which the solution method is not known in advance" (NCTM, 2000, p. 52).

Tutee. A person who receives help from another person; in this study each tutee was a younger students who received help from an older student

Tutor. An person who instructs another person; in this study each tutor was an older student who instructed a younger student

Chapter 2

Review of Literature

At a time in American history when mathematical proficiency is essential for "economic opportunity and meaningful participation in society," anxiety has become an impediment (Vukovic, et al., 2012, p. 1). Mathematics anxiety has been linked to reduced enjoyment in mathematics, lower perceptions of mathematical abilities, inability to view the value of mathematics in everyday life, and avoidance of mathematics (Ashcraft, Krause, & Hopko, 2007; Hembree, 1990; Vukovic et al., 2012). As mathematics anxiety continues to trouble many students, cross-age tutoring may present a solution, because it has been shown to benefit students' attitudes, self-concept, confidence, and other academic areas (Fogarty & Wang, 1982; Mitchell, 2016; Sharpley, et al., 1983; Topping, et al., 2010).

This study focused on mathematics anxiety and cross-age tutoring. The following sections detail findings and recommendations of research on mathematics anxiety and cross-age tutoring, as well as problem-solving strategies and Cognitively Guided Instruction (CGI).

Mathematics Anxiety

In a study by Jackson and Leffingwell (1999), only 7% of students reported having positive experiences with mathematics from kindergarten through college. Furthermore, Burns (1998) reported that more than two-thirds of adults admit they "fear and loathe mathematics" (p.165). To understand mathematics anxiety it is important to examine its causes, effects, and possible solutions.

Causes of mathematics anxiety. Cemen (1987) reported three different factors associated with mathematics anxiety: dispositional, situational, and environmental. Dispositional factors include self-doubt, lack of confidence in mathematical ability, and negative attitudes.

Cemen asserts that negative attitudes may be demonstrated by perceiving mathematics as useless and seeing mathematics as a male dominated subject.

Situational factors include classroom elements, such as the way mathematics is taught, the nature of mathematics, and situational antecedents of test anxiety. The way teachers approach mathematics can make a difference. If teachers are enthusiastic about mathematics, their perspective can lower anxiety. Similarly, if teachers are process-oriented instead of being focused solely on obtaining correct answers, they can create a safe environment for students.

Environmental factors include parental encouragement, negative experiences with mathematics, and prior mathematics achievement. Any combination of these factors may contribute to varying degrees of mathematics anxiety. Ashcraft, et al. (2007) have shown that mathematics anxiety usually begins in the classroom, emphasizing how influential these factors may be on a student. Although many adults experience mathematics anxiety, Harari, Vukovic, and Bailey (2013) claimed that mathematics anxiety may begin as early as first grade.

Effects of mathematics anxiety. Mathematics anxiety has been connected to a variety of negative outcomes, including lower academic scores, avoidance of mathematics classes, and perceived uselessness of mathematics (Ashcraft & Kirk, 2001; Cemen, 1987). Research by Hembree (1990) showed that in grades five through nine, as students' mathematical anxiety increased, their mathematical performance decreased. Hembree reported that the indicators of decrease in mathematical performance included students' mathematics course grades and test scores. In 2012, Vukovic and colleagues conducted a study with second and third graders to determine if they experienced mathematics anxiety and if it affected their mathematical performance. They found a negative correlation between mathematics anxiety and mathematical performance, meaning that as students mathematics anxiety increased, their performance in mathematics decreased.

When students encounter anxiety, they may or may not cope with the issue. Cemen's (1987) research showed that if students spend a large amount of time coping, they might begin to avoid the use and study of mathematics. Studies have found that middle school to college students who had mathematics anxiety avoided mathematics courses and careers related to mathematics (Cemen, 1987; Vukovic et al., 2012). Furthermore, results showed high school students who had cases of high anxiety in mathematics enrolled in fewer high school mathematics courses and were likely to discontinue their mathematics education in college (Furner & Gonzalez-Dehass, 2011; Hembree, 1990). The students were not being limited by others, but rather by themselves by self-selecting out of courses and careers. These decisions could have implications for future incomes and confidence in social circles. With that in mind, mathematics anxiety is a problem that must be taken seriously.

Solutions for mathematics anxiety. Furner and Gonzalez-Dehass (2011) examined the practices of using student achievement goals, as well as making mathematics relevant for students to help alleviate mathematics anxiety. Their paper reported that assisting students to see mathematics in real-life situations and working on students' self-confidence helped reduce the students' mathematics anxiety. Furner and Gonzalez-Dehass also discussed the benefits of using cooperative learning, students working together in groups to solve problems. This style of instruction allows students to collaborate, support each other, and possibly feel less threatened by the task or environment.

In a meta-analysis, Hembree (1990) examined 151 studies to better understand the relationship between mathematics anxiety and performance, mathematics anxiety and test anxiety, and mathematics anxiety in males or females. His meta-analysis again found a negative correlation between mathematics anxiety and performance with a medium effect size. Hembree found studies displaying a variety of techniques used to help alleviate anxiety; ranging from changing classroom curriculum and using classroom interventions to psychological treatments outside of the classroom. In the classroom, teachers tried using small groups and peer tutoring to assist in working on material, as well as using computers and other technologies. The studies in Hembree's meta-analysis found that none of the in-class changes had a significant impact on decreasing anxiety. However, out-of-class psychological treatments did show some results. Using systematic desensitization along with anxiety management training, conditioned training, and relaxation training showed success in reducing mathematics anxiety levels. The question remains as to how classroom teachers might help large numbers of students with mathematics anxiety. Hebree did find that positive attitudes, enjoyment, and self-confidence with mathematics consistently related to lower mathematics anxiety. Cross-age tutoring has shown gains in students' attitudes and confidence towards the subject they focus on, therefore; cross-age tutoring may be a practical solution worthy of further examination (Jenkins & Jenkins 1981).

Cross-age Tutoring in the Classroom

Tutoring is a practice that has been in place for a long time and has taken many forms (Gordon, Morgan, O'Malley, & Ponticell, 2007). In the past, some researchers have focused on the outcomes for the tutees and the effects of utilizing higher-achieving students as participants in tutoring programs. Also, tutoring programs have shown to help at-risk students and affect tutors' academic levels outside the tutoring focus (Dillner 1971). Gordon et al. reported that although there are many variations for tutoring programs, certain elements are used in programs that have demonstrated consistent benefits.

Components of cross-age tutoring. Jenkins and Jenkins (1981) discussed many factors to be considered when implementing a cross-age tutoring system. The teacher needs to decide which students will participate, what curriculum will be covered in the sessions, the frequency and duration of the program, and if tutors will be trained. These researchers believed that most students are capable of participating in cross-age tutoring sessions. Students with major behavior issues are cause for concern if they display aggression or tend to be noncompliant. Selecting curriculum for the program depends heavily on the purpose of the program. Some programs work better when tutors have the option of choosing their material during the tutoring session rather than being assigned specific work. On the other hand, other programs work well if the material to be covered during the sessions is pre-assigned for the tutors and tutees. Mayhall and Jenkins (1974) recommend that the most effective tutoring programs should occur daily for approximately 30 minutes (as cited in Jenkins & Jenkins, 1981). Other programs have shown results using longer tutoring sessions less frequently. The frequency has been found to be more critical than duration, meaning meeting more often for less time is more beneficial than meeting less often for greater amounts of time (Jenkins & Jenkins 1981).

Training tutors is an optional approach in tutoring programs. Jenkins and Jenkins (1981) reported that when older students are in charge of younger students, the tutors might become impatient or bossy. This impact on tutors can lead to a negative and less useful tutoring experience for the tutors and the tutees. The purpose in training tutors is to provide them with guidance in using appropriate behaviors and understanding the curriculum. Niedermeyer (1970) compared the use of trained tutors to the use of untrained tutors. He found that untrained tutors only confirmed correct responses 49% of the time and never praised their tutees. Conversely, the trained tutors confirmed correct responses 98% of the time and offered praise for tutee work.

Tutoring programs that do incorporate tutor trainings are open to a variety of interpretations based on the focus of the study.

Benefits of tutoring programs. Fogarty and Wang (1982) investigated how cross-age tutoring affected student performance in remedial mathematics and computer literacy skills. The tutors in the program attended three sessions lasting 30 minutes each. The tutoring sessions occurred twice a week for 8 weeks in 30-minute increments. In this study, the tutees' mathematics scores, which were based on the completion of their work and not accuracy, increased significantly above the control group and they maintained their higher scores 4 weeks after the tutoring sessions had concluded.

Sharpley et al. (1983) conducted a study in which fifth and sixth graders tutored second and third graders for 30 minutes a day, 4 days per week for 5 weeks on mathematics operations. The results in this study showed academic gains for tutors and tutees that were significantly higher than for those who were not involved. Furthermore, Sharpley and her associates found that the tutors showed advances in other mathematical areas in addition to the tutored areas. The other mathematical areas included estimation, geometry, fractions, and time.

In a study by Topping et al. (2010), 11-year-old students tutored 7-year-old tutees in mathematics. This study focused on students' self esteem and attitudes toward mathematics. The results showed a gain in self-esteem and attitude for the tutors, although it was statistically insignificant. The tutees showed gains in their self-esteem and attitudes that were statistically significant. Currently, there is no research that directly explores the impacts of cross-age tutoring on mathematics anxiety.

In a study by Mitchell et al. (2016), fourth-grade students tutored second-grade students during 20-minute sessions over a 9-week period on spelling strategies. Prior to the cross-age tutoring sessions, the researcher trained the tutors in three 20-minute sessions. The trainings supported the fourth graders in becoming tutors and clarified what was expected of them during the sessions. Students' writing samples were collected before and after the cross-age tutoring program. After the intervention, the tutees who worked with trained tutors showed significant academic gains. No significant differences in scores were found between fourth-grade students who participated as tutors and those who did not (Mitchell et al., 2016). Qualitative data showed that the tutors actively took the role of teacher and assisted the tutees in reaching the correct answers with minimal support.

Paquette (2009) studied how cross-age tutoring might impact students writing abilities using the 6+1 writing traits. Fourth-grade students assigned as tutors paired with second-grade students assigned as tutees. The tutors in the study received training on the 6+1 writing traits. This study was implemented over a 10-week period, wherein the tutoring pairs met once a week for an hour. At the conclusion of the study, the tutees showed no academic difference from the second grade students who did not participate in the study. However, the fourth-grade students who participated in the study did show higher academic gains than the fourth-grade students who did not participate in the cross-age tutoring study. One reason for the tutors being the only ones to show growth may stem from the fact that they received extra trainings and were more actively involved in the entire process.

Cairo et al. (2005) conducted research on seventh- and eighth-grade students as tutors and third-, fourth-, and fifth-grade students at tutees in a study to explore how cross-age tutoring impacted student knowledge in fraction operations. The tutoring pairs met in daily 30-minute sessions over a 15-day period. Cairo found no significant gains in knowledge of fraction operations for the tutees or tutors in the program when compared to the control group. This finding seems to contradict the results of the previously mentioned studies. Perhaps the difference could be due to the shortened duration of the intervention. Cairo's program only lasted 3 weeks while the other studies presented, which did show positive effects, lasted from 5 to 10 weeks.

Studies have shown positive and neutral effects for students engaged in cross-age tutoring programs. However, the general trend has been an increase in students' academic performance, attitudes, self-concepts, and confidence. Research by Jenkins and Jenkins (1981) also showed that daily tutoring sessions over a longer period are more effective than longer sessions occurring a few times weekly. Tutoring also nurtures conversation between students, which is an essential component when exploring mathematical principles. "Children adapt strategies as they engage with other children using different strategies and discuss mathematical ideas with their teacher or other children" (Carpenter, Fennema, Franke, Levi, & Empson, 2015, p. 4). With the research thus far, there is little to no work on the effectiveness of cross-age tutoring programs to improve children's abilities to solve mathematics word problems. It is yet to be discovered if in a cross-age tutoring program, tutors could help tutees progress in their use of problem-solving strategies in mathematics, as well as lowering mathematics anxiety.

Problem-Solving Strategies

The Common Core State Standards for Mathematics and the Utah Core Standards for Mathematics require students to learn how to read and solve word problems in several ways. In order to accomplish this task, students must first understand what the question is asking, which can be difficult considering the various types of word problems. CGI recommends that during the initial reading of the problem, the teacher needs to check if the students understand the context of the problem. Student understanding is essential because it is what drives their choice of strategies to use in solving the problem (Carpenter, Fennema, Franke, Levi, & Empson, 2015). Children must then exhibit a variety of skills when attempting to solve a mathematical word problem. Students need to be able to identify numerical information, examine the unrelated part(s) of the problem, and comprehend the correct strategy needed to answer the problem (Hegart et, al. 1995; Xinhua, Swanson, & Marcoulides, 2011). In order to help students develop these skills, teachers (and in this study trained tutors), need to understand how they can use guided instruction to move students through problem-solving strategies. CGI is one method that combines all components of problem solving expected in the Common Core Standards (Carpenter, et al., 2015).

Components of problem solving. Several major skills needed to understand problems include, the ability to represent mathematical problems, devise solution methods, and produce the correct answer (Kilpatrick, Swafford, Findell, & National Research Council, 2001). Students may use a variety of representations. A few examples of representational tools include: oral and written language, drawings, symbols, and fingers (NCTM, 2000). Representations act as a way for students to organize and share their thoughts. As students work through a multistep problem, they can represent each step of the process to assist them in internalizing the problem.

As students create a strategy, they start by creating a model or representation. In order to make the strategy, as Smith & Smith (2014) described as, “workable,“ the representation needs to replicate the problem. Kilpatrick et al. (2001) discussed the value of avoiding simply selecting numbers from a problem, and preparing arithmetic operations. Instead, they advised generating a model or representation that demonstrates mathematically what is happening in the problem. As not all problems are the same, not all strategies are the same either. “The differences in the strategies used to solve. . . problems reflect the different actions described in the problems" (Carpenter, Fennema, Franke, Levi, & Empson, 2015, p. 3). Once the representation and strategy have been accomplished, the student must then accurately solve the problem. For this last step, the students need to use their representation to calculate the correct answer. If both the representation and strategy are accurate, then solving the problem is simple computation.

Common Core standards. *The Common Core State Standards for Mathematics* and the *Utah Core Standards for Mathematics* are sets of college and career readiness standards along with K-12 standards published in 2010 by the National Governor's Association and the Council of Chief State School Officers (National Governor's Association and the Council of Chief State School Officers, 2010). Teachers, parents, and school administrators had the opportunity to give feedback during the creation of the standards. In 2010 Utah decided to create the *Utah Core Standards for Mathematics,* which are exactly the same as the Common Core State Standards. *The Utah Core Standards for Mathematics* are organized into clusters and then into domains. A cluster is a group of related standards and a domain is a mathematical principle made up of a larger group of related standards and clusters. In first grade there are four domains, operations and algebraic thinking, number and operations in base ten, measurement and data, and geometry. Fourth grade mathematics core consists of the same four domains, with an additional domain labeled numbers and operations-fractions.

The first grade standards in the Utah Core Standards for Mathematics state that students should be able to represent and solve problems involving addition and subtraction. A description for the standards specifies that students should be able to use addition and subtraction within 20 to solve word problems involving adding to, taking from, and putting together. This means that the total when adding must equal less than 20 and the amounts in subtraction problems must be less than 20. Kilpatrick et al. (2001) stated that mathematical proficiency has five strands, one of which is strategic competence. Strategic competence is defined as the "ability to formulate, represent, and solve mathematical problems"(p. 116). Another strand included in mathematical proficiency is adaptive reasoning, which means having the "capacity for logical thought, reflection, explanation, and justification" (p. 116). Solving a mathematical problem is a complex procedure. In order for students to proficiently solve mathematical word problems, they need to be able to represent the problem, explain their strategies for solving it, and calculate the correct solution. One method that can be used to help them do this is Cognitively Guided Instruction.

Cognitively Guided Instruction

CGI developers view learning mathematics as going beyond simply completing algorithms. Understanding means that knowledge is connected, knowledge is generative, students can describe and explain their mathematical thinking, and students identify themselves as mathematical thinkers who see that mathematics should make sense and that they have the power to make sense of it (Carpenter, et al., 2015).

When learning is readily connected, students build new knowledge upon previous knowledge. Mathematics that is new to students is easily linked to a variety of existing schemata. These connections support students' movement through the evolution of problem-solving strategies. It is critical for teachers to understand the connections students are making in order to assess their knowledge (Carpenter et al., 1994).

CGI focuses on solving problems. In CGI, problem solving procedures are not stated explicitly; instead, students develop their own strategies, revise their strategies to make them more efficient, and make connections among their ideas. This method allows students to continually enhance their skills and deepen connections when presented with mathematical tasks that are new to students (Carpenter et al., 2015).

Describing, explaining, and justifying mathematical thinking are critical in CGI. Students must learn how to communicate why their strategies work. Students cannot build upon previous knowledge or make deep connections when they do not fully comprehend the work they have done. It can also be beneficial to have students explain others' strategies and even compare strategies to see if they are equivalent. Carpenter and Lehrer (1999) discussed how articulating an idea stems from reflecting on ideas. It is difficult to reflect on an unfamiliar topic; therefore students must understand their work and their thoughts in order to articulate their thinking to others.

Carpenter et al. (2015) also discussed how students who participated in CGI saw themselves as capable problem solvers. These students have developed identities as mathematical thinkers who could use connections, ask questions, and use representations to explore different strategies. Students who are mathematical thinkers will still encounter challenging problems, but they have developed thinking skills they know can help them in their progression through problem-solving strategies and multiple types of strategies.

Progression through problem-solving strategies. Building on cognitive science regarding how students learn, students progress through stages of solving word problems, moving from concrete strategies to more abstract strategies. Initially, children use direct modeling strategies. In the direct modeling stage, students think of the problem one part at a time and use concrete ways of thinking. Students need to represent each part of the problem separately and then count to find the result.

Once students comprehend the direct modeling strategy, they move onto counting strategies. "Counting strategies are related to direct modeling strategies in that they are essentially abstractions of the corresponding direct modeling strategies" (Carpenter et al., 2015, p. 186). Counting strategies is more efficient, more abstract, and can help students develop the ability to view numbers as abstract entities. Counting strategies allow students to focus more on the counting sequence by using numerals in order, rather than using drawings or objects to represent the numbers. As students move through this stage, they become more fluent when they realize how to reverse the method of counting.

The last stage of addition and subtraction strategies is using number facts. "Children learn number facts by noticing relations among number facts. To construct derived facts, children relate unknown to known number facts by implicitly drawing on fundamental properties of number operations" (Carpenter et al., 2015, p. 186). When using derived number fact strategies, students use number facts over time and begin to recall them. As the students are given more experience and opportunities to discuss their strategies, they become more fluent in using derived fact strategies to solve word problems. Many times students will remember a few number facts first, such as doubles, and will use this knowledge to find the answer to other problems.

Cemen (1987) hypothesized that the abstract nature of mathematics could potentially influence the development of mathematics anxiety. Shown in the CGI model, as students progress their thinking becomes more abstract. When given time to explore and understand their work, moving to more abstract ideas is manageable for students. However, when students are forced to move faster than their understanding, the abstract nature of mathematics can be overwhelming and difficult to comprehend. This implies that as students are presented with mathematical work beyond their understanding, their mathematics anxiety may inherently increase. However, if tutors are available to assist children as they use their strategies, anxiety may be kept at bay.

Types of problem-solving strategies. The developers of CGI provide many different types of addition, subtraction, multiplication, and division problems. The three types of problems start simply and move toward more difficult problems. The types of problems used in this study were chosen based on first-grade curriculum. The three types of word problems are *join result unknown, separate result unknown,* and *part-part whole result unknown*.

A *join result unknown* problem starts with a quantity and then adds more to the initial amount. The total is not stated in the problem, thus the student must solve the problem by adding the two numbers together to find the total. (Example: Bruce has 5 apples. Bruce picked 2 more apples. How many apples does Bruce have now? 5 + 2 =). A *separate result unknown* problem starts with a quantity and then removes an amount from the initial quantity. The ending quantity is not stated in the problem, thus the student would typically solve the problem by subtracting the second amount from the first in order to find the total. (Example: Bridget had 8 flowers. She gave away 4 flowers. How many flowers does Bridget have now? 8 – 4 =) A *part-part-whole result unknown* problem starts with one quantity and then gives a completely different amount. The total is not stated in the problem, but it is expected that the student will add the two amounts together to find the solution (Carpenter 2015). (Example: Jeremy has 3 toy cars. Jason has 4 toy cars. How many toy cars are there all together? 3 + 4 =)

Summary

Mathematics anxiety is an issue that was researched from the 1970s to the 1990s and has begun to resurface in the literature over the past 15 years. Recent research is conflicted on whether mathematics anxiety is present in early childhood students. However, the research community agrees that mathematics anxiety may be identified by the later elementary years, (e.g., fourth-, fifth-, and sixth-grade students). Students who experience mathematics anxiety may show minimal symptoms from, not liking mathematics to severe symptoms, to avoiding mathematics courses and decreased academic scores.

Unlike the negative outcomes seen in connection with mathematics anxiety, there are a variety of positive results with the use of cross-age tutoring. Cross-age and peer tutoring research have been employed since the 1970s and continues to the present day. Studies have examined academic achievement, attitude, vocabulary, and many other effects that cross-age tutoring may have on those participating. The majority of the results favor the use of tutoring programs, if they are implemented properly. There is also a great deal of research on different ways to create tutoring programs that consider factors such as duration, frequency of sessions, and tutor trainings.

Chapter 3

Methods

Research has been conducted to examine effects of cross-age tutoring on children's academic growth, attitudes, use of vocabulary, and writing skills. Research has yet to consider how cross-age tutoring sessions, in which older students help younger students, in solving mathematics word problems might affect mathematics anxiety levels for both tutors and tutees.

In this study, I measured the difference from pre-intervention to post-intervention in mathematics anxiety levels for fourth- and first-grade students in each group (trained tutors, untrained tutors, tutees with trained tutors, tutees with untrained tutors, and students with no tutors). Comparisons were made only within grade level and not between levels. I now consider the research design, selection of the participants, the data sources that were used, the procedures that were followed, and how the data were analyzed.

Design

This study followed a mixed methodological approach combined with a pre-post-assessment quasi-experimental design along with participant observation. Three first-grade classes and two fourth-grade classes were included in this study. One intact fourth-grade class and one intact first-grade class constituted the trained-tutors intervention group. One intact fourth-grade class and one intact first-grade class formed the untrained-tutors intervention group. The control group, which used no tutors, comprised one intact first-grade class. This design was chosen in order to explore a practical method of implementing cross-age tutoring. McClure and Vaughan (1997) recommended that a cross-age tutoring program should include one primary grade level along with one intermediate grade level. Based on McClure's suggestion, I chose to use fourth-grade students as the tutors and first-grade students as the tutees.

Participants and Context

The students in this study attended a Title 1 elementary school in Utah. During the 2015-2016 school year, 52% of the students in this school received free or reduced-price lunches. Of the 1,000 students at the school, 692 were White, 212 Hispanic, 29 Pacific Islander, 5 Native American, 12 Asian, 8 African American, and 42 were multiple races. There were 102 students living in homes in which a language other than English was spoken. In this school, 75 of the students were enrolled in special education. There were 150 first graders and 136 fourth graders enrolled in the school during the time of the study, of these students 53 first-grade students and 37 fourth-grade students participated in this study. Of the students who participated in this study, 100% received parental consent (see Appendices A and B). The school and participants were chosen based on convenience sampling. When teachers created the participating classes for the school year, they distributed the students equally among the classes to ensure that they were well balanced in terms of gender, special education, English language learners, academic levels, and behavioral issues.

Data Sources

For this study, I collected pre- and post-test data to examine the extent to which cross-age tutoring affected participants' mathematics anxiety. Two measures were used in this study, one for the tutees and one for the tutors. The same measures were used for each group's pre- and post-test.

Tutee mathematics anxiety measure. I selected the Mathematics Anxiety Scale for Young Children (see Appendix C) by Harari, Vucovik, and Bailey (2013) to use with first graders to measure their pre- and post mathematics anxiety levels. This measure uses 12 items scored on a 4 point scale ranging from yes, kind of, not really, and no. The ranges for final scores are 12-48, with higher scores indicating greater anxiety. The measure created by Harari et al. (2013) uses a mixture of regularly coded items (e.g., “I like being called on in math class.”), and reversely coded items (e.g., “ When it is time for math my head hurts.”). Cronbach’s alpha for the items in this measure was .70. The study reported that mathematics anxiety was negatively correlated with computation skills ($r = -.30$, $p = .002$), and mathematics concepts ($r = -.35$, $p < .001$). In this study, the measure was created and tested on solely first-grade students. Harari and associates created this measure after studying the only other study on the topic at the time focusing on young children by Krinzinger et al. (2009). Krinzinger’s study was unable to determine if their measure adequately assessed young children’s mathematics anxiety. This led Harari to the creation of Mathematics Anxiety Scale for Young Children*,* made specifically to use with first-grade students. The current study assisted in answering the first three research questions in this study. This measure was specified for young children, therefore another age-appropriate measure was selected to assess the fourth graders’ mathematics anxiety.

Tutor mathematics anxiety measure. I chose to use Suinn, Taylor, and Edwards (1988) Mathematics Anxiety Rating Scale, Elementary Form (MARS-E) for the fourth-grade students (see Appendix D). The MARS-E was created for grades 4, 5, and 6. The measure includes 26 items in which students respond on a 5-point Likert rating scale ranging from “not at all nervous” to “very, very nervous.” One example question reads, “When getting your math book and seeing all the numbers in it, how nervous do you feel?” Cronbach’s alpha for the items in this measure was .88. Construct validity was determined through correlations between the MARS-E and scores on the Stanford Achievement Test (SAT). Correlations were significant at the .001 level, including SAT mathematics concepts subtest ($r = -.29$), mathematics applications ($r = -.26$), mathematics computation ($r = -.26$), and SAT score ($r = -.31$). The items were designed to reflect the levels of anxiety students may feel when confronted with situations seen in grades four, five, and six. The outcomes from this measure were used to inform research questions 1, 2, and 3.

Procedures

Specific procedures used in this study were: (a) selection of intervention and control groups; (b) teachers' self reports; (c) pre- and post-test measures; (d) instructions on problem-solving strategies; (e); training of tutors; (f) cross-age tutoring sessions; and (g) verification of implementation fidelity.

Intervention and control groups. The first-grade classes participating in the study remained intact and were randomly assigned to participate in the trained-tutors intervention group, untrained-tutors intervention group, or in the control group with no tutors. Students in the fourth-grade classes were randomly assigned to the trained tutors intervention group or the untrained tutors intervention group. Each fourth grader participating as a tutor in the cross-age tutoring sessions was paired with a first-grade tutee from his or her assigned group with no attention to academic levels.

Teachers' self reports. To account for each group having a different regular classroom teacher, the teachers were given a self-report survey (see Appendix E). The purpose of the survey was to assess if the teachers were using standards-based instructional strategies (Ross, McDougall, Hogaboam, & LeSage, 2003). This study used a total of nine dimensions when creating the items to assess the use of standards-based teaching. The dimensions are as follows: program scope, student tasks, discovery, teacher's role, manipulatives and tools, student-student interaction, student assessment, teacher's conceptions of mathematics as a discipline, and student confidence. The survey has 20 items scored on a Likert 6-point scale. The five teachers who participated in the cross-age tutoring study, received averages ranging from 3.3 to 4.1. These scores show that the participating teachers engaged in standards-based teaching at what appears to be a moderate level.

Just as Ross et al., used classroom visits as evidence of concurrent validity, I observed each participating teacher for 20 to 30 minutes during her mathematics instruction time. The purpose of this observation was to see if the teachers were similar in their teaching styles as to not highly impact the outcome of the study.

Pre- and post-test measures. Before implementing cross-age tutoring, I gave a mathematics anxiety assessment, Mathematics Anxiety Scale for Young Children (Harari, Vucovik, & Bailey, 2013), to the tutees. When administering this measure, I read the instructions and then gave the test orally to each student one at a time. I also recorded the answers for each student. At the conclusion of the cross-age tutoring program, I administered the mathematics anxiety assessments following the same protocol.

The tutors also received a mathematics anxiety assessment, Mathematics Anxiety Rating Scale, Elementary Form (Suinn, Taylor, & Edwards, 1988), administered by myself. The assessment was administered individually. The same measures were given to the same students at the end of the 10-week cross-age tutoring sessions. The protocols remained the same when administering the tests.

Instructions on how to solve problems. Before beginning the cross-age tutoring sessions, I taught three 20-minute mini lessons to all of the first grade students participating in the study. The purpose for these lessons was to help all first graders to become familiar with the problem solving process they were expected to use during the tutoring sessions. During the mini lessons, students were presented with a mathematics word problem and asked a question to check for understanding of the problem. All word problems that were used during the mini lessons, tutor trainings, and tutoring sessions were either extracted or adapted problems developed by Smith and Smith (2013) (see Appendix F). Although this adaptation has not been used previously, a measurement and evaluation specialist who guides a doctoral program examined this measure for face validity. These problems were also tested for face validity on students who were similar ages and academic levels to the participants in the study.

Next the students were given time to solve the problem. Students were allowed to use manipulatives such as blocks to help them find the solution, and they were encouraged to create drawings to represent the problem. Students were asked to solve the problem two different ways. At the end of the lesson, I met with the first graders to review some of the ways they found to solve their problems. Students had the chance to explain how they solved the problems and to ask questions. The regular education teachers did not participate during the tutoring sessions, and the sessions did not take the place of the regular classroom mathematics lessons.

The two intervention groups and the control group were to use the problem-solving processes learned from the mini lessons during the tutoring program. The trained and untrained tutoring groups received help from a tutor when solving the assigned word problem, while the untutored group was expected to work independently. Detailed lesson plans for the mini lessons are included in Appendix G.

Training of tutors. Prior to the cross-age tutoring sessions, I taught three 20-minute training lessons to the fourth-grade tutors who participated in the trained-tutor group. The untrained-tutor group did not receive this training. The training was created using concepts from CGI and *Principles and Standards for School Mathematics* (NCTM, 2000). These resources focus on the use of social interaction with peers, communicating ideas and processes, making connections to prior knowledge, and receiving instant feedback. By implementing and teaching skills such as these during the tutor trainings, the tutors were prepared to work with the tutees by having experienced the skills first hand in a structured environment. The goal was that by applying these processes, the students would feel more comfortable and confident in their mathematical abilities and that, in return, would lower their anxiety of mathematics. The protocols for the tutor training sessions are included in Appendix H.

Students in the training were given a problem and asked a comprehension question to check for understanding of the problem. Then they were asked to find two ways of solving the problem and given time to solve the problem. Students were allowed to use materials such as blocks, fingers, and drawing space as needed. I then met with the students and discussed ways of solving the problem. Students were asked to share how they solved the problem and to ask questions. Tutors were told that this would be the procedure during their tutoring sessions. The trained tutors were also taught how to assist and guide the tutees through the problem without giving direct answers. Trained tutors learned to help only when the tutee had already tried using known strategies. The trained tutors learned how to ask questions to help the tutees progress through solving the problem (see Appendix I). If the tutee still struggled to solve the problem, then the trained tutor was instructed to use strategic questions to help guide the tutee. If the tutee still struggled, the tutor could give the tutee smaller numbers to use in the problem or give the tutee a completely new problem. A checklist was provided for the fourth grade trained tutors to record their tutees' understandings of the problem, what type of strategy and tools they used to solve the problem and insights or questions they gained from the session that day (see Appendix J). During the lessons, the tutors were shown how to use the checklist.

Tutors received a tutoring folder. In this folder, the tutors kept notes from their trainings and papers from their tutoring sessions, such as the work they did during the tutoring session with their tutees. I explained that the folders should be passed to me after every time we meet and then I would distribute the folders at the beginning of every tutoring training and cross-age tutoring session.

Throughout the cross-age tutoring sessions, I met with the trained-tutors group every week for 15 minutes to continue practicing the tutoring session procedures and to talk about any questions from the tutors. During the weekly tutor trainings, the group continued to work on comprehending, solving, and explaining word problems as they did during their previous tutoring trainings. Time was also left each week for students' questions.

Cross-age tutoring sessions. Modeled after the Mitchell et al. study (2016), which displayed differences after a 9-week program, this study was conducted over 10 weeks. During the program there were 2 weeks during which the pairs met only once a week because of breaks in the school year. The tutees in the intervention groups met with their tutors twice a week for 15 minutes in the first-grade classrooms. A total of 18 cross-age tutoring sessions were held, totaling 4.5 hours. The total amount of time I spent training and debriefing with the trained tutors was 8.5 hours, similar to the 9.75 hours reported by Mitchell et al. (2016). While the tutors in the intervention groups met with their tutees in the classrooms, the untutored first graders worked independently on solving their mathematical word problems in their own classrooms. I scheduled each group to work at a different time so that I could be present for all of the tutoring sessions. For the students with no tutors, I read the problem aloud with the group and then monitored the class as they worked alone. I did not give any additional help. All three groups, trained, untrained, and no tutors worked on the same problems and received the same lessons.

As mentioned previously, the trained tutors received tutoring folders during their trainings to keep all work from the sessions and their trainings. Then, on the first day of the tutoring sessions the untrained tutors and the students with no tutors also received a tutoring folder. The students were told to keep all papers from their tutoring sessions in their tutoring folder. Students were told that they will return the folders to me and that I would pass out the folders at the beginning of every tutoring session.

At the time of each session, the tutoring pairs or students with no tutors received a paper with a word problem. The tutor and tutee wrote their names at the top of the paper. During the cross-age tutoring sessions, the tutors worked with their tutees to read the word problems and worked together to solve the problem. The trained tutors used checklists to record what strategies were used and other notes. The trained tutors had the opportunity to refer to their notes from their trainings and use their previous knowledge to help their tutee. The untrained tutors had the freedom to help their tutee however they deemed fit. The students with no tutors worked alone and used any strategy they chose. Each group met in a separate classroom to keep the sessions private from one another. At the end of each session, the word problem paper along with any other papers that may have been used were placed in the tutoring folders and returned to me.

Implementation fidelity. Multiple approaches were used to assure fidelity when implementing the strategies. I reviewed the trained-tutors' checklists to assess the use of the CGI word problem strategies. Furthermore, I watched the cross-age tutoring sessions to verify that the tutors and tutees were staying on task and completing the assigned work. Observations were recorded in field notes.

Tutor Checklist and Tutoring Session Work

Every trained tutor was given a researcher-developed checklist for each tutoring session based on the items being assessed by the problem solving measure. Tutors used the checklist to record what they worked on that day with their tutees. The checklist included a space for the tutors to record whether the tutee was able to understand the problem, solve the problem correctly, and record the type of strategy the student used (see Appendix J). Tutors were also allotted space to write questions they had, problems they had, or any other notes they wanted to record. Along with the checklist, I collected the tutees' work used during the session to show how they calculated the answer.

Researcher Field Notes

During the study I kept detailed notes after my conversations with the tutors and my classroom observations. These notes helped me to track interactions between the tutors and tutees, the work being done, and the overall implementation of the study. As I conducted each tutoring session, I listened to conversations and observed the atmosphere of the room. Then I would review my notes and observations of each session and add any thoughts or notes I had in regards to this study.

Data Analysis

Using the statistics program, *Statistical Package for the Social Sciences* (IBM Corporation, 2013), I analyzed the pre- and post-test outcomes from the tutees and tutors mathematics anxiety assessments. I ran a split plot analysis of variance to find the main effect for time, the main effect for the different groups, and the interaction between time and groups. This model determined if there was a significant difference between the pre- and post-outcome for each group. A split plot analysis of variance was used to compare first-grade students' within grade level and fourth-grade students' within grade level results on their mathematics anxiety. This analysis was used to answer research questions 1, 2, and 3.

I chose to use *Designing Qualitative Research* (Marshall & Rossman, 2011) to guide my analysis of the qualitative data kept in the form of researcher field notes and observations. The authors recommend organizing the data, immersing yourself in the data, coding the data, and creating themes. I chose to organize data during and after the study. As I observed the tutoring sessions and viewed student work, I asked myself questions to direct my note taking. I questioned the type of language I heard from the students and if the students were trying new strategies or using the same strategies from week to week. I also listened to see if tutors were asking questions to their tutees, having their tutees explain their work, and if there was any positive feedback occurring between the pairs. After every session I reviewed my observations and added more notes of the insights I gained that day. When reviewing my data at the end of the program, I discovered some major themes including: feedback, mathematical processes, and tutor/tutee conversations. These themes helped me to make sense of the environment created by the different groups of students.

Chapter 4

Results

This study examined the effects of cross-age tutoring on students' mathematics anxiety. Mathematics anxiety was measured between groups within each grade level. This chapter includes descriptive statistics for each grade level and results to answer the research questions. The first three research questions addressed the effect of cross-age tutoring on mathematics anxiety based on time and assigned tutoring group. The fourth research question dealt with interactions of the tutees with their tutors based on assigned groups. The results for the first-grade students are presented first, followed by the results for the fourth-grade students, and finally the comparison of the trained tutor pairs' and the untrained tutor pairs' interactions.

First-Grade Students' Mathematics Anxiety

A total of 53 first-grade students participated in the study. All students completed the entire 10-week program. Table 1 shows the number of first-grade students involved and their pre- and post-test mean, median, and standard deviation. There was no change in the median score for the grade level, however the mean decreased by 1.19.

Table 1

First-Grade Mathematics Anxiety Pre- and Post-Test Results

	Mean	Median	SD
First-Grade Pretest Mathematics Anxiety (n= 53)	21.34	20.00	4.93
First-Grade Posttest Mathematics Anxiety (n=53)	20.15	20.00	5.07

A 3 X 2 mixed-design ANOVA was calculated to examine the effects of the tutees (trained tutor, untrained tutor, no tutor) and time (pretest and posttest) on mathematics anxiety. As shown in Table 2, no significant main effects or interactions were found. The time x tutee interaction ($F(2,50) = .509$, $p > .05$), the main effect for time ($F(1,50) = 2.28$, $p > .05$), and the main effect for tutee ($F(2,50) = .141$, $p > .05$), were not significant. Mathematics anxiety scores were not influenced by either time or tutee. Figure 1 displays that each of the first-grade groups did decrease in mathematics anxiety, however insignificantly. The greatest decline is seen in the first-grade tutees who were partnered with an untrained tutor, whereas the group with the least amount of decline in mathematics anxiety were the first-grade tutees who received no tutor.

Table 2

Split Plot ANOVA Results for Tutees

Parameter	*df*	*f*	*p*
Time	1	2.29	.137
Group	2	.14	.868
Interaction	2	.51	.604

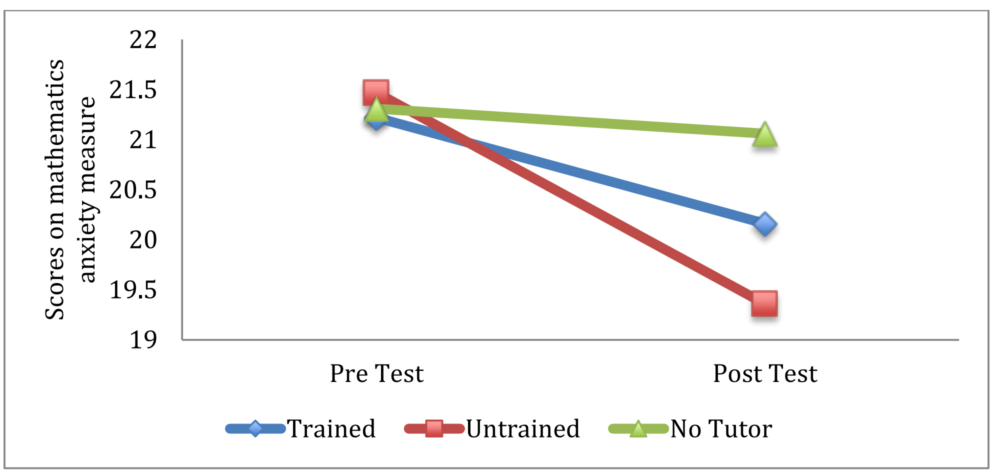

Figure 1. First-grade students' mathematics anxiety pre- and post-test scores by group

Fourth Grade Students' Mathematics Anxiety

A total of 37 fourth-grade students participated in the study. All students were present for the entire 10-week program. Table 3 shows the number of fourth-grade students involved and their pre- and posttest mean, median, and standard deviation. Table 3 shows a six-point decrease in the median mathematics anxiety score from before the intervention to after the intervention, as well as the 0.57 decrease in the mean score.

Table 3

Fourth-Grade Mathematics Anxiety Pre- and Post-Test Results

	Mean	Median	SD
Fourth-Grade Pretest Mathematics Anxiety (n= 37)	48.43	46	14.33
Fourth-Grade Posttest Mathematics Anxiety (n=37)	48.43	40	16.11

A 2 X 2 mixed-design ANOVA was calculated to examine the effects of the tutors (Trained tutor, untrained tutor) and time (pretest and posttest) on mathematics anxiety. The time x tutor interaction ($F(1,35) = 2.16$, $p > .05$), the main effect for time ($F(1,35) = .154$, $p > .05$), and the main effect for tutor ($F(1,35) = 427.12$, $p > .05$), were not significant. Mathematics anxiety scores were not influenced by either time or tutor. Figure 2 shows that as the trained tutor group's mathematics anxiety decreased, the untrained tutor group's mathematics anxiety increased, although neither group was significant.

Trained Tutoring Pairs and Untrained Tutoring Pairs

The fourth research question addressed the difference in how trained tutors and untrained tutors interacted with their tutees during the tutoring sessions. Observations and field notes kept during the study showed rich conversation and on-task behavior from the trained tutor pairs. The untrained tutor pairs spoke much less to one another concerning the work and had to be redirected multiple times during each tutoring session. The following section reports the feedback, mathematical processes, and conversations of each group.

Table 4

Split Plot ANOVA Results for Tutors

Parameter	*df*	*f*	*p*
Time	1	0.15	.697
Group	1	0.03	.870
Interaction	1	2.16	.150

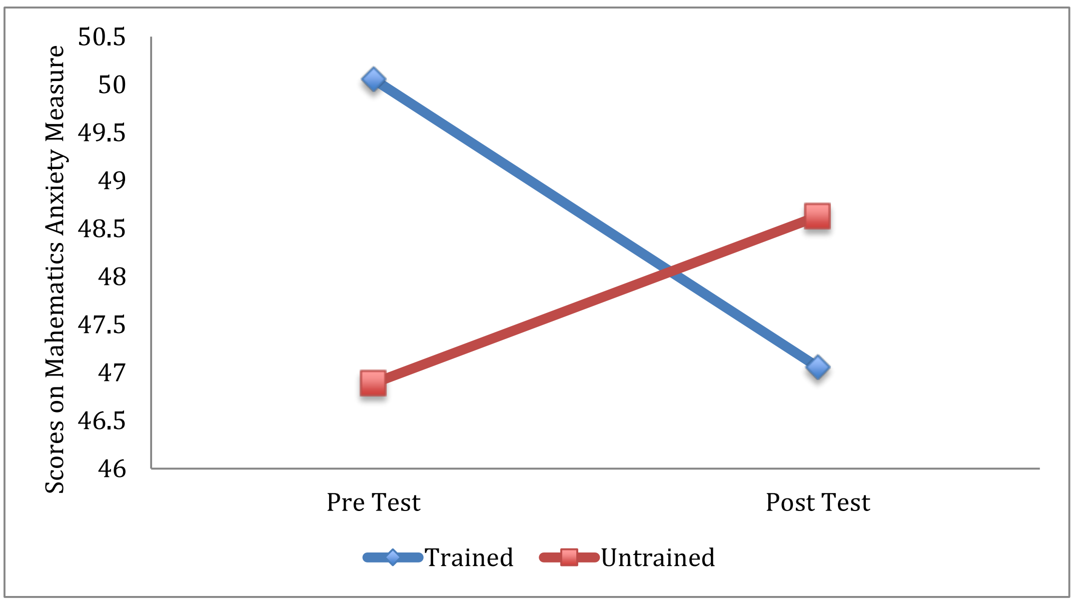

Figure 2. Fourth-grade students' mathematics anxiety pre- and post-test scores by group

Feedback. The trained tutors used a variety of methods to praise and redirect. Examples of verbal praises the tutors used include, "Great" (Field Notes, 11/11/15) and, "You are so close" (10/14/15). Overall, the pairs in the trained group stayed on task, but one tutee struggled to keep his focus most days. His tutor did an effective job of staying with him and trying new ideas to get him excited. The tutor would say, "Let's talk about that after math" (Field Notes, 11/6/15) and she would find ways to relate the problem to the tutee's life, such as by asking, "Have you ever been to the store with your mom?" The tutor also moved the tutee to a new location that was quieter to help remove the distractions. The untrained group also used verbal praise throughout the sessions such as, “Good job” (11/20/15) and “Yes” while throwing hands in the air (11/11/15). These examples of feedback show higher levels of positive attitude than the control group. When working together the pairs were excited and exemplified their attitudes through verbal and physical feedback.

Mathematical processes. Appendix K shows student samples from session 3 to session 15 for each group. The example from the control group shows almost no change from the beginning of the study to the end. As shown, the student draws out each amount from the problem in their work area on the paper. The only difference is the organization of the representation. One thing to note is the use of the equation in the first sample and that the equation is not included in the second sample.

The untrained tutor group was able to show progress overall in their use of problem-solving strategies but did not advance as far as the trained group. The untrained pairs started the same way by representing problems with blocks and drawings and then moved on to writing equations and counting on from the initial amounts. However, as shown in Appendix K this student’s work was almost identical from beginning to end. The major differences are the use of the plus sign to organize the amounts and adding the total for the second example.

The trained group showed the widest variety of ways to solve problems from using blocks to represent the problem, to drawing circles to represent the problem, to writing an equation, to simplifying the equation into smaller more manageable steps. With the help of the trained tutors, the tutees were able to try and learn new skills and strategies. This group showed more focus and progress compared to the other groups. By creating new strategies and trying different methods, the tutees in this group showed a great level of confidence than before.

Appendix K displays how the students in the trained group started with the same strategy as the students from the other groups. However, when looking at the work from session 15, it is apparent that the student has progressed and developed new ways of solving word problems. The student has circled numbers from the problem showing that they first wanted to understand the problem and then picked amount from the problem that they are familiar with in order to make solving the problem easier. By viewing the three student samples it is simple to see the difference in mathematical processes chosen by each group.

Tutor/ tutee conversation. For the duration of the 18 tutoring sessions, the trained tutors stayed focused on their tutees. Before the tutoring sessions began, I taught three mini lessons to the tutors and conducted trainings every week during the study. During that time I worked with the trained tutors on how to ask questions and discuss the problems with their tutees.

From the first session, the trained tutors used questions to help guide their work with their tutees. Trained tutors asked questions such as, “Could we add a plus sign in the picture?” (Field Notes, 10/21/15) and “Could we solve the problem another way?” (Field Notes, 10/28/15) and, “Will you tell me what you drew and why?” (11/13/15).

In the untrained group, the pairs were in closer proximity and not as focused on the work as the trained group. The pairs would sometimes talk to other pairs in the classroom about other subjects. The tutees and tutors spent time during the sessions talking about what was happening in their lives and took time getting to know each other. On multiple occasions, I redirected this group to get back to work, which they usually did quickly. Some tutors in this group were paired with tutees who struggled to focus and get their work done. These tutors were unable to get much done with their tutees and typically the pairs would waste the majority of the time as the tutees got distracted with manipulatives and drawings.

Chapter 5

Discussion

Mathematics anxiety is an issue that has been present in elementary-aged students for decades and continues to be a problem today. Few studies have examined in-class methods to help students who struggle with anxiety. Furthermore, recent research is beginning to study if mathematics anxiety exists in primary grade levels and how to identify it (Harari, Vucovik, & Bailey, 2013; Jameson, 2013; Krinzinger, Kaufman, & Willmes, 2009). This study set out to determine if cross-age tutoring could help alleviate the anxiety. This chapter will include a personal reflection, discuss mathematics anxiety, and the effects on first- and fourth-grade students. I then conclude with the implications and limitations of the study and how these results may impact current and future education and research.

Reflection

The overall results indicate that mathematics anxiety is present in young students, however I was unable to determine if cross-age tutoring has the potential to alleviate students' anxiety levels significantly. Although the results from the quasi-experimental portion of my research were insignificant, this study offers insights into detecting mathematics anxiety and ways to benefit multiple grade levels by implementing cross-age tutoring. As I was able to take a step back from being the teacher to fulfill my role as qualitative researcher, I was able to see results from different perspectives. I was surprised to find how vastly different each group behaved and progressed. The control group showed almost no change from the beginning of the program to the end, while others advanced quite far in their work and relationships.

Identifying Mathematics Anxiety

Results of this study included an unexpected finding that mathematics anxiety was identified in students as young as six years old. The creation of mathematics anxiety measures for young children is in its infancy, and still has not been able to identify if anxiety even exists. The measure I used to gauge mathematics anxiety in first-grade students (Harari, Vucovik, & Bailey, 2013), proved effective in identifying first-grade students who have mathematics anxiety and showing the level of that anxiety. In their study, Harari et al. (2013) reported an average score on their measure of 22.69, which the author considered a moderate score. I found that of the 53 first-grade students participating in this study, 45% received a score of 22 or higher on their mathematics anxiety pre-test. This research supports the measure created by Harari et al., and the other researchers working to identify mathematics anxiety in primary grades. Furthermore, as I tested one first-grader with high mathematics anxiety, he began to express his feelings on mathematics and how frustrated and stressed it made him feel. The boy had already displayed feelings of hopelessness and anger towards mathematics by the age of six. This experience does not imply that all first-grade students have mathematics anxiety or that it is the grade level with the highest amount of anxiety. However, mathematics anxiety does exist in young children and can be identified at an early age.

Effects of Tutoring Sessions on First Graders

As expected, the students who worked independently showed the lowest decrease in mathematics anxiety. From field notes and collected work, I was able to witness the almost nonexistent progress made in this group. For the entire 10-week period, most students in this group remained in their comfort zone of solving problems by using blocks or drawing direct representations of the problems in their assignments. As the numbers in the problems increased in value, the non-tutored group showed more signs of hesitation to complete the work and produced more incorrect answers than any other group of first graders.

Compared with the non-tutored group, the first graders who worked with tutors showed substantial progress throughout the tutoring program. The tutees who worked with untrained tutors surprisingly had the highest decrease in mathematics anxiety for their grade level. Though insignificant, this trend was not consistent with my hypothesis that the tutees with trained tutors would decrease the most. Observations showed there were positive outcomes with the untrained group as well as some undesirable outcomes. This group seemed to create strong relationships as a whole. In observed field notes, I recorded multiple conversations happening between the pairs unrelated to mathematics (10/29/15). The pairs were, instead, focusing on their personal lives and making connections with one another (11/5/15). The pairs seemed to be developing meaningful relationships and trust. From the teacher's point of view, the students were off task and not working to their full potential on their mathematics assignments. The pairs were not having meaningful mathematical conversations and typically did not talk about how or why the tutees solved the problems using certain strategies. Many students in this group did show progression through the CGI problem-solving strategies; however they did not show not as much progression as the tutees with the trained tutors. I wonder if having the casual and relaxed environment enabled the tutees to feel more relaxed and thus helped to relieve their anxiety mildly.

Unlike the casual and relaxed environment of the tutees with untrained tutors, the tutees with the trained tutors had a more structured environment. These pairs still exhibited positive relationships and took small amounts of time to get to know one another; however, the trained tutors appeared to keep their tutees on task during the sessions (11/11/15). From a teacher's perspective, this group was most effective. The pairs were on task, having focused conversations about mathematics, trying new strategies, and working as teams (11/13/15). The students in this group eventually stopped using manipulatives and started creating and exploring their own strategies to solving problems (11/11/15). The tutors asked great questions, allowing the tutees to explain and discuss their ideas about their work (12/2/15). The tutors in this group acted more as guides, helping their tutees when needed instead of trying to explicitly tell them what to do to solve the problems (12/4/15). Contrary to my prediction, this group showed a slightly lower trend in decreased mathematics anxiety as compared to the tutees with untrained tutors. There are numerous reasons why this may have occurred. It could have been because the tutees with trained tutors had to do more work than the tutees with the untrained tutors, the presence of the checklist, or that they did not feel as friendly with their tutors as the other group did.

Overall, observations showed both tutored groups showed benefits compared to the group with no tutors. If I were going to implement this practice in my classroom, I would say that cross-age tutoring could be beneficial in keeping students on task and creating social relationships. I could not use the method confidently to decrease mathematics anxiety.

Effects of Tutoring Sessions on Fourth Graders

There were only two groups of fourth graders, trained and untrained tutors. Consistent with my predictions, the trained tutors' mathematics anxiety did decrease as the untrained tutors anxiety increased, though not significant. I had expected to see a larger drop in the trained tutors' mathematics anxiety than that of the untrained tutors; however, I was surprised to see that the untrained tutors' anxiety actually increased from their pre-test score.

As noted earlier, the untrained tutor group was extremely relaxed and casual. As the 10-week program continued, I found myself having to quiet the group and redirect them frequently

(12/4/15). I never had to do this in the trained tutors' sessions. The untrained tutors worked well to create positive relationships with their tutees, but they also distracted each other often (12/11/15). This seemed to amplify the relaxed environment by allowing the pairs to work and socialize simultaneously. These tutors were also given minimal expectations and support. This may have impacted the type of work being produced.

Observations of the trained tutor group contrasted the views of the untrained tutor group. The environment was more hushed and each member of the pair was focused on his or her partner rather than those around them (11/19/15). This focus enabled the tutors to talk more with their partners and aid them in trying new ideas. The trained tutors were also given additional support to help them throughout the tutoring sessions. I met with the trained tutors once each week throughout the tutoring program. I would work with them on using different strategies, communicating with their tutees, and encouraging the use of questions and praising (11/16/15). I would answer any questions they had such as, "What do I do when the first grader won't try?" or "What if he gets it wrong?" (10/19/15)

The tutors received a checklist and question guide for every session. The checklists seemed to help the tutors when they got stuck. Tutors showed skills by using their question guide to help them in making conversations with their tutees about the work being done (11/20/15). The trained tutors also made connections from our class discussions to their work with their tutees. For example, after discussing giving specific praise, I recorded high numbers of specific compliments (10/21/15). The trained tutors appeared to have taken on the role of teacher for their tutees, whereas the untrained tutors took on the role of friend (11/4/15). The trained tutors could redirect and help their tutees focus without much help from me. These tutors took on the responsibility of finding new ways to support their tutees.

There is no question from this research about which group I would recommend concerning the use of tutors. The trained tutor group showed more progress than the untrained tutors in developed conversations, connections to content knowledge, and self-directed management. The untrained tutors showed none of the growth of the trained tutors, although they did develop good friendships with their tutees.

Implications

Perhaps the greatest implication of this study was unplanned. It validated the use of the Mathematics Anxiety Scale for Young Children and showed it was effective in identifying first graders with mathematics anxiety (Harari, Vucovik, & Bailey, 2013). In many cases, teachers take the responsibility of teaching and helping students on themselves. During this research, I found that using cross-age tutoring in the classroom has the potential to help in multiple ways. It may or may not help alleviate mathematics anxiety, based on the qualitative results of this study. However qualitative measures showed that cross-age tutoring seemed to motivate students to try new methods for learning and feel excited about the work. Prior to this study, I viewed cross-age tutoring in elementary school as superficial and troublesome to implement. Now I see how multiple types of tutoring, trained and untrained, may benefit both the tutors and the tutees.

Limitations

This mixed methodological study consisted of a small sample size including only 53 first graders and 37 fourth graders. The small sample may be one reason there were no significant results. Furthermore, in order to leave the classes intact, I was unable to use random sampling of the participants. Lastly, the classroom teachers in this study were a confounding variable. Although steps were taken to assess the teachers, there was no way to control what or how the teachers taught lessons in their own classrooms. Nevertheless, qualitative results do produce insights that may be useful to educators using or considering cross-age tutoring, although results are not transferrable.

Future Research

This study provided information regarding the identification of childhood mathematics anxiety, but the in-class reduction intervention was not effective. More research is needed in order to examine cost-effective ways to lower mathematics anxiety. Further research replicating these research questions may be completed with larger sample sizes to determine significance for a general population. Additional studies may also look at conducting the tutoring program for a longer duration, as well as increasing the frequency of tutoring sessions. As Jenkins and Jenkins (1981) found, it is most beneficial for the tutors and tutees to have daily tutoring sessions. It would also be interesting to include interviews concerning anxiety of the first- and fourth-grade students and their perceptions of the tutoring sessions. This study showed that trained tutors were more effective in working with partners and engaging them in problem solving than the untrained tutors. Future research should examine the effect of cross-age tutors on problem solving skills as well as mathematics anxiety. Lastly, this is the first study to use both the MARS-E and the Mathematics Anxiety Scale for Young Children. More research should be done to see how these two measures correlate. There is much more to be discovered about how cross-age tutoring affects tutors and tutees when focusing on mathematics.

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APPENDIX A:

Parental Permission Form

Parental Permission for a Minor

Introduction

My name is Camille Rougeau. I am a graduate student from Brigham Young University. I am conducting a research study about how cross-age tutoring affects mathematics anxiety. I am inviting your child to take part in the research because he or she is in either fourth or first grade at Vineyard Elementary School and will have the opportunity to participate in the tutoring sessions.

Procedures

If you agree to let your child participate in this research study, the following will occur:
You child will be assigned to be a tutor or a tutee. All tutees will have three lessons on solving mathematics word problems. The lessons will each last about 20 minutes. The trained tutors will have three training lessons were they practice solving mathematics word problems and learning how to help their tutee. These trainings will last about 25 minutes. Some tutors will receive extra training. Some tutees will have tutors with training, others will have tutors with no training, and some will have no tutors. This will take place in their regular classroom. There will be 20 tutoring sessions that will last for 15 minutes. The trained tutors will also meet with me for 15 extra minutes every week during the study to talk about their findings. The students will be tested on their mathematics anxiety and problem solving skills before and after the study. Overall the tests should take about 20 minutes to complete.

Risks

There is a risk of loss of privacy, which the researcher will reduce by not using any real names or other identifiers in the written report. The researcher will also keep all data on a password-protected computer. Only the researcher will have access to the data. At the end of the study, data will be kept on a password protected hard drive.
There may be some discomfort caused by being asked some of the questions on the tests or by participating in the tutoring sessions. If the child indicates in any way that he/she does not want to participate by crying or other behavior, we will stop immediately. Your child may stop the entire process at any time without affecting his/her standing in school or grades in class.

Confidentiality

The research data will be kept on a password protected computer and only the researcher will have access to the data. At the conclusion of the study, all identifying information will be removed and the data will be kept on the password protected computer. The data will be kept for five years.

Benefits

There are no direct benefits for your child's participation in this project.

Compensation

Participants will receive a miniature candy bar for returning this form. Students who do not return this form will also receive a miniature candy bar after the due date.

Questions about the Research

Please direct any further questions about the study to Camille Rougeau at crougeau@alpinedistrict.org. You may also contact Brad Wilcox at brad_wilcox@byu.edu. Questions about your child's rights as a study participant or to submit comment or complaints about the study should be directed to the IRB Administrator, Brigham Young University, A-285 ASB, Provo, UT 84602. Call (801) 422-1461 or send emails to irb@byu.edu.
You have been given a copy of this consent form to keep.

Participation

Participation in this research study is voluntary. You are free to decline to have your child participate in this research study. You may withdraw you child's participation at any point without affecting your child's grade or standing in school**.**

Child's Name: ______________________________

Parent Name: ____________________

Signature: ________________________

Date: ____________

APPENDIX B:

Student Assent Forms

Child Assent (7-14 years old)

What is this research about?

My name is Camille Rougeau and I am a graduate student at Brigham Young University. I want to tell you about a research study I am doing. A research study is a special way to find the answers to questions. We are trying to learn more about tutoring and if it makes you feel less nervous during math time. You are being asked to join the study because you are in fourth grade and have the chance to be in a tutoring group.

If you decide you want to be in this study, this is what will happen.

1. You will answer some questions about how you feel in math class.
2. You will solve 3 math word problems.
3. You may get to go to trainings and work with me on how to solve math problems.
3. You will become a tutor and will get to work with a partner to solve word problems. You will do this twice a week for 10 weeks. Some tutors will be trained and will get to meet again for an extra 15 minutes every week.
4. At the end of the tutoring program, you will answer the same questions about how you feel in math class.
5. After that you will solve the same 3 math word problems.

Can anything bad happen to me?

You may not want to answer questions or work with a partner.

Can anything good happen to me?

We don't know if being in this study will help you, but we hope to learn something that will help other people some day.

Do I have other choices?

You can choose not to be in this study.

Will anyone know I am in the study?

We won't tell anyone you took part in this study. When we are done with the study, we will write a report about what we learned. We won't use your name in the report.

What happens if I get hurt?

Your parent or legal guardian has been told what to do if you become hurt during this program.

What if I do not want to do this?

You don't have to be in this study. It's up to you. If you say yes now, but change your mind later, that's okay too. All you have to do is tell us.

You will receive a miniature candy bar for being in this research study. Before you say yes to be in this study be sure to ask Camille Rougeau to tell you more about anything that you don't understand.

If you want to be in this study, please sign and print your name.

Name (Printed): ____________________

Signature ________________________ Date: ____________

First grade students were read the following script and asked for oral assent.

"My name is Ms. Rougeau and I am a student at Brigham Young University. I am working on a project where I get to work with students during a tutoring program. A tutoring program is where students work with a partner to finish their work. I am inviting you to join me because you are in first grade. If you choose to join me, you might get to work with a fourth grade student while you solve math problems. You will answer some questions about how you feel during math time. You will also get to answer a few math word problems. You will also have a few lessons with me on how to solve word problems. You get to choose if you join me in the project or not. If you would like to join me please say yes, if you would not like to join me, please say no."

APPENDIX C:

Mathematics Anxiety Scale for Young Children by Harari, R. R., Vukovic, R. K., & Bailey, S. P. (2013)

Name: ____________________

1. I like doing a math problem like this: 124 + 329[a] ___________

2. When it is time for math my head hurts.[b] ___________

3. Math gives me a stomachache.[b] ___________

4. I am scared in math class.[b] ___________

5. I like being called on in math class.[a] ___________

6. When it is time for math my heart beats fast.[b] ___________

7. I like doing math problems on the board in front of the class.[a] ___________

8. I get nervous about making a mistake in math.[b] ___________

9. Getting out my math books makes me nervous.[b] ___________

10. I like to raise my hand in math class.[a] ___________

11. Figuring out if I have enough money to buy cookies and a drink is fun.[a] ___________

12. When the teacher calls on me to tell my answer to the class, I get nervous.[b] ________

Note. Students responded to each item using a 4-point scale; values from 1 to 4 were assigned to each item so that higher scores indicated greater anxiety.

[a]Item was coded so that yes = 1, kind of = 2, not really = 3, and no = 4. [b]Item was coded so that yes = 4, kind of = 3, not really = 2, and no = 1.

APPENDIX D

Mathematics Anxiety Rating Scale- Elementary Form

MATHEMATICS ANXIETY RATING SCALE-E (MARS-E)

The items below are about things that may bother you or cause you to be nervous or anxious or tense when you have to do them. Place a check (✓) in the circle that shows how nervous you would feel.

Here is an example:

Mark how nervous or anxious you would feel: in adding 4 + 5.

If you would feel very, very nervous in adding 4 + 5, then you would place a check (✓) in the circle under "Very, very nervous".

Not at all nervous	Not very nervous	Fairly nervous	Very nervous	Very, very nervous
O	O	O	O	✓

If you would not feel nervous at all adding 4 + 5, then you would put a check (✓) in the circle under "Not at all".

Not at all nervous	Not very nervous	Fairly nervous	Very nervous	Very, very nervous
✓	O	O	O	O

Now do the following sample:

Mark how nervous you would feel: in adding 976 + 50 in your head.

Not at all nervous	Not very nervous	Fairly nervous	Very nervous	Very, very nervous
O	O	O	O	O

Now read each of the items on the next pages and mark how nervous or anxious or tense you would feel. Be sure to answer every question.

Published by RMBSI, Inc., P.O. Box 1066, Fort Collins, CO 80522.

		Not at all nervous	Not very nervous	Fairly nervous	Very nervous	Very, very nervous
1.	How nervous or tense would you feel if you had to solve this problem: *George brought 4 boxes of toy cars to class. If each box had 7 cars, how many toy cars did George bring?*	O	O	O	O	O
2.	Mark how nervous or tense you would feel if you had to decide if this problem is right: (3 + 4) + 2 = 4 + (2 + 3).	O	O	O	O	O
3.	How nervous or tense do you feel reading this problem: *Babe Ruth was known as the Home Run King. He had 54 home runs in 1920, 59 in 1921, and his best of 80 in 1928. How many home runs did he hit in all three years?*	O	O	O	O	O
4.	Mark how nervous you feel when you have to add 976 + 777 + 458 on paper.	O	O	O	O	O
5.	If you had to add up a cash register receipt after you bought several things.	O	O	O	O	O
6.	When counting how much change you should get back after buying something, how nervous do you feel?	O	O	O	O	O
7.	When getting your math book and seeing all the numbers in it, how nervous do you feel?	O	O	O	O	O
8.	Getting called on by the teacher to do a math problem on the board (how nervous do you feel)?	O	O	O	O	O
9.	Raising your hand in math class to ask a question about something you don't understand.	O	O	O	O	O

		Not at all nervous	Not very nervous	Fairly nervous	Very nervous	Very, very nervous
10.	Looking at how much two different sizes of two different kinds of soft drinks cost and deciding which is cheaper.	O	O	O	O	O
11.	Starting to read a hard new chapter for your math homework.	O	O	O	O	O
12.	Being asked by your teacher to tell how you got your answer to a math problem.	O	O	O	O	O
13.	Taking a big test in your math class.	O	O	O	O	O
14.	Sitting down to do your math homework on things you are just starting to learn.	O	O	O	O	O
15.	Thinking about a math test the night before the test.	O	O	O	O	O
16.	Thinking about a math test an hour before the test.	O	O	O	O	O
17.	Thinking about a math test 5 minutes before the test.	O	O	O	O	O
18.	Waiting to get a math test back on which you think you didn't do very well.	O	O	O	O	O
19.	Being given a set of multiplication problems to solve on paper.	O	O	O	O	O
20.	Being given a set of division problems to solve on paper.	O	O	O	O	O
21.	Having to figure out how much each of you owe when you buy a pizza and three soft drinks with two friends.	O	O	O	O	O

		Not at all nervous	Not very nervous	Fairly nervous	Very nervous	Very, very nervous
22.	Counting your change after buying a movie ticket because you think you didn't get enough money back.	O	O	O	O	O
23.	Figuring out what time it will be in 25 minutes.	O	O	O	O	O
24.	Figuring out if you have enough money to buy a candy bar and a soft drink.	O	O	O	O	O
25.	Having someone watch you while you correct your math homework on the blackboard.	O	O	O	O	O
26.	Listening as your teacher tries to help you see how to work a math problem.	O	O	O	O	O

APPENDIX E:

Teacher Self-Report Instrument

1. I like to use math problems that can be solved in many different ways.
   Strongly Agree **Strongly Disagree**
   6 5 4 3 2 1

2. I regularly have my students work through real-life math problems that are of interest to them.
   Strongly Agree **Strongly Disagree**
   6 5 4 3 2 1

3. When two students solve the same math problem correctly using two different strategies I have them share the steps they went through with each other.
   Strongly Agree **Strongly Disagree**
   6 5 4 3 2 1

4. I tend to integrate multiple strands of mathematics within a single unit.
   Strongly Agree **Strongly Disagree**
   6 5 4 3 2 1

5. I often learn from my students during math time because my students come up with ingenious ways of solving problems that I have never thought of.
   Strongly Agree **Strongly Disagree**
   6 5 4 3 2 1

6. It is not very productive for students to work together during math time.
   Strongly Agree **Strongly Disagree**
   6 5 4 3 2 1

7. Every child I my room should feed that mathematics is something he/she can do.
   Strongly Agree **Strongly Disagree**
   6 5 4 3 2 1

8. I integrate math assessment into most math activities.
   Strongly Agree **Strongly Disagree**
   6 5 4 3 2 1

9. In my classes, students learn math best when they can work together to discover mathematical ideas.
   Strongly Agree **Strongly Disagree**
   6 5 4 3 2 1

10. I encourage students to use manipulatives to explain their mathematical ideas to other students.

Strongly Agree **Strongly Disagree**
6 5 4 3 2 1

11. When students are working on math problems, I put more emphasis on getting the correct answer than on the process followed.
Strongly Agree **Strongly Disagree**
6 5 4 3 2 1

12. Creating rubrics for math is a worthwhile assessment strategy.
Strongly Agree **Strongly Disagree**
6 5 4 3 2 1

13. In my class it is just as important for students to learn data management and probability as it is to learn multiplication facts.
Strongly Agree **Strongly Disagree**
6 5 4 3 2 1

14. I don't necessarily answer students' math questions but rather let them puzzle things out for themselves.
Strongly Agree **Strongly Disagree**
6 5 4 3 2 1

15. A lot of things in math must simply be accepted as true and remembered.
Strongly Agree **Strongly Disagree**
6 5 4 3 2 1

16. I like my students to master basic mathematical operations before they tackle complex problems.
Strongly Agree **Strongly Disagree**
6 5 4 3 2 1

17. I teach students how to explain their mathematical ideas.
Strongly Agree **Strongly Disagree**
6 5 4 3 2 1

18. Using computers to solve math problems distracts students from learning basic math skills.
Strongly Agree **Strongly Disagree**
6 5 4 3 2 1

19. If students use calculators they won't master the basic math skills they need to know.
Strongly Agree **Strongly Disagree**
6 5 4 3 2 1

20. You have to study math for a long time before you see how useful it is.
Strongly Agree **Strongly Disagree**

6	5	4	3	2	1

Source: Ross, J. A., McDougall, D., Hogaboam-Gray, A., & LeSage, A. (2003). A survey measuring elementary teachers' implementation of standards-based mathematics teaching. *Journal for Research in Mathematics Education. 34(4),* 344-363

APPENDIX F:

Word Problems Used in Tutoring and Training Sessions

I had 6 shells. Then I found 3 more shells. How many shells do I have altogether?

Madison had 7 books on her reading log. Then she put 4 more books on her reading log. How many books are on Madison's reading log now?

Alyssa had 5 pennies. Her father gave her 12 more pennies. How many pennies does Alyssa have now?

I bought 3 gummy worms. Mom gave me 11 gummy worms, and Dad gave me 4 gummy worms. How many gummy worms do I have altogether?

Ron did 11 jumping jacks on Monday. He did 7 jumping jacks on Tuesday and 8 jumping jacks on Wednesday. How many jumping jacks did Ron do altogether?

Tyler had 9 blocks. He put 5 blocks away. How many blocks did Tyler have left?

Sadie had 19 stickers. She gave 7 of them to her mom. How many stickers does Sadie have left?

There are 25 napkins on the tables. 8 children threw their napkins away. How many napkins are left on the tables?

Lance blew 26 bubbles. 18 of the bubbles popped. How many bubbles are left?

There were 31 children on the bus. 12 children got off. How many children are left on the bus?

I bought 6 apples. Mom gave me 11 apples, and Dad gave me 8apples. How many apples do I have altogether?

I brought 24 cupcakes for my birthday. I gave 15 of them to my friends. How many cupcakes do I have left?

There were 34 popsicles in the freezer. I bought 25 more. How many popsicles are in the freezer?

There are 14 boys and 12 girls on the playground. How many children are on the playground?

Kiara has 2 orange marbles, 13 purple marbles, and 8 red marbles. How many marbles does Kiara have altogether?

Jonathan has some socks. He has 11 black socks, 13 blue socks, and 4 white socks. How many socks does Jonathan have altogether?

I had 28 carrots. My dad ate 12 carrots and my mom ate 6 carrots. How many carrots do I have left?

I have 15 crayons, 4 pencils, and 8 markers. How many do I have altogether?

APPENDIX G:

Tutee Mini Lessons

FIRST MINI LESSON FOR TUTEES

1. Read a *join result unknown* word problem to the group without reading the numbers in the problem. (Example: Clarissa had three rocks. She found five more rocks. How many rocks does Clarissa have now?) Have the students retell the problem. Then place the problem on the board for the tutees to see. Read the problem again, this time including the numbers. Have the students retell the problem aloud as a whole class. (3 minutes)
2. Ask the class a comprehension question to check for understanding. Does Clarissa now have more than or fewer than five rocks? Call on a student to answer the question aloud. (1 minute)
3. Tell the students it is now their turn to solve the problem individually. Show the students the available tools for their use (pencil and paper or manipulatives). Tell the students they need to find two ways to solve the problem. If the student already knows the answer, give him or her higher numbers to use in the problem. (1 minute)
4. Allow the students time to work. During this time, walk around the room and look at the students' work. Take notes during this time of which students will share in front of the class. It is important to have students using direct modeling share first, then students using counting strategies, and finally, students using number fact strategies. This order shows a progression in the development of strategies. (5 minutes)
5. Once most of the students are done working and you have selected who will share and in what order, bring the students back together and ask the first person to share his or her

solution strategy and solution. While the student is presenting his or her strategy you and the other students may ask questions. Repeat this process with each student chosen to share. (5 minutes)

6. Once the students have finished sharing, talk about the different strategies that were shared and what the class noticed. Talk about how each strategy arrived at the same correct answer. Help students to see there are more ways than one to find the correct answer. (2 minutes) You may also share incorrect answers and strategies and analyze them as well.

SECOND MINI LESSON FOR TUTEES

1. Read a *separate result unknown* word problem to the group without reading the numbers in the problem. (Example: I had nine chocolate chip cookies. I ate four of them. How many cookies do I have now?) Have the students retell the problem aloud as a whole class. Then place the problem on the board for the tutees to see. Read the problem again, this time including the numbers. Have the students retell the problem again aloud as a whole class. (3 minutes)
2. Ask the class a comprehension question to check for understanding. Do I have more than or fewer than nine cookies now? Call on a student to answer the question aloud. (1 minute)
3. Tell the students it is now their turn to solve the problem individually. Show the students the available tools for their use (pencil and paper or manipulatives). Tell the students they need to find two ways to solve the problem. If the student already knows the answer, give him or her higher numbers to use in the problem. (1 minute)

4. Allow the students time to work. During this time, walk around the room and look at the students' work. Take notes during this time of which students will share in front of the class. It is important to have students using direct modeling share first, then students using counting strategies, finally, students using number fact strategies. This shows a progression in the development of strategies. (5 minutes)
5. Once most of the students are done working and you have selected who will share and in order, bring the students back together and ask the first person to share his or her solution strategy and solution. While the student is presenting his or her strategy you and the other students may ask questions. Repeat this process with each student chosen to share. (5 minutes)
6. Once the students are done sharing, talk about the different strategies that were used and what the class noticed. Clarify that each strategy arrived at the same correct answer. Help students to see there are multiple ways to find the correct answer. (2 minutes) You may also share incorrect answers and strategies and analyze them as well.

THIRD MINI LESSON FOR TUTEES

1. Read a *part-part whole result unknown* word problem to the group without reading the numbers in the problem. (Example: There are five children at the blue table and six children at the orange table. How many children are there altogether?) Have the students retell the problem aloud as a whole class. Then place the problem on the board for the tutees to see. Read the problem again, this time including the numbers. Have the students retell the problem again aloud as a whole class. (3 minutes)

2. Ask the class a comprehension question to check for understanding. Are there more or fewer than six children at the tables? Call on a student to answer the question aloud in front of the class. (1 minute)
3. Tell the students it is now their turn to solve the problem individually. Show the students the available tools for their use (pencil and paper or manipulatives). Tell the students they need to find two ways to solve the problem. If the student already knows the answer, give him or her higher numbers to use in the problem. (1 minute)
4. Allow the students time to work. During this time, walk around the room and look at the students' work. Take a mental note during this time of which students will be invited to share in front of the class. It is important to have students using direct modeling share first, then students using counting strategies, finally, students using number fact strategies. This shows a progression in the development of strategies. (5 minutes)
5. Once most of the students are done working and you have selected who will share and in order, bring the students back together and ask the first person to share his or her solution strategy and solution. While the student is presenting his or her strategy you and the other students may ask questions. Repeat this process with each student chosen to share. (5 minutes)
6. Once the students are done sharing, talk about the different strategies that were shared and what the class noticed. Point out that each strategy arrived at the same correct answer. Help students to see there are many ways to find the correct answer. (2 minutes) You may also share incorrect answers and strategies and analyze them as well.

APPENDIX H:

Tutor Trainings Example

FIRST TUTOR TRAINING

1. Explain to the fourth graders that they will be paired with first-grade students. They will be meeting with their first graders twice a week for 15 minutes. During their meeting, they will receive a mathematics word problem that they will be helping their first-grade students complete. (30 seconds)
2. Clarify that they are not to tell the answers to the first graders. Their job is to guide and support the first graders in finding the solutions on their own. They are there to help the first graders through the process of using problem-solving strategies and help when the first graders get stuck on a section or find an incorrect answer by asking questions. (30 seconds)
3. Distribute tutoring folders and explain to the tutors that they will keep all of their papers from the trainings and tutoring sessions in their folders. Tell the students that during their tutoring sessions, they may use the notes from their folder to help them. Have the students write their names on the front of their folders. Tell students that they will not keep the folder and that the folders will be collected after every meeting.
4. Read a *join result unknown* word problem to the group without reading the numbers in the problem. (Example: On Monday, the baker baked 129 cookies. On Tuesday, she baked 152 cookies. How many cookies did the baker bake?) Have the tutors retell the problem aloud as a whole class. Then place the problem on the board for the tutors to see. Read the problem again, this time including the numbers. Have the tutors retell the problem again aloud as a whole class. (3 minutes)

5. Ask the class a comprehension question to check for understanding. Did the baker bake more or fewer than 152 cookies? Call on a tutor to answer the question aloud in front of the class. (1 minute)
6. Tell the tutors it is now their turn to solve the problem individually. Show the tutors the available tools for their use (pencil and paper or manipulatives). Tell the tutors they need to find two ways to solve the problem. Students who use a learned algorithm still need to demonstrate one other way to solve the problem. (1 minute)
7. Allow the tutors time to work. During this time, walk around the room and look at the students' work. Take a mental note during this time of which students will share in front of the class. It is important to have students using direct modeling share first, then students using counting strategies, finally, students using number fact strategies. This shows a progression in the development of strategies. However, since the fourth grade students should be more advanced than first-grade students, they may not need to demonstrate direct modeling. Only review this strategy if you see students using it. (5 minutes)
8. Once the tutors are done working and you have picked those who will share and in what order, bring the tutors back together and ask the first person to explain what answer he or she found and how. After that person has shared, talk about this strategy as a class. Then ask the next person to share his or her answer and explain the steps taken to solve the problem. After that person has shared, talk about this strategy as a class. Repeat this process with each student chosen to share. (5 minutes)

9. Once the tutors are done sharing, talk about the different strategies that were shared and what the class noticed. Talk about how each strategy arrived at the same correct answer. Help students to see there are many ways to find the correct answer. (2 minutes)
10. Tell the students, “What you did today is very similar mathematically but the numbers and contexts will be smaller to what the first graders will be doing in your tutoring sessions. You will be working one-on-one with a first-grade student instead of in a group. You will receive a word problem at the beginning of the session. Let’s talk about what happened in the beginning of our work today. Can anyone tell me what did I do first?” (Students respond, “You read the question before we saw it and we talked about it.”)
11. Continue, “Yes, I read the question first before you could see the words. I also didn’t tell you the numbers from the story. I did this to help you listen to the story before you started trying to solve the problem. It is important to help your tutees understand the word problem context before they start to think about the numbers they will be using. It helps to have the first grader retell the story after each time you read it. After I read the story once, what did I do?” (Students respond, “You showed us the problem and you read it again.”)
12. Continue, “That’s right. I showed you the problem so you could follow along as I read. I also added the numbers in during the reading to complete the problem. When you are working with your first grader, you need to read the problem once without the numbers and then again with the numbers included and with the story placed in front of the first grader. After each time you read, you need to have the first grader retell the story. It is very important to see that the first grader understand the story before he or she starts to

talk about the numbers and steps for solving the problem. What did I do after I read the story a second time?" (Students respond, "You asked us if the baker had more or fewer than 152 cookies.")

13. Continue, "Yes! I asked you a simple question about the story. Notice that the question was not about the numbers or asking about how to solve the story. I only asked a question to help you think about what happened in the story. After you and your first grader have read through the story twice, ask them a question to see if they really understand the story. (3 minutes)
14. Tell the tutors, "Today we practiced reading, solving, and explaining how we solved a word problem. This is what you will be doing during your tutoring session. We also talked about how to read through the story with your first grader and that it is important to ask a question to see if your first grader comprehends the story. We will continue to work on these skills next time." (1 minute)
15. Ask students if they have any questions. (1 minute)
16. Tell the students to put their papers from the day into their folders and then collect the folders. (30 seconds)

SECOND TUTOR TRAINING

1. (REPEAT) Explain to the fourth graders that they will be paired with first-grade students. They will be meeting with their first graders twice a week for 15 minutes. During their meetings, they will receive a mathematics word problem that they will be helping their first-grade students complete. (30 seconds)
2. (REPEAT) Remind the fourth graders that they are not to tell the answers to the first graders. Their job is to guide and support the first graders in finding the solutions on

their own. They are there to help the first graders through the process of using problem-solving strategies and help when the first graders get stuck on a section or find an incorrect answer. (30 seconds)

3. Read a *separate result unknown* word problem to the group without reading the numbers in the problem. (Example: Our class had 207 paper clips. We used 159. How many paper clips do we have left?) Have the tutors retell the problem aloud as a whole class. Then place the problem on the board for the tutors to see. Read the problem again, this time including the numbers. Have the tutors retell the problem again aloud as a whole class. (3 minutes)
4. Ask the class a comprehension question to check for understanding. Does our class have more or less than 207 paper clips? Call on a tutor to answer the question in front of the class. (1 minute)
5. Tell the tutors it is now their turn to solve the problem individually. Show the tutors the available tools for their use (pencil and paper or manipulatives). Tell the tutors they need to find two ways to solve the problem. Students who use a learned algorithm still need to demonstrate one other way to solve the problem. (1 minute)
6. Allow the tutors time to work. During this time, walk around the room and look at the students' work. Take a mental note during this time of which students will share in front of the class. It is important that students using direct modeling share first, then students using counting strategies, finally, students using number fact strategies. This shows a progression in the development of strategies. However, since the fourth grade students should be more advanced than first-grade students, they may not need to demonstrate direct modeling. Only review this strategy if you see students using it. (5 minutes)

7. Once the tutors are done working and the students who will share and in what order have been selected, bring the tutors back together and ask the first person to explain what answer he or she found and how. After that person has shared, talk about this strategy as a class. Then ask the next person to share his or her answer and explain the steps used to solve the problem. After he or she has shared, talk about this strategy as a class. Repeat this process with each student chosen to share. (5 minutes)
8. Once the tutors are done sharing, talk about the different strategies that were shared and what was noticed. Point out that each strategy arrived at the same correct answer. Help students to see there are multiple ways to find the correct answer. (2 minutes)
9. Tell the students, "What you did today is very similar to what the first graders will be doing in your tutoring sessions, only you will be working one-on-one instead of in a group. You will receive a word problem at the beginning of the session. Last time we talked about reading the story and understanding the story. Today, we are going to talk about solving the problem.
10. Continue, "During your tutoring session, you should let your first grader use any tool he or she wants to use to solve the problem. Tools include fingers, pencil, paper, manipulatives, thinking in their head, or anything else they may ask to use. While the student is working, you will notice the student using one of three solving methods. These methods are called, direct modeling, counting, and number facts. Let's talk about each of them. Please write these down in your tutoring journal.
11. Continue, "Direct modeling is when the student shows all parts of the problem either by drawing a picture or using manipulatives. Here is an example of direct modeling using a first grade problem."

12. Read the problem, “Clarissa had three rocks. She found five more rocks. How many rocks does Clarissa have now? Explain that if the first grader was using direct modeling he or she would need to represent both parts of the problem. The student could create a drawing or use manipulatives, or any other way he or she might choose to show that Clarissa had three rocks and then to show five more rocks.” Draw an example on the board of a group of three rocks. Then draw a group of five rocks next to the first group. Say, “This is direct modeling. Counting is when the first grader only counts one part of the problem. He or she does NOT count the entire problem.” Provide an example of counting using Clarissa’s rock problem. The student might have written the number three and then represented the second group of five rocks. The student could create a drawing or use manipulatives, or any other way he or she might choose to show five more rocks. He or she could also have chosen to represent the three rocks and then written the number five. Show what that would look like. Draw on the board the numeral 3. Next to the numeral 3, draw five rocks. Say, “This is what counting looks like. Finally, number facts strategy is when the student knows the answer immediately or has a quick way to solve the problem like by using an equation.” Provide an example using Clarissa’s rock problem. The student would not draw anything but would write 3 + 5 = 8 (write the equation on the board), or simply say aloud the answer is 8 without writing anything. The student did not need to draw any part of a picture or count. Show what the number facts strategy looks like. (6 minutes)
13. Have the tutors talk to a partner about the three different types of strategies.
14. Tell the tutors, “Today we practice reading, solving, and explaining how we solved a word problem. This is what you will be doing during your tutoring session. We also

talked about the three types of strategies to solve a problem. They are direct modeling, counting, and number facts. We will review these again next time." (1 minute)

15. Ask students if they have any questions. (1 minute)
16. Tell the students to put their papers from the day into their folders and then collect the folders. (30 seconds)

THIRD TRAINING SESSION

1. Explain to the fourth graders that they will be paired with first-grade students. They will be meeting with their first graders twice a week for 15 minutes. During their meetings, they will receive a mathematics word problem that they will be helping their first-grade students complete. (30 seconds)
2. Remind the fourth graders that they are not to tell the answers to the first graders. Their job is to guide and support the first graders in finding solutions on their own. They are there to help the first graders through the process of using problem-solving strategies and help when the first grader gets stuck on a section or finds an incorrect answer. (30 seconds)
3. Read a *part-part whole result unknown* word problem to the group without reading the numbers in the problem. (Example The Natural History Museum has 522 animal fossils and 798 plant fossils in its collection. How many fossils are in the museum's collection?) Have the tutors retell the problem aloud as a whole class. Then place the problem on the board for the tutors to see. Read the problem again, this time including the numbers. Have the tutors retell the problem again aloud as a whole class. (3 minutes)

4. Ask the class a comprehension question to check for understanding. Does the museum have more or less than 798 fossils? Pick a tutor to answer the question in front of the class. (1 minute)
5. Tell the tutors it is now their turn to solve the problem individually. Show the tutors the available tools for their use (pencil and paper or manipulatives). Tell the tutors they need to find two ways to solve the problem. Students who use a learned algorithm still need to demonstrate one other way to solve the problem. (1 minute)
6. Allow the tutors time to work. During this time, walk around the room and observe the students at work. Take a mental note during this time of which students will share in front of the class. It is important that students using direct modeling share first, then students using counting strategies, finally, students using number fact strategies. This order shows a progression in the development of strategies. However, since the fourth grade students should be more advanced than first-grade students, they may not need to demonstrate direct modeling. Only review this strategy if you see students using it. (5 minutes)
7. Once the tutors are done working and the students who will share and in what order have been chosen, bring the tutors back together and ask the first person to explain what answer he or she found and how. After the person has shared, talk about this strategy as a class. Then ask the next person to share his or her answer and explain the steps used to solve the problem. After he or she has shared, talk about this strategy as a class. Repeat this process with each student chosen to share. (5 minutes)

8. Once the tutors are done sharing, talk about the different strategies that were shared and what the class noticed. Point out that each strategy arrived at the same correct answer. Help students to see there are many ways to find the correct answer. (2 minutes)
9. Tell the students, "What you did today is very similar to what the first graders will be doing in your tutoring sessions, only you will be working one-on-one instead of in a group. You will receive a word problem at the beginning of the session. Last time we talked about the three strategies to use when solving a problem, which are direct modeling, counting, and number facts. Today, we are going to talk about explaining your work and giving help.
10. Once your first grader has found his or her solution, the student needs to be able to tell you how the problem was solved. Make sure the student tells you everything done and ask your student from time to time, 'Why did you do that?' This will help the student to justify his or her steps. (2 minutes)
11. Explain that one thing they may notice is the first grader may get stuck or get the wrong answer. Say, "It is NOT your job to tell the student the answer. If your student gets stuck, ask him or her questions about the work so far and refer back to the problem. If your student gets the wrong answer, have him or her explain the steps. While they are explaining the student may find the mistake. If not, when the student gets to the mistake, talk to the student about what was done. Ask why he or she did it, and refer back to the word problem to see if it was the right thing to do. (2 minutes)
12. Introduce students to their Tutoring Checklist. Tell students that they will use this each week during their tutoring session. Explain each part of the checklist to the tutors. "First, you will write your name and the first graders' name. Then as you work, you will

mark the box with an x if the student understood the problem. Then put an x in the box next to the tools your student used. Then you will put an x in the box next to what strategy you believe your first grader used to solve the problem. At the bottom, you can write things you noticed or questions you had during the session."

13. Ask students if they have any questions. (1 minute)
14. Tell the students to put their papers from the day into their folders and then collect the folders. (30 seconds)

APPENDIX I:

Sample Questions for Tutors

How many were in the first group?

How many were in the second group?

Are you adding more or taking some away?

How can you show me what is happening?

Will the total be smaller or larger than _____?

How did you get that answer?

Explain how you got that answer.

Explain what you just did.

APPENDIX J:

Tutor Checklist

4^{th} grader Name:______________________________

1^{st} grader Name: ______________________________

☐ My first grader understands what the problem requires before they began working.

My first grader used these tools to solve the problem.

☐ pencil and paper

☐ manipulatives

☐ mental math

☐ fingers

My first grader solved the problem by ______________

____.

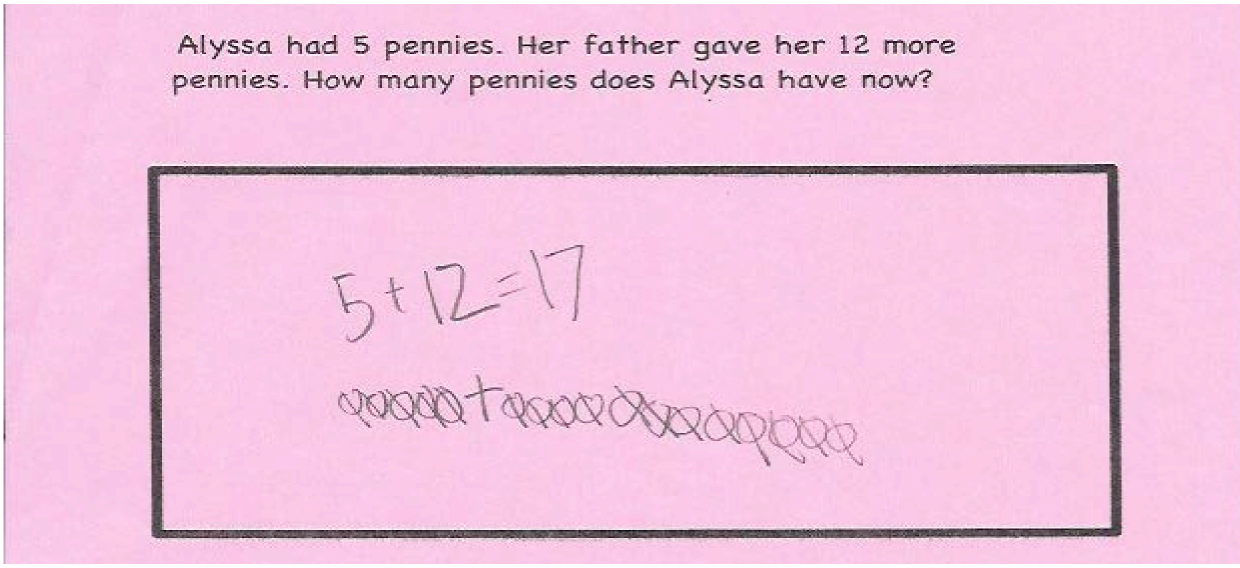
☐ My first grader could explain what their answer meant.

Questions or ideas to talk about during the next training:

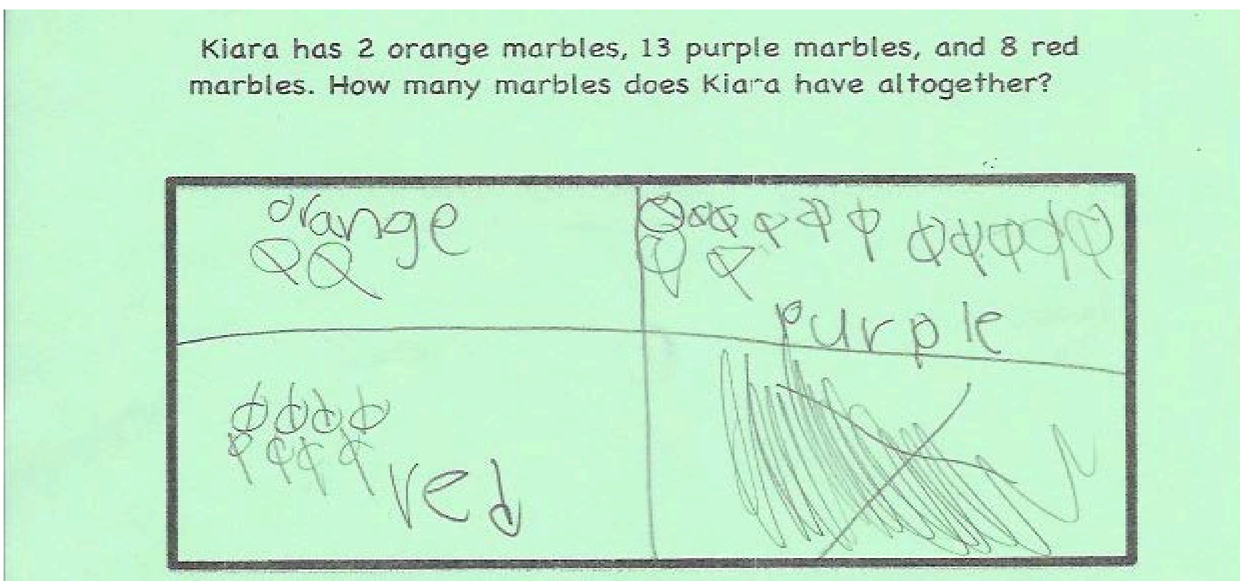
APPENDIX K:

Tutee Work Samples

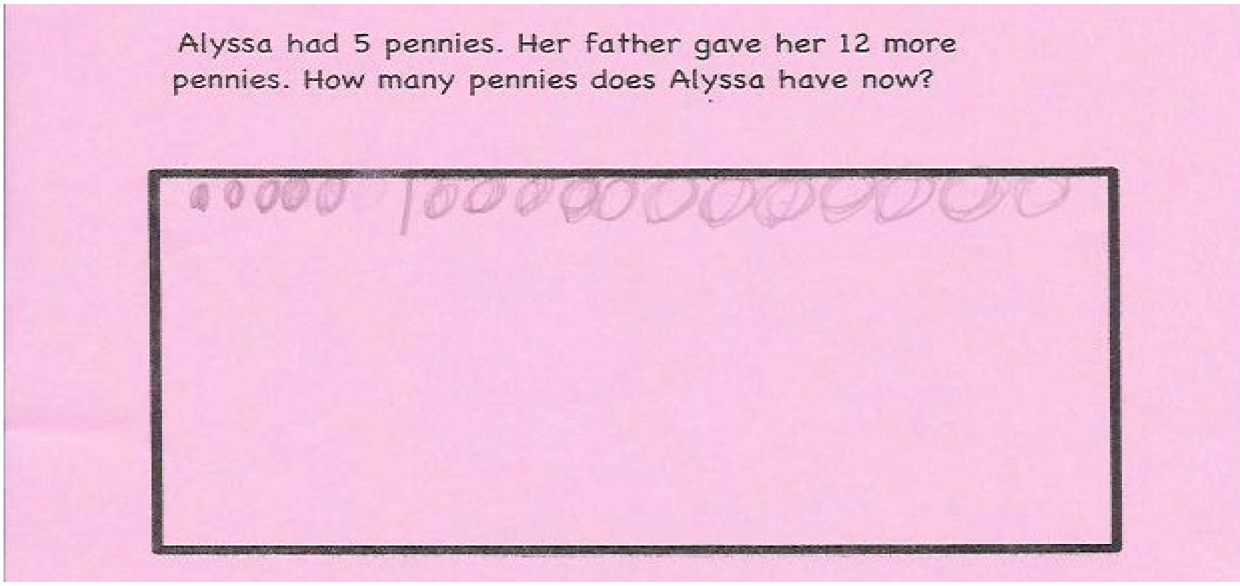
Tutee with no tutor session 3



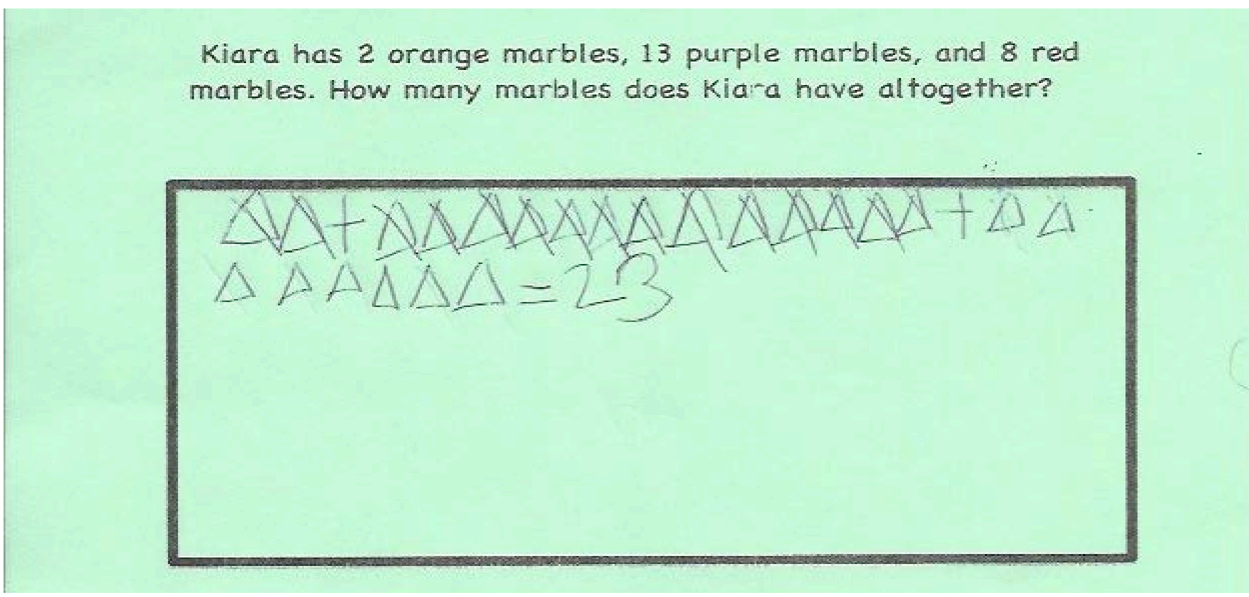
Tutee with no tutor session 15



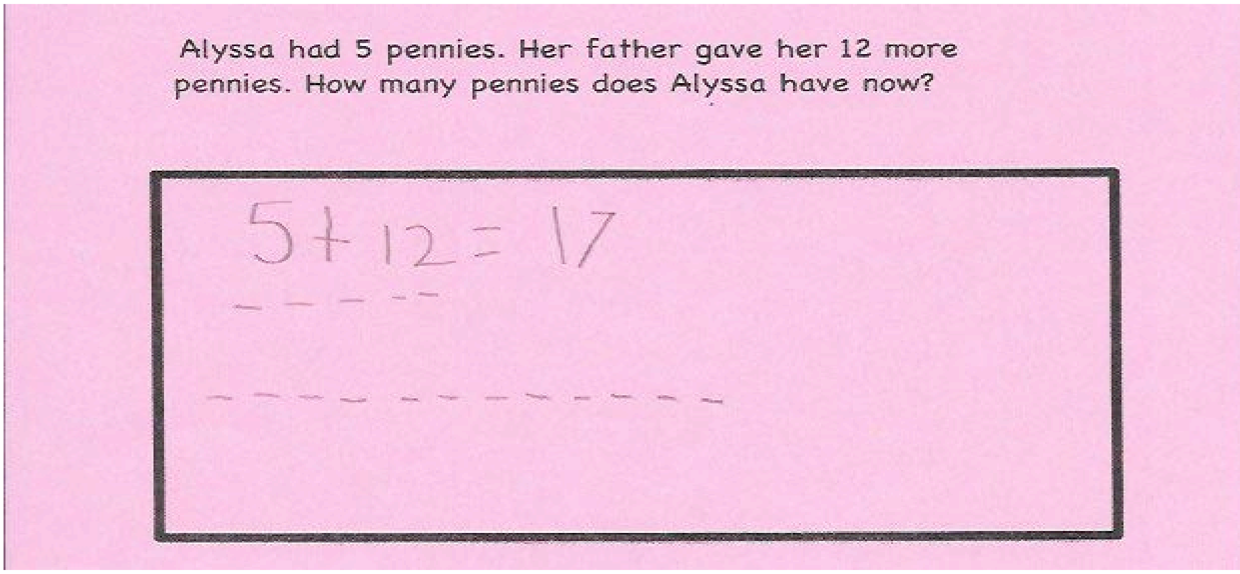
Tutee with untrained tutor session 3



Tutee with untrained tutor session 15



Tutee with trained tutor session 3



Tutee with trained tutor session 15