EFFECTS OF PEER TUTORING ON HISPANIC STUDENTS' OUTCOMES IN MATHEMATICS

A Dissertation

by

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ABSTRACT

A critical problem facing Hispanic students in the United States is their low achievement in mathematics. Therefore, it is crucial to implement effective instructional programs that will improve their mathematics achievement. Peer tutoring is one effective research-based instructional practice that has been found to have positive effects on academic outcomes across grade levels and subject areas. Few studies, however, have examined the effects of peer tutoring in mathematics for Hispanic students. This dissertation consists of three research studies that examine peer tutoring for Hispanic elementary and middle school students in mathematics.

Study 1 was a meta-analysis that examined the effects of peer and cross-age tutoring on academic achievement in mathematics for 3,035 participants in kindergarten through grade 12 across 21 experimental or quasi-experimental studies. The overall mean-weighted effect size for the 21 studies was 0.49 ($p < 0.001$, 95%, confidence interval = 0.34 - 0.65). Moderator analysis indicated that peer tutoring interventions were most effective for at-risk, low socioeconomic status, suburban, minority, and secondary school students.

Study 2 investigated the effects of a cross-age tutoring intervention on elementary and middle school students' academic and nonacademic outcomes in mathematics. Most students who participated in this program were from Hispanic and low socioeconomic status backgrounds. The results revealed statistically significant improvements in mathematics achievement. Large positive effects were found on basic

mathematics facts (*ES* = 1.39) and problem-solving skills (*ES* = 1.25) among elementary school students and moderate to large effects on academic achievement of middle school students (*ES* = 0.67). Mixed results were found for enjoyment in mathematics and self-perceptions.

Study 3 investigated the implementation of a cross-age-peer-tutoring program in elementary and middle schools serving predominantly Hispanic students. Classroom observations and face-to-face interviews were used to examine instructional practices and behaviors of teachers, tutors, and tutees during tutor preparation and actual tutoring sessions. The program's strengths included the development of positive emotions and relationships among students and evidence of a classroom environment that fostered warm and supportive relationships. Weaknesses were related to lack of fidelity of the implementation of the program.

Overall, findings from the studies included in this dissertation suggest that cross-age tutoring interventions are effective for improving mathematics achievement for Hispanic students. Positive effects of peer tutoring combined with lower cost of implementation compared to other programs make peer tutoring an educational alternative worth considering as a solution for improving mathematics outcomes among Hispanic students.

DEDICATION

This dissertation is dedicated to my family. I thank my mother, my brothers, and sisters that always believed in me, kept me in their prayers, and supported me in this journey.

I thank my husband for always encouraging me to continue on the path to attain my goals. I appreciate his assistance and motivations through my doctoral studies.

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TABLE OF CONTENTS

LIST OF FIGURES

FIGURE Page

LIST OF TABLES

TABLE		Page

TABLE Page

CHAPTER I

INTRODUCTION

Mathematics is essential in our daily lives, from simple purchase transactions to more complicated decisions such as investments and financial planning (NCTN, 2000). Students need to learn the appropriate mathematics skills to be prepared to compete in an increasingly complex and competitive global economy. Mathematics competence is the key that can open the door to future success (NCTM, 2000). Yet, one major educational problem facing Hispanic students in the United States is their low achievement in mathematics. The 2015 Nation's Report Card, for example, revealed that only 26% of fourth-grade Hispanic students achieved at or above proficient in mathematics on the National Assessment of Educational Progress (NAEP), compared to 51% of their White peers. This achievement gap was wider for Hispanic students enrolled in grade 8: only 19% of Hispanic students scored at or above proficiency in mathematics while 43% of White eight-grade students reached that level (U.S. Department of Education, National Center for Education Statistics [NCES], 2016).

Achievement gaps among Hispanic, Black, American Indian/Alaska Native students and their White peers have been documented over the past 40 years, raising concerns about the ability of public schools to provide education that effectively addresses the needs of minority students (National Education Association [NEA], 2015). The persistent achievement gap between White and Hispanic students is a critical problem further intensified by the rapid growth in the number of Hispanic children in public schools. The National Center for Education Statistics revealed that the number of Hispanic students enrolled in prekindergarten through grade 12 in U.S. public schools increased by 44% between 2001 and 2011, from 8.2 million to 11.8 million. In contrast, the total enrollment in public schools grew only 4%, from 47.6 million to 49.5 million (U.S. Department of Education, NCES, 2014). This accelerated growth of the Hispanic children population increases the need for solutions that close achievement gaps and help Hispanic students succeed in school.

In Texas, where this study takes place, the number of Hispanic students enrolled in public schools increased from 1.9 million in 2003-04 to 2.7 million in 2013-14 (Texas Education Agency [TEA], 2015b). While the enrollment of Hispanic students increased by 42% over this 10-year period the total school enrollment in Texas grew by 19%. During the 2013-14 school year, Hispanic students comprised 51.8% of the total student population in Texas, making Hispanics the majority of public school students in this state (TEA, 2015b).

The increasing number of Hispanic students in public schools combined with their low academic performance highlights the need for better educational practices and interventions to help them improve academic outcomes (Padrón, Waxman, & Rivera, 2002). These researchers found that one of the factors associated with the underachievement of Hispanic students is the prevalence of inappropriate teaching approaches in many schools that serve Hispanic students. One of the most common instructional practices found in many classrooms comprised predominantly of Hispanic students was teacher-directed instruction, which focuses on teacher-led lectures, memorization, repetition, and student seatwork (Padrón et al., 2002). Solving the problem of Hispanic and African American students' mathematics underachievement requires that schools reevaluate the structure of learning opportunities and implement curricular changes early to build strong foundations for high school (Walker, 2007). Furthermore, improving teaching and learning in mathematics classrooms entails that teachers implement research-based instructional practices identified as effective for minority students, especially for Hispanic children.

One of the research-based instructional practices that has been found to be effective in improving students' outcomes in mathematics is peer tutoring. Several meta-analyses have reported that peer tutoring has positive effects on students' academic achievement in mathematics (Bowman-Perrott, Davis, Vannest, Williams, Greenwood, & Parker, 2013; Cohen, Kulik, & Kulik, 1982; Ginsburg-Block, Rohrbeck, and Fantuzzo, 2006; Hartley, 1977; Kunsch, Jitendra, & Sood, 2007; Leung, 2015; Rohrbeck, Ginsburg-Block, Fantuzzo, & Miller, 2003). In addition, a meta-analysis that calculated mean effect sizes for demographic moderator variables reported stronger peer tutoring effects for minority, urban, and low SES students than for mainstream, suburban-rural, and higher SES children (Rohrbeck et al., 2003). These research findings make peer tutoring a promising strategy for Hispanic students since they are part of the minority population who is potentially more sensitive to the positive effects of peer tutoring than other student populations.

Some researchers indicated that poverty is one of the factors that have placed Hispanic children at-risk of academic failure (Berliner, 2006). Many Hispanic students live in communities of concentrated poverty and attend to schools that have limited resources to fulfill their needs (Padrón, et al. 2002). Furthermore, the U.S. Census Bureau (2015) reported that in the last four decades the rate of poverty in the Hispanic population was more than double the rate of poverty among non-Hispanics. For example, in 2014, the poverty rate for Hispanics was 23.2% while the poverty rate for non-Hispanic Whites was 10.1%. In addition, the U.S. Department of Education, NCES (2015d) reported that 45% of Hispanic students attended high-poverty public schools while only 8% of White students were enrolled in these schools. More than 75% of students enrolled in high-poverty schools are eligible for free or reduced-price lunch (U.S. Department of Education, NCES, 2015e, p. 110). As mentioned above, since empirical research in peer tutoring has found that this instructional approach is more effective in vulnerable student groups, such as the students whose families live in poverty, professional educators and school administrators should consider peer tutoring when they want to improve the academic outcomes of Hispanic students.

Purpose of this Study

A growing body of empirical research has found that peer tutoring has a positive impact on mathematics achievement (Bowman-Perrott et al., 2013; Cohen et al., 1982; Codding, Chan-Iannetta, George, Ferreira, & Volpe, 2011; Dwyer & Tilley, 2001; Heller & Fantuzzo 1993; Kunsch et al., 2007; Leung, 2015; Menesses & Gresham, 2009; Rohrbeck et al., 2003; Sharpley, Irvine, & Sharpley, 1983; Sprinhall & Scott, 1989; Topping, Miller, Murray, Henderson, Fortuna, & Conlin, 2011). Researchers have also found stronger effects of peer tutoring among ethnic minority students, urban students, and low SES (Ginsburg-Block, et al., 2006; Greenwood, Delquadri, & Hall, 1989; Heller & Fantuzzo, 1993; Menesses & Gresham, 2009; Rohrbeck et al., 2003). Additionally, peer tutoring is a very cost-effective strategy (Levin, Glass, & Meister, 1984; Yeh, 2010). Given this evidence, the implementation of peer tutoring in schools that predominantly serve Hispanic students seems promising. However, more research exploring the full potential of tutoring interventions for Hispanic students is needed. Although there is a growing body of research about the effects of peer tutoring on academic achievement in the general school population, there is a dearth of studies about the effectiveness of peer tutoring on the academic performance of minority students (Robinson, Schofield, & Steers-Wentzell, 2005).

Furthermore, the studies that concentrated on minority students focused on the effects of peer tutoring interventions for African-American students, leaving a big gap in the literature for studies focusing on specific effects of these instructional practices for Hispanic students. This dissertation includes three studies related to peer tutoring. Overall, the purpose of the studies in this dissertation is to evaluate the effects of peer tutoring in mathematics for kindergarten, elementary, and middle schools that predominately serve Hispanic children. In addition, considering that low-income, minority, at-risk, and low SES status are variables associated with the Hispanic population, the analysis of these variables will be included in this research.

Research Questions

Study 1: Examining the Magnitude of the Effects of Peer Tutoring Interventions on Mathematics Achievement

Research question: What is the magnitude of the effects of peer tutoring interventions on mathematics achievement? To answer this question, I conducted a meta-analysis to examine the findings of 21 studies published between 1982 and 2015 about the effectiveness of peer tutoring interventions in mathematics in kindergarten, elementary, and secondary public schools. This meta-analysis included an evaluation of demographic moderators relevant to Hispanic students, encompassing minority status, students at risk of academic failure, SES, and school location. Meta-analytic techniques were used to calculate mean effect sizes for studies included in this research.

Study 2: The Effects of Peer Tutoring on Mathematics Achievement, Enjoyment of Mathematics, and Mathematical Self-Perceptions

Research question: Are there significant changes in students' math achievement scores, enjoyment of mathematics, and mathematical self-perceptions following participation in the peer tutoring program? To answer this question, I conducted an evaluation of a peer tutoring program in mathematics for elementary and secondary students enrolled in public schools that predominantly serve Hispanic students. This study examined the extent to which cross-age peer tutoring implemented in urban settings improves the academic achievement of Hispanic students who have underperformed in mathematics, their enjoyment of mathematics, and mathematical self-perceptions.

Study 3: Prevalent Instructional Practices and Behaviors Exhibited by Students during Tutoring Sessions

Research question: What are the prevalent instructional practices and behaviors during tutoring sessions? Examining the instructional practices and behaviors during tutoring instruction is very important to explore the strengths and weaknesses of this educational approach, determine areas that could be improved, and strategies that could be used to maximize students' learning in tutoring settings. To achieve this objective, I evaluated the results of classroom observations conducted during tutor preparation sessions and the actual peer tutoring instruction.

Before exploring the specific effects of peer tutoring for Hispanic students, it is necessary to review the findings of empirical research that focus on academic achievement in general education classrooms. Furthermore, it is important to underline the rationale for selecting peer tutoring as an instructional strategy in mathematics classrooms, what makes peer-tutoring an effective educational approach, and why it is important to consider a cost-effectiveness analysis when policy makers, teachers, and administrators make important educational decisions. Finally, it is key to frame tutoring within a theoretical framework that justifies its implementation in the mathematics classroom from a scientific point of view.

Selecting Effective Educational Practices and Interventions to Improve Teaching and Learning in Mathematics Classrooms

John Hattie (2009), in his book *Visible Learning*, presented a synthesis of over 800 meta-analyses that focus on the effects of various educational influences and interventions on academic achievement. He evaluated and calculated the effect size (*d)* of 138 variables in the following domains: student, teacher, teaching, school, curricula, and home. This synthesis included over 800 meta-analyses that comprised 52,637 studies and about 236 million students. Hattie found that the average effect size on the achievement of all educational influences and interventions included in the 800 meta-analyses was 0.40. Further, he analyzed which interventions decreased achievement, which generated small effects, and which produced significant effects. For example, after analyzing 207 studies that focused on retention, Hattie found a negative effect of -0.16. This means that rather than helping a child, retention decreases his or her achievement. Examples of an educational influences that generates a very small effect size on achievement are *distance education* (d = 0.09), *out of school curricula experiences* (d = 0.09), *gender* (d = 0.12), *charter schools* (d = 0.20). Examples of powerful teaching approaches are peer tutoring (d = 0.55), meta-cognitive strategies (d = 0.69), and questioning (d = 0.46).

Hattie' synthesis has important implications for teaching and learning across content areas, including mathematics. It is remarkable that this author found that 90% of all effect sizes in education are positive and only 10% are negative. This means that almost everything that researchers, administrators, and teachers implement to enhance achievement is successful in improving student learning. However, since time and resources are limited, it is very important that administrators and teachers select the interventions and strategies that generate the most educational productivity and are efficient to implement. To illustrate how to select the best educational practices from dozens of available alternatives, Hattie used the average effect size $d = 0.40$ as a benchmark or hinge-point to analyze the contribution of different educational practices and interventions on achievement. Since each intervention generates different effect sizes, schools should select alternatives that generated above average effect sizes. Hattie indicated that an effect size of $d = 1.0$ can be reasonably qualified as a large effect, $d = 0.4$ as medium and $d = 0.2$ as small. Consequently, wiser decisions will involve the selection of educational practices with effect sizes greater than 0.4. According to Hattie, an effect size of $d = 1.0$ can be associated with advancing students' achievement by two to three years. In addition, an effect size of 0.5 can be associated with one-grade improvement in exam results.

Hattie emphasizes that educators should target educational outcomes that make a significant contribution in the learning curve of their students. Teaching and learning will be a good pathway when the effect sizes reach above average levels ($d = 0.40$ or higher). Gains in achievement greater than $d = 0.60$ could be considered excellent. Teachers and administrators should work with measurable goals in mind. Continuous evaluation of teaching and learning can help to ensure that the interventions implemented by schools lead students toward high academic standards.

Hattie (2009) indicated that *visible teaching and learning* happens in active and engaging classroom environments when teacher and students follow an explicit, attainable, measurable, and challenging goal. Both teacher and students know when classroom practices are leading to achieve that goal. In this learning environment, teachers are agents of change. Students' learning become a priority. One of the fundamental tasks of teachers is to evaluate the impact of teaching on student learning.

Hattie's explanation of "visible teaching and learning" provides valuable guidance for researchers, school administrators, and professional educators. A wise selection of educational interventions that generate above average effects on academic achievement can help low-performing students accelerate their learning rate and close the gap with their peers. Hattie reported 63 influences and interventions that generate above average effects on achievement, one of which was peer tutoring (d = 0.55). Peer tutoring has more influence on achievement than the following interventions: small group learning (d = 0.49), early intervention (d = 0.47), questioning (d = 0.46), quality of teaching (d = 0.44), school size (d = 0.43), matching style of learning (d = 0.41), enrichment programs (d = 0.39), integrated curriculum programs (d= 0.39), computer assisted instruction (d = 0.37), homework (d = 0.29), among others. The results of Hattie's synthesis show that peer tutoring generated greater effect size than 102 variables evaluated in this study.

One more important reason for the implementation of peer-tutoring programs in elementary and secondary school is its cost-effectiveness in improving reading and mathematics outcomes (Levin, et al., 1984; Yeh, 2010). This means that the school can obtain more academic gains for dollar invested using peer tutoring than other approaches. This cost-benefits relationship is very important to decision makers who want to identify the best educational programs that involve affordable costs.

Selecting cost-effective intervention is key for school districts that face financial challenges that constrain the amount of resources available to cover expenses generated by educational programs and interventions target to help the most disadvantaged students. Consequently, it is critical to analyze not only the effect size generated by school programs, instructional strategies, or interventions but also the cost-benefit of these interventions.

Peer-Based Instruction

Research has shown that peer-based instructional approaches have the potential to promote positive academic, affective, and social outcomes (Ginsburg-Block, et al., 2006; Robinson et al., 2005; Slavin & Cooper, 1999). Damon and Phelps (1989) stated that peer tutoring, peer collaboration, and cooperative learning are the three major peer-based instruction approaches and explained that although these approaches differ in the level of equality and mutuality, they share some common features. First, a peer-based instruction is an effective alternative to traditional teacher-centered instruction, where the adult controls the flow of information in the classroom. Peer tutoring transfers the source of information from teachers to students. Tutors assume the role of instructors and share knowledge, experiences, and ideas with tutees. Second, peer-based teaching promotes the development of academic and social skills under student-centered learning environments where students have the opportunity not only to share their knowledge but also to build personal relationships with other members of the learning community. Third, peer-based instruction enhances students' engagement in academic activities (Damon & Phelps, 1989).

Peer tutoring involves a one-to-one teaching and learning process in which one student (tutor) provides instruction to another student (tutee) (Cohen, 1986; Damon & Phelps, 1989). From the academic perspective, peer tutoring incorporates teaching, learning, and emotional factors generated by the unique dyad partnership where the tutor assumes the role of teacher and the tutee learns from the tutor (Cohen, 1986). From an interpersonal perspective, peer tutoring can be viewed as a social system where two partners engage in a social contact that provides them opportunities to communicate and develop social skills (Cohen, 1986). According to Damon and Phelps (1989), peer tutoring is low in equality since the tutor, who provides instruction to the tutee, has more knowledge and skills on the subject being taught. In addition, peer tutoring is high in mutuality since it promotes extensive dialogue during children's peer engagements (Damon & Phelps, 1989).

Peer collaboration involves two or more students working together to complete a common task, solve problems or construct meaning (Ding & Harskamp, 2011). In contrast to peer tutoring, where tutors have more knowledge or ability than tutees, peer collaboration involves students who have almost the same level of competence. Consequently, this instructional approach is high in equality (Damon & Phelps, 1989). Peer collaboration promotes the creation of learning environments rich in constructive dialogue, frequent sharing of perspectives or ideas, reciprocal feedback, and mutual discovery (Damon & Phelps, 1989; Ding & Harskamp, 2011) which makes this approach high on mutuality.

Cooperative learning is an instructional approach that involves a group of students working collaboratively in academic tasks (Damon & Phelps, 1989). Effective cooperative groups work as a team composed of diverse students that rely on the contribution of all members to complete a task (Slavin, 2014). The number of team members in the group varies according to goals of the instructional activities since some activities can be completed by only two students while other activities demand the participation of more students (Slavin, 2014). Unlike peer collaboration, students can work in separate parts of the same task. According to Damon and Phelps (1989), cooperative learning is high in equality since members of the group can have similar level of competence; however the level of mutuality can be limited when the division of work to complete a task demands a significant amount of individual work in detriment of the time students share with the members of their cooperative group.

Rationale for Planning and Implementing Peer Tutoring Programs

In order to offer high-quality instruction in mathematics to Hispanic students, it is necessary to create an appropriate learning environment and implement effective instructional practices that facilitate the learning and mastery of mathematical ideas and concepts (Valle, Waxman, Diaz, & Padrón, 2013). The extensive synthesis of research conducted by Hattie (2009) reported that the effect of peer tutoring on academic achievement (d = 0.55) exceeded the average effect of all possible programs, instructional strategies, or interventions (d = 0.40), which suggests that peer instruction can have a powerful influence in learning.

Peer tutoring can also promote student's engagement in math learning and lead to better academic outcomes (Walker, 2007). In addition, peer tutoring can enhance academic language development, which can allow students to understand the mathematics ideas and concepts included in every lesson. Topping, Campbell, Walter, and Smith (2003), for example, found that peer tutoring promoted meaningful instructional conversations among students. Tutor-tutee interactions provide multiple opportunities to build conversations around math ideas. Topping et al. (2003) found that tutoring interventions promoted strategic dialog and increased conversation exchanges that enhance academic language in mathematics. These researchers found statistically significant gains in the use of mathematical words, strategic dialog, and length of utterances. As a result of academic language scaffolding provided during tutoring sessions, students felt more confident using mathematic language, and, consequently, conversational exchanges lasted longer and tutees were more willing to ask for help (Topping et al. 2003).

Peer Tutoring Is a Cost-Effective Strategy

Low achievement in mathematics increases the need to select research-based instructional practices that improve the student' learning process. Effective educational decisions should be guided by the potential effects of instructional practices or interventions and for the costs necessary to implement them. Cost-effectiveness analysis allows us to determine the quantitative relation between the effect size of any educational approach and the amount of costs involved. This relationship is represented in the effectiveness-cost ratios that are calculated by dividing the annualized student achievement effect size by the annual cost per student (Yeh, 2010). For example, Yeh (2010) meta-analysis reported that the effect size for cross-age tutoring in mathematics was 0.97 while the annual cost per student participating in tutoring interventions was $555.61. Consequently, the effectiveness-cost ratio for cross-age tutoring was 0.001746 (0.97/555.61). The importance of this effectiveness-cost ratio is that it allows placing in the same balance effect sizes and cost of different interventions which can lead teachers and administrators to make better educational decisions.

Levin et al. (1984) used meta-analysis and cost-effectiveness techniques to evaluate four different interventions for improving mathematics and reading achievement for elementary school children. In order to calculate the cost-effectiveness ratio. These researchers divided the effect size of every intervention by the cost per student and multiplying this result by 100. The results of this meta-analysis showed that cross-age peer tutoring was the most cost-effective strategy in reading and mathematics (cost-effectiveness ratio = 0.34), followed by computer assisted instruction (cost-effectiveness ratio = 0.15), class reduction from 35 to 30 students (cost-effectiveness ratio = 0.11), and increase of instructional time (cost-effectiveness ratio = 0.09). Furthermore, Levin and colleagues reported that cross-age peer tutoring interventions generated the highest cost-effectiveness ratio in mathematics (cost-effectiveness = 0.46). In contrast, the cost-effectiveness ratio for computer assisted instruction in mathematics was only 0.10, class size reduction from 35 to 30 students in mathematics classrooms generated a cost-effectiveness ratio of 0.14, and increasing 30 minutes a day of instructional time in mathematics yielded a cost-effectiveness ratio of 0.05.

Yeh (2010) used meta-analysis and cost-effectiveness techniques to evaluate 22 approaches for raising student achievement. Yeh reported that cross-age tutoring was one of the most cost-effective approaches for raising academic achievement in mathematics and reading. According to the results of this meta-analysis, cross-age tutoring was the third most cost-effective approach among the 22 instructional interventions evaluated in this study.

The estimation of the effectiveness-cost ratios in this meta-analysis is slightly different than the formula used by Levin et al. (1984). While Levin and colleagues calculated the cost-effectiveness ratio dividing effect size by the cost per student and multiplying this result by 100, Yeh (2010) divided effect size by the annual cost per student and called this result *effectiveness-cost ratio.* Consequently, although Yeh's ratios are apparently smaller than the ratios reported by Levin, the interpretation of ratios is basically the same (i.e. the effectiveness of any educational intervention per dollar invested). For example, in order to estimate the *effectiveness-cost ratio* of cross-age tutoring in mathematics, Yeh divided the effect size of peer tutoring (0.97) by the annual expenditure per student ($555.61) which result in an *effectiveness-cost ratio* of 0.001746.

Yeh's (2010) results suggested that cross-age peer tutoring was more cost effective per dollar in mathematics (0.001746) than computer-assisted instruction (0.000504), longer school day (0.000188), class size reduction from 24 to 17 students (0.000094), an additional year of schooling (0.000011), among other approaches used by schools to improve academic achievement in mathematics. These effectiveness-cost ratios are very important in the selection of the best alternatives to enhance students' outcomes. If we reexamine the above example, we could see that an annual expenditure of $555.61 per pupil in cross-age peer tutoring programs in mathematics enhanced student' achievement in mathematics by about 0.97 standard deviations (SD) generating a *effectiveness-cost ratio* of 0.001746, this is an undoubtedly a better cost-effective approach than other alternatives such as an additional school year that requires an average investment of $14,271.76 per pupil and improved student achievement by approximately an average of 0.15 SD, yielding a *effectiveness-cost ratio* of 0.000011. In summary, the results reported in this meta-analysis evidence the powerful cost-effectiveness of peer tutoring compared to other educational alternatives.

Positive Effects of Peer Tutoring on Academic Achievement

A growing body of research published in the last decades has documented that peer tutoring generates a significant effect on students' academic performance in mathematics. Cohen, et al. (1982) conducted a meta-analysis of 65 studies that focused on the effects of peer-tutoring in elementary and secondary schools. These researchers reported an effect size in mathematics of 0.62 for tutors and 0.60 for tutees. It is remarkable that the effect for mathematics found by Cohen and colleagues was superior to the effect size found for reading, 0.21 for tutors and 0.29 for tutees.

Another meta-analysis (Kunsch et al., 2007) examined the effectiveness of peer-mediated interventions on mathematics outcomes for students with and without disabilities in grades 6-12. They reported that the overall effects size of the 17 studies included in this study was 0.47. They found that peer-mediated interventions were more effective in general education classrooms (ES = 0.56) than in special education classrooms (ES = 0.32) and for students at-risk (ES = 0.66) than for students with learning disabilities (ES = 0.21). Recently, Bowman-Perrot et al. (2013) conducted a meta-analytic review of 26 studies that focused on the academic effects of peer tutoring for elementary and secondary. They reported a TauU effect size of 0.86 for mathematics, greater than the effect size for reading (ES = 0.77).

Positive Effects of Peer Tutoring on Nonacademic Outcomes

Besides the substantial effects of peer tutoring on academic achievement in mathematics, research has found that this instructional strategy has also positive influence in students' nonacademic outcomes. For example, the meta-analytic review conducted by Cohen et al. (1982) reported positive tutoring effects on students' self-concept and attitudes toward the subject matter, for example, students who participated in a peer tutoring program in mathematics developed better attitudes toward this subject.

Furthermore, Ginsburg-Block, et al. (2006) also explored the effects of peer tutoring on nonacademic outcomes of elementary school students. They conducted a meta-analysis that included 36 studies and reported positive effects of peer tutoring on students' self-concept (ES = 0.40), behavior (ES = 0.65), and social skills (ES = 0.52). A more recent meta-analysis (Bowman-Perrot Burke, Nan, & Zaini, 2014), examined the effects of peer tutoring on social and behavioral outcomes for students enrolled in PK-12 across 20 studies. These researchers found that peer tutoring was effective in improving social skills and social interactions (TauU ES = 0.69), enhancing academic engagement (TauU ES = 0.38) and reducing disruptive behaviors (TauU ES = 0.60).

Theoretical Framework that Support Peer Tutoring Implementation

The effectiveness of peer tutoring in mathematics could be supported by Bandura's (1977) social learning theory that suggests that humans can learn by observing behaviors of other individuals around them. In addition, Vygotsky's (1978) sociocultural theory provides a strong theoretical foundation for peer tutoring since this author illustrates how children can learn from others by interacting in social environments. The following sections include a more detailed explanation about the platform provided by these theories for the implementation of peer tutoring in mathematics classrooms.

Bandura's Social Learning Theory

Bandura's social learning theory postulates that learning is a cognitive process that can occur by observing other people's actions (Bandura, 1977). After observing different actions, strategies, or tasks performed by *models*, the observed information is processed and coded in the brain and will be remembered and reproduced. Bandura stated that "most human behavior is learned observationally through modeling: from observing others one forms an idea of how new behaviors are performed, and on later occasions this coded information serves as a guide for action." (Bandura, 1997, p. 22).

Bandura coined the term *modeling* to describe people observing what others do and learning from them. These people serve as *models* for the observers, who will use this *observational learning* to reproduce their own behaviors (Bandura, 1977). Children learn every day from multiple *models* in their social environment. Examples of *models* are parents, brothers, sisters, teachers, friends, and peers. These *models* can have a powerful influence on children's cognitive development.

The concept of modeling is very important when we apply it to tutoring contexts. Tutees learn behaviors and skills from their tutors all the time. Tutors are the *models* to follow for their tutees. For example, during mathematics peer tutoring sessions, tutees can learn from tutors how to analyze information, solve problems, manipulate or design graphic representations to visualize math information, etc.

Vygotsky Social Development Theory

According to Vygotsky (1978), social environment plays a fundamental role in cognitive development. Social interactions help humans learn from others, analyze information, and solve problems. Speech helps individuals exchange valuable information necessary to perform specific tasks or solve problems. Peer tutoring strategies promote student-center environments that provide children multiple opportunities to communicate and interchange information with their peers which improve their cognitive development (Rohrbeck, et al., 2003).

Vygotsky (1978) explained that children achieve different levels of mental functions as they grow and develop. The mental age of a child could be different from his/her chronological age. In every stage of mental development, there are tasks that children can complete and problems that they can solve by themselves but there are additional tasks or problems that they can solve with the assistance of others. Vygotsky called this space for potential learning the *Zone of Proximal Development*. To illustrate this concept, Vygotsky (1978) provided an example of two ten-year-old children with a chronological mental development similar to an eight-year old's. Both were able to perform a task with equal or less level of difficulty than the ones standardized for eight-year-old levels, one of these children was absent from school half of the academic year while the other attended to school regularly. When the adult guidance was added to this scenario, the child that missed half of the school year was able to solve problems up to a nine-year-old level and the other child was able to deal with problems up to a twelve-year-old level.

Vygotsky (1978) stated that the *zone of proximal development* "is the distance between the actual development level as determined by independent problem-solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers." (p. 86). If we transfer this concept and the example provided by Vygotsky to peer tutoring environments, we could conclude that children can achieve new levels of knowledge and skills when they have the support of more knowledgeable peers. For example, in this study, third-grade students could solve problems beyond their normal ability when they are guided and supported by their fifth-grade tutors.

Peer Tutoring for Hispanic Students

Padrón, et al. (2002) stated that the educational status of Hispanic students in the United States is critical. They highlighted that while this segment of the student population is rapidly increasing in public schools, their academic performance is considerably low compared with other groups of students.

One of the factors associated with the critical condition of Hispanic education is the lack of appropriate instruction that really fulfill the needs of this group of students. Padrón et al. (2002) found that the most common classroom practice in schools that enroll Hispanic students is direct instruction, where the majority of instructional time is devoted to lecture, seatwork, drill, and memorization (Padrón et al., 2002). Peer tutoring is an effective classroom practice that can help transform teacher-center instruction into student-centered instruction, individual seatwork into engaging teamwork, and boring drill and memorization of concepts and formulas into meaningful classroom discussions. Topping et al. (2003), for example, found that peer tutoring improved cooperation among students, tutor-tutee pairs have multiple opportunities to discuss their ideas, ask for help, and formulate questions about math. These unique features of peer tutoring could help Hispanic students who are English language learners (ELLs) to improve their academic language, which is key in promoting academic achievement in mathematics.

Although there is some research about the effects of peer tutoring in mainstream classrooms more research is needed about the benefits of peer tutoring for Hispanic students who are learning English as a second language. Previous research suggests that peer tutoring could help Hispanic students to enhance their academic language and at the same time improve their knowledge and skills in mathematics. Peer tutoring could help teachers to create a collaborative team environment where academic language can be promoted through meaningful discussions between tutors and tutees.

Definition of Terms

Peer tutoring is an instructional approach where one student (tutor) provides instruction to another student (tutee) (Damon & Phelps, 1989; Ding & Harskamp, 2010). In this partnership, the tutor is more knowledgeable or has greater competence than the tutee (Damon & Phelps, 1989; Miller, Topping, & Thurston, 2010). The term *peer tutoring* is used to refer to same age or different age partnerships.

Cross-age tutoring is a more specific term for partnerships between students of different ages or different grade levels, with older students in higher-grade levels tutor younger students in lower grade level (Robinson et al., 2005). For example, in this study, students in fifth grade are the tutors of students in third grade.

Reciprocal peer tutoring (RPT) as an instructional practice that involves students with comparable academic ability and about the same age, working collaboratively in pairs or dyads. One of the students in this partnership assumes the role of tutor and the other the role of tutee. Dyads members alternate between the tutor and tutee role after a given period of time or after the conclusion of structured academic tasks (Heller, Rio, & Fantuzzo, 1993; Ginsburg-Block & Fantuzzo, 1997).

English language learner (ELL) The term LEP and ELL are used interchangeably in official documents. According to the Texas Education Code (TEC), 29.052 students whose primary language is other than English and have difficulties performing ordinary classwork in English (Texas Education Agency, 2016).

Hispanic or Latino "refers to a person of Cuban, Mexican, Puerto Rican, South or Central American, or other Spanish culture or origin regardless of race" (U.S. Bureau, 2010, p. 2).

Significance of the Study

Expectations and demands linked to academic outcomes in elementary and secondary schools have greatly increased, especially after the enactment of the No Child Left Behind (NCLB) Act of 2001 (NCLB, 2002). Peer tutoring has been extensively recognized as an effective strategy to promote academic success. Tutoring programs can help Hispanic students improve academic performance in mathematics, reading and other subjects across several grade levels and various student ability levels. In addition, research has found that peer and cross-age tutoring has a positive impact on socio-emotional outcomes such as attitudes toward the subject matter that they were being taught.

Based on the evidence presented about positive effects of peer-assisted tutoring instruction, this practice could be used to improve the learning process of low-performing students. Since Hispanic students perform persistently low in mathematics, peer tutoring could be an effective strategy to provide at-risk students the kind of instruction that fits their individual needs. Moreover, it could be an excellent alternative for students who are in the beginning phase of second language acquisition but are currently placed in classrooms where the language of instruction is English. The flexibility of peer-assisted tutoring could allow the opportunity to provide students at risk with bilingual tutors who could help them in their native and second language.

Summary of Chapters

Chapter 1 of this dissertation contains an introduction for the three studies that portraits the educational challenges for Hispanic students in mathematics classrooms, how we can improve teaching and learning in mathematics by selecting effective educational practices and interventions, the rationale for selecting peer tutoring as an instructional strategy to improve academic achievement of Hispanic students, and the theoretical framework that support the implementation of peer tutoring as a successful instructional practices in mathematics classrooms.

Chapter 2 presents the first study which is a meta-analytic review of 21 studies that reported the effects of peer tutoring on academic achievement in mathematics. This chapter provides a panoramic view of the effectiveness of peer tutoring in elementary and secondary school as well as the specific effects of peer tutoring for several moderator variables including students' SES, race, education level, students at-risk, and school location.

Chapter 3 reports the second study which explores the academic and nonacademic outcomes of a cross-age peer tutoring program implemented in elementary and middle schools with predominantly Hispanic students.

Chapter 4 reports on the third study of this dissertation. This study evaluates the implementation of a cross-age-peer-tutoring program in elementary and middle schools that serve predominantly Hispanic students. Classroom observations and face-to-face interviews were used to evaluate the instructional practices and behaviors of teachers, tutors, and tutees during tutor preparation sessions as well during actual tutoring instruction.

Finally, Chapter 5 summarizes the three studies in this dissertation and presents conclusions and recommendation for further research, and practice.

CHAPTER II

A META-ANALYSIS OF THE EFFECTS OF PEER AND CROSS-AGE TUTORING ON MATHEMATICS ACHIEVEMENT

Overview

This meta-analytic review examines the effects of peer and cross-age tutoring on academic achievement in mathematics for 3,035 participants in kindergarten through grade 12 across 21 experimental or quasi-experimental studies. The results showed that peer tutoring interventions were effective for improving students' academic achievement in mathematics. The overall mean-weighted effect size for the 21 studies included in this meta-analysis was 0.49, $p < 0.001$, and 95%, confidence interval = 0.34 - 0.65. Demographic moderator analyses indicated that peer tutoring interventions were most effective for at-risk, low socioeconomic status, suburban, African American, and secondary school students. Treatment moderator analysis suggested that cross-age peer tutoring programs were more effective than same-age peer tutoring programs. Interventions offered 1 to 2 times a week, during 6 to 12 weeks, and interventions with a total amount of instruction greater than 24 hours generated the highest effect on mathematics achievement.

Introduction

Mathematics is very important in our highly technological society of the 21st century. People need mathematics every day in the workplace, at school, and in almost every aspect of daily living, such as shopping, preparing a personal budget, buying a car, borrowing from the bank, counting calories, etc. The NCTM in the Executive Summary of the Principles and Standards for School Mathematics highlighted that we live in a time characterized by rapid changes in knowledge, information, and technology. Mathematics knowledge and skills are continuously evolving in response to these changes. The demand for individuals who can understand and use mathematics in daily life activities and in the job market will continue to increase (NCTN, 2000).

In this complex technological and digital world, mathematics is the gateway to success. The NCTM highlights that mathematics skills can open doors to success, while the lack of mathematical competence closes those doors (NCTM, 2000). Consequently, it is very important that schools provide students a high-quality education in mathematics that will allow them to succeed not only in academics but will also prepare them to succeed in a competitive labor market and in their personal life.

Unfortunately, many students experience problems in mathematics classrooms. The National Center for Education Statistics (2016) informed that on average only 40% of students in grade 4 and 33% of students at 8th grade performed at or above proficient on the 2015 National Assessment of Educational Progress (U.S. Department of Education, NCES, 2016). One instructional practice that has been identified by researchers as effective to improve students' academic outcomes in math classrooms is peer tutoring (Cohen, et al., 1982; Hartley, 1977; Robinson, et al., 2005, Topping et al., 2011). In addition, studies have found that peer tutoring has a positive impact on socio-emotional outcomes such as attitudes toward the subject matter that they were being taught (Cohen, et al., 1982), self-concept (Cohen, et al., 1982; Robinson, et al., 2005), and sense of their academic self-efficacy (Robinson, et al., 2005).

Previous Research

I selected meta-analysis to evaluate and synthesize the research on effects of peer tutoring in mathematics achievement because this is a powerful statistical technique that allows examining the magnitude, direction, and consistency of the effects of educational interventions such as peer tutoring, which is the focus of this study. Lipsey and Wilson (2001) stated that one of the major advantages of meta-analysis compared to narrative literature reviews is that this method allows the evaluation of results across studies and summarizes these findings in a numerical value, called *effect size*, which encodes the variables of interest into a common index that is comparable across studies and portrays the magnitude and direction of effects.

The term "meta-analysis" was coined by Gene Glass and presented to the American Educational Research Association in 1976 (Cohen, et al., 1982). Before Glass developed the meta-analysis technique, reviews of literature in education were limited to a descriptive summary of research findings. These reviews did not provide information about the magnitude and direction of the effects of educational interventions such as cooperative learning, small groups, peer tutoring, etc. This limitation prevented accurate conclusions about the expected gains from the peer tutoring in classroom settings

(Cohen et al., 1982). After Glass and Smith (1976) used meta-analysis to summarize the outcomes from psychotherapy studies, other researchers used this technique in studies that appeared in educational literature.

One of the first persons to use meta-analysis techniques to summarize results from previous studies was Hartley (1977), who used meta-analysis in her doctoral dissertation as an alternative technique to aggregate research findings from literature. Hartley explored the effects of four instructional methods used in math classrooms: computer assisted instruction, peer tutoring, programmed instruction, and individual learning packets, and peer-programed instruction. The results of Hartley's study revealed a superior effect for peer tutoring (ES =0.60) compared to the other three instructional techniques: computer assisted instruction (ES = 0.41), programmed instruction (ES = 0.11), and individual learning packets (ES = 0.16).

Cohen et al. (1982) conducted a meta-analysis that included Hartley's work. These researchers evaluated 65 studies published between 1961 and 1980 that focused on the effects of peer tutoring on mathematics, reading, and other content areas for students in Grades 1-12. The effects of tutoring programs were reported for tutors and tutees. The mean effect size in mathematics was 0.62 for tutors and 0.60 for tutees, greater than the effect size in reading of 0.21 for tutors and 0.29 for tutees, evidencing the great effectiveness of peer tutoring in improving mathematics academic achievement. Furthermore, Cohen and colleagues reported that the mean effect size for tutees who participated in cross-age tutoring programs was 0.49, greater than the mean effect size for children who did not participate in cross-age tutoring (ES = 0.29). A mean effect size of 0.95 for tutees was reported for programs that lasted four weeks or less while an effect size of 0.16 was found for studies that provided treatment from 19 to 36 weeks. In addition, the mean effect size for tutees in grades 1-3 was 0.45, while the mean effect size for children in grades 4-6 was 0.25; the mean effect size for tutees in grades 7-9 was 0.33. Cohen et al. also found positive effect sizes of tutoring for both tutors and tutees on attitude toward the subject that they were being taught and self-concept. (Cohen et al., 1982).

Rohrbeck, et al. (2003) conducted a meta-analytic review of a group of 90 studies that examined peer-assisted learning (PAL) interventions with elementary school students. These studies were published between 1972 and 2000. It is important to note that the PAL interventions examined in this study included not only peer tutoring but also other forms of cooperative learning such as small groups integrated by 3 to 6 participants (43 studies), pairs (40 studies), combination of pairs and small group (5 studies), and small groups that did not report the number of students (2 studies).

Rohrbeck et al. (2003) found a positive mean effect size for mathematics (ES = 0.22) and for reading (ES = 0.26). A moderator analysis indicated that the effect of PAL interventions was significantly higher for minority, low-income, and urban students compared with their majority, higher income, and suburban-rural peers (p. 240). They reported larger effect size in studies that included more than 50% ethnic minority students (ES = 0.51) compared with studies that included fewer minority students (ES = 0.23). In addition, studies that included more than 50% of children from low socio-economic status had larger the effect size (ES = 0.45) than studies were less than 50% of the children were from low SES (ES = 0.32). Studies that included students in Grades 1-3 had a larger effect size (ES = 0.37) than studies that included students in Grades 4-6 (ES = 0.28). Finally, the effect size of PAL interventions for students in urban classrooms (ES = 0.44) was stronger than the effect size for students in suburban-rural classrooms (ES=0.23).

Although Rohrbeck and colleagues (2003) provided important information about the effectiveness of PAL interventions for different types of cooperative groups across several content areas, only 44% of the studies focused specifically on peer tutoring and only 28% of the studies focused on mathematics. This makes difficult to separate the effects of peer tutoring from the other forms of peer-assisted learning included in this meta-analysis and the specific effects of this intervention on academic achievement of mathematics through the analysis of the moderator variables included in this study: minority status, SES, school location, tutee grade, etc.

Ginsburg-Block, et al. (2006) used meta-analysis to examine the effects of peer-assisted learning (PAL) on social skills, self-concept, and behavioral outcomes for elementary school students. They included 36 PAL studies published from 1976 to 2000 and reported a mean ES of 0.40 for self-concept, 0.65 for behavior, 0.52 for social skills, and 0.48 for academic achievement. In addition, they found a correlation of $r = 0.57$ ($p < 0.1$) between self-concept and academic achievement outcomes, $r = 0.59$ ($p < 0.1$) for social skills and academic achievement, and a positive but not statistically significant correlation between behavior and academic achievement, $r = 0.\ 13$. Furthermore, their homogeneity analysis and mean effect sizes for demographic moderator variables showed stronger PAL intervention effects on self-concept, behavioral, and social skills for minority, urban, and low SES students than for mainstream, suburban-rural, and higher SES.

Kunsch, et al. (2007) investigated the effectiveness of peer-mediated interventions on academic achievement in mathematics for students with and without disabilities in grades 6-12. They examined 17 studies published from 1982 to 2003 and reported an overall mean ES of 0.47 for mathematics performance. Moreover, they found that peer-mediated interventions were more effective in general education classrooms (ES = 0.56) than in special education classrooms (ES = 0.32) and for students at-risk (ES = 0.66) than for students with learning disabilities (ES = 0.21).

Although Kunsch et al. meta-analysis provides important information about the effects of peer-mediated instruction in mathematics classrooms, these researchers included only low achieving students and did not analyze demographic moderator variables that would have allowed us to know the effects of these interventions on minority students, SES, and school location.

Hattie (2009) conducted a mega-meta-analysis that synthesized more than 800 meta-analyses. This researcher emphasized the importance of selecting instructional interventions that maximize the educational benefits for students. An effective selection should be guided by the knowledge of the effect size generated by each educational alternative. Hattie found that the average effect size was $d = 0.40$ across more than 800 meta-studies related to achievement. He used the average effect size $d = 0.40$ as a benchmark to evaluate the contribution of different instructional practices and interventions on academic achievement. Hattie suggested that educators should select instructional interventions that have the potential to generate above-average effect sizes, or $d > 0.40$. Hattie (2009) indicated that an effect size $d = 1$ is equivalent to an increase of one standard deviation on the outcome and that "one standard deviation increase is typically associated with advancing children's achievement by two to three years, improving the rate of learning by 50%" (Hattie, 2009, p.7).

Likewise, Hattie (2009) illustrated the relevance of the magnitude of the effects of educational interventions. He stated that almost everything that teachers implement at school have the potential to enhance academic achievement. He found that the effect size of about 90% of all educational practices or interventions was positive. Consequently, knowing that the effect size of a given intervention is positive is not enough to determine its effectiveness —teachers need to know the magnitude of the effect size in order to select instructional practices that can maximize their students' academic achievement. Hattie created a barometer of influence to illustrate what works and what does not work in education. He stated that all interventions that generate effect sizes greater than d = 0.40 are located in the "*zone of desired effects*" since these are the kind of interventions that can have a significant impact on student achievement. He found that one of the interventions in the *zone of desired effects* was peer tutoring (d = 0.55).

A more recent meta-analysis was performed by Bowman-Perrott, et al. (2013). They examined 26 studies, published from 1984 to 2011 focused on the academic effects of peer tutoring in Grades 1-12. They limited their analysis to single-case research experiments and use single-case design methods to calculate effect size. The TauU effect size for the studies included in this meta-analysis was 0.71 with a confidence interval of CI_{95} equal to 0.71 to 0.78. In addition, they found that peer tutoring yielded a larger effect (ES = 0.86) in mathematics than in reading (ES = 0.77). The majority of studies included in this meta-analysis (n = 23) involved students with identified disabilities or students considered at risk of disabilities because of their poor academic performance. Only four studies did not include students with or at risk for disabilities. Moderator analysis revealed a mean effect size of 0.76 for students with or at risk for disabilities and a mean effect size of 0.65 for students without disabilities. Unfortunately, moderator analysis did not tested the specific effects of peer tutoring for students with disabilities and students at-risk of academic failure.

Bowman-Perrott, et al. (2014) examined 20 studies that focused on the effects of peer tutoring on social and behavioral outcomes for students enrolled in PK-12. They included only studies that used single-case research designs published between 1985 and 2011. The overall effect of peer tutoring on students' social and behavioral outcomes was (Tau ES = 0.62). Furthermore, the moderator analysis revealed that cross-age tutoring had a stronger effect on students' behavior and social skills (Tau ES = 0.73) than same age tutoring (Tau ES = 0.52). In contrast to the meta-analysis conducted by Bowman-Perrott et al. (2013) that examined the academic effects of peer tutoring for students with or without disabilities in Grades 1-12, Bowman-Perrott et al. (2014) explored the effects of peer tutoring on behavioral and social outcomes for students with identified disabilities in Grades PK-12. Only one of the 20 studies included in this meta-analysis did not include students with disabilities. Bowman-Perrott et al. (2014) also reported a correction between behavioral and social outcomes and academic achievement (r = 0.57), similar to the findings of Ginsburg-Block et al. (2006), who reported a correlation of r = 0.59 between social skills and academic achievement. Finally, Bowman-Perrott et al. (2014) also reported an effect size (Tau ES = 0.61) equivalent to a Cohen *d* of 1.31 for academic achievement. This effect size was slightly smaller than the effect size reported by Bowman-Perrott, et al. (2013) (Tau ES = 0.71).

Leung (2015) examined the effects of peer tutoring on academic achievement at kindergarten, elementary, secondary, college, and university levels. This meta-analysis included 72 studies, 20 of them focused on mathematics. It reported a similar effect size for reading ($d = 0.34$) and mathematics ($d = 0.34$). Although Leung (2015) provided important information about moderators that affect achievement outcomes, this analysis does not involves an independent evaluation of mathematics since includes other subjects such as reading, language, science and technology, physical education, arts, and other areas. Consequently, it is not possible to know the extent to which important moderators that could influence achievement in mathematics.

Even though previous meta-analytic reviews have reported the effects of peer tutoring on student academic and nonacademic outcomes, there are several gaps in the literature. Previous research has focused on peer-assisted learning that includes several types of cooperative learning—small groups, peer tutoring, and cross-age tutoring—across a wide span of academic areas. This heterogeneity makes it difficult to discern how one-to-one tutoring affects mathematics achievement specifically. In addition, the majority of studies focused on peer tutoring interventions in elementary schools, neglecting interventions in secondary schools. Therefore, the purpose of this meta-analysis is to summarize the effects of peer tutoring interventions on mathematics achievement of K-12 students and to identify and analyze relevant moderators that influence the effectiveness of peer tutoring interventions in mathematics for minority students.

Types of Peer Tutoring

As explained before, one effective instructional practice in education than can generate positive effects on academic and nonacademic outcomes is peer tutoring. This strategy involves students teaching other students. In general, an academically stronger student takes the role of teacher and provides specific content instruction to an academically weaker student (Fuchs, Fuchs, Phillips, Hamlett, & Karns, 1995). All students in the classroom are actively engaged in peer tutoring activities.

Classwide Peer Tutoring

Fuchs, et al. (1995) explained that in classwide peer-assisted learning strategies (PALS) student dyads work during a class on academic content. Generally, the more knowledgeable student takes the role of tutor, and this role is interchanged after a period of time (i.e., one week or two weeks) when the tutee adopts the role of tutor.

Cross-age Peer Tutoring

Dyads are composed of students of different ages or different grade level (Robinson, et al. (2005). The older and more knowledgeable student assumes the role of tutor while the younger student becomes the tutee (i.e., a fifth grade student provides instruction to a third grade child).

Reciprocal Peer Tutoring

Reciprocal peer tutoring (RPT) involves tutors and tutees who have homogeneous knowledge of the subject matter that they are learning in class (Miller, Topping, & Thurston, 2010). "In this cooperative strategy, students alternate between student and teacher roles and follow a structured format to help team members make academic progress. Two or more students work together to prompt, teach, monitor, evaluate, and encourage each other" (Fantuzzo, King, & Heller, 1992, p. 332).

Nonreciprocal Peer Tutoring

Nonreciprocal tutoring involves two students working together. One of the students assumes the role of tutor during the whole tutoring intervention and the other students takes the role of tutee (Menesses & Gresham, 2009).

Method

Search Procedure

An electronic search of the literature was conducted to identify relevant studies related to peer tutoring in mathematics published between 1982 and 2015. Only studies that focus on one-to-one peer tutoring or cross-age tutoring in mathematics were selected. Search engines included Educational Resource Information (ERIC), PsycINFO, and Google Scholar. Search terms including *peer tutoring, cross-age tutoring, peer teaching, peer-assisted learning*, *peer collaboration*, *reciprocal tutoring* were combined with the descriptors: *mathematics, math achievement*, *math outcomes, elementary schools*, *secondary schools, elementary education*, *secondary education*, and *school-age* *children*. This search generated a list of 178 studies. All abstracts were reviewed to identify the studies that met the inclusion criteria.

In addition, studies included in the reference lists of peer tutoring review articles and relevant studies that focus on the effect of peer tutoring in mathematics included in previous meta-analyses were reviewed. Furthermore, three journals were hand-searched for relevant studies in the last 5 years (2010-2015), the *American Educational Research Journal, Review of Educational Research,* and the *Journal of Educational Psychology*. These journals were selected because they were cited numerous times in previous meta-analytic reviews that focused on peer tutoring.

Inclusion Criteria

Abstracts and methods sections were reviewed to determine if studies met the selection criteria. Only studies that met the following selection criteria were included in this meta-analysis: (a) studies that were experimental or quasi-experimental in design, (b) participants were children enrolled in Grades K through 12, (c) studies that reported quantitative outcome measures related to the effects of peer or cross-age tutoring on academic achievement in mathematics, (d) studies had to provide sufficient quantitative information to allow a calculation of the effect size, (e) studies that were presented in a published journal article between 1982 and 2015. Studies that focused exclusively on students with learning disabilities were excluded since this study focuses on the effects of peer and cross age tutoring of students in the general population. These students could have different characteristics and needs than children in special education classrooms.

After applying these guidelines, I identified 21 studies that met the selection criteria. These studies are displayed in the results section.

Identifying and Coding Variables

After the selection of studies included in this meta-analysis, variables of interest were coded using the guideless provided by Lipsey and Wilson (2001). All codes were entered into an Excel spreadsheet. Appendix "A" displays the variables identified and coded under the following categories: (a) bibliographic reference, (b) sample descriptors, (c) research design descriptors, (d) nature of treatment descriptors, (e) nature of control descriptors, and (f) effect size data. The following paragraph contains a more detailed explanation of each of the above categories.

The bibliographic reference contains information about study identification number, type of publication, and publication year. The sample descriptors include information about the demographic characteristics of students who participated in tutoring program, including age, ethnicity, gender, socioeconomic status (SES), at-risk students, grade level, academic ability, and language of instruction. Research design descriptors include characteristics of the experimental and control groups. The nature of treatment descriptors include type of peer tutoring program, settings and duration of the treatment, frequency of tutoring sessions, length of each tutoring session in minutes, and total number of hours that students were involved in tutoring programs. The effect size data includes the type of the effect size data used in this study, such as means and standard deviations, t-test, F-value, and p-value. The effect size data also includes the calculated effect size *d* for each study or Hedges *g*.

Effect Size

The three most common effect size indexes used in meta-analysis are: standardized mean difference (*d* or *g*), odds-ratio and risk-ratio (*OR* and *RR*), and correlation coefficient (*r*) (Wilson, 2011a). The *standardized mean difference effect size* is used in studies that have a fundamental research design that include group contrasts (e.g. experimental group versus control group), and the outcome is measured in a continuous scale such as math achievement that can go from low to high. The *odds-ratio* is used in studies with similar research designs and variables are measured on two or more groups. The difference between *odds ratio effect size* and *standardized mean difference effect size* is that the outcome construct reported by researchers is dichotomous (e.g. pass, no pass) in *odd ratio effect size* while outcomes in *standardized mean difference effect size* are measured in continuous variables (e.g. a letter grade). Finally, the *correlation coefficient effect size* (*r*) is used in studies that report the relationships between two constructs (Wilson, 2011a), such as the relationship between self-concept and academic achievement in mathematics.

This meta-analysis uses the s*tandardized mean difference effect size* (ES_{sm}) since the research design of all the studies involve comparison groups. Effect sizes were computed using the information reported in each research study and the procedures suggested by Lipsey and Wilson (2001). Equation (1) compares the mean of experimental and control groups and standardizes this difference by dividing by the pooled standard deviations of the two groups.

$$ES_{sm} = \frac{\overline{X}_1 - \overline{X}_2}{s_{pooled}} \quad (1)$$

where X_1 and X_2 are the mean of Group 1 and group 2 respectively and s_{pooled} is the pooled standard deviation of the two groups calculated using equation (2) (Lipsey & Wilson, 2001):

$$Sp = \sqrt{\frac{(n_1 - 1)s^2_1 + (n_2 - 1)s^2_2}{(n_1 + n_2 - 2)}} \quad (2)$$

where n_1 and n_2 are the number of participants in group 1 and group 2 respectively, s_1 is the standard deviation of group 1, and s_2 is the standard deviation of group 2, and s_p is the pulled standard deviation of the two groups.

Since effect size could be slightly upwardly biased for small sample sizes, this potential bias was corrected using the Hedges correction adjustment (Lipsey & Wilson, 2001). Even though this correction has a small impact in large samples, I applied this correction to all the effect sizes in this meta-analysis. Consequently, all effect sizes in this meta-analysis are unbiased.

$$ES_{sm}' = \left[1 - \frac{3}{4N - 9} \right] ES_{sm} \quad (3)$$

where ES_{sm}' is the unbiased *Standardized Mean Differences Effect Size* and *N* represents the total sample size.

In addition, it is very important to have a measure of the precision of the effect size. This can be measured with the *standard error of d.* (SE_d). This statistic was computed using the following equation (Lipsey &Wilson, 2001):

$$SE_{sm} = \sqrt{\frac{n_1 + n_2}{n_1 n_2} + \frac{ES_{sm'}^2}{2(n_1 + n_2)}} \quad (4)$$

SE_{sm} is the standard error of the effect size, n_1 and n_2 are the number of participants in group 1 and group 2 respectively. The above formula shows that the standard error of the effect size is mostly a function of sample size, which means that bigger sample sizes generate more precise effect size (Wilson, 2011a).

Furthermore, effect sizes from some studies are more precise than the effect sizes in others; therefore, meta-analytic reviews need an index of precision. This index can be represented by the inverse variance (*w*), computed as the inverse of the standard error square, as displayed in the following equation:

$$w = \frac{1}{SE_{sm}^2} \quad (5)$$

The method described above is known as *inverse variance weighting* and the meta-analysis that uses it is called *inverse variance weighting meta-analysis* (Wilson, 2011b). I used this method in this study because it offers several advantages. First, the effect size measured in the individual studies is more precise. Second, this procedure allows a better evaluation of the consistency of the effect size across studies, and it generates a more precise effect size that summarizes the whole meta-analysis.

Excel files were used to input the formulas described above and compute the information included in the results section of each one of the studies enclosed in this meta-analysis. The application of the above equations generated an unbiased *standardized mean difference effect size*s (*ES_{sm}')* for each study so that direction and magnitude can be easily compared across studies. The direction is denoted by the sign of the effect size. Positive effect size indicates that students in experimental groups performed better than students in control groups. Magnitudes allows quantitative comparisons between studies, for example, and effect size of $d = 1.0$ in one study is twice as big as an effect size of $d = 0.5$ computed in another study. Moreover, effect sizes are independent of sample size.

If studies did not report means and standard deviations, effect size was computed using *t* or *F* statistics. Furthermore, since the majority of studies reported more than one research finding in mathematics, the information of each study was entered in a separated Excel sheet to calculate a single effect size that reflects the overall effect of peer tutoring for all variables included in the study. For example, Codding, et al. (2011) reported means and standard deviations that involved four variables: number identification, missing number, quantity discrimination, and *Test of Early Mathematics Ability*. Effect sizes were calculated for each variable and then summarized and reported as an average effect size for the whole study. A commercial software were used to calculate the overall effect size and moderators. The name of this software is *Comprehensive Meta-Analysis.*

Results

General Descriptive Results

Demographic characteristics. The total number of participants in the 21studies included in this meta-analysis were 3,035 students enrolled in kindergarten through twelfth grade. The majority of studies focused on tutoring programs implemented in elementary schools (Table 2.1). Results show that 9.5% of studies (n = 2) included tutors in kindergarten, 57.1% (n = 12) in elementary school, 19% (n = 4) in secondary school, and 14.3% (n = 3) reported mixed groups of tutors from elementary and secondary school. Furthermore, 9.5% of studies (n = 2) involved tutees in kindergarten, 76.2% (n = 16) in elementary school, 9.5% (n = 2) in secondary school, and 4.8% (n = 1) in both elementary and secondary school.

Table 2.1

Descriptive Statistics of Participants at Study Level (N = 21)

Variable	*n*	%
Education Level of tutors		
Kindergarten	2	9.5
Elementary (Grades 1-5)	12	57.1
Secondary (Grades 6-12)	4	19.0
Both elementary and secondary	3	14.3
Education Level of tutee		
Kindergarten	2	9.5
Elementary (Grades 1-5)	16	76.2
Secondary (Grades 6-12)	2	9.5
Both elementary and secondary	1	4.8
Race		
> 50% White	3	14.3
> 50% Hispanic	0	0.0
> 50% Black	7	33.3
> 50% Asian	1	4.8
Mixed, cannot estimate proportion	2	9.5
Unknown (not reported)	8	38.1
Gender		
> 50% male	10	47.6
> 50% female	4	19.0
50% male and 50% female	1	4.8
Unknown (not reported)	6	28.6
Socioeconomic status (SES) of participants		
< 50% low SES	1	4.8
≥ 50% low SES	15	71.4
Unknown (not reported)	5	23.8
School location		
Urban United States	13	61.9
Suburban United States	1	4.8
Rural United States	2	9.5
Outside United States	5	23.8
At risk students or low achievement		
> 50% students at risk or low achievement	11	52.4
≤ 50% students at risk or low achievement	4	19.0
Unknown (not reported)	6	28.6

Note: n = number of studies

Only 52% of studies (*n* = 11) reported the racial status of participants. Fourteen percent of studies (*n* = 3) indicated that White students accounted for greater than 50% of participants, 33.3% (*n* = 7) reported that African American students comprised more than 50% of participants, and one study stated that the majority of participants were Asian. Unfortunately, none of studies reported more than 50% Hispanic participants. Additionally, 71% of studies reported the gender of participants. Male participation was predominant in these studies, 47.6% of them reported that males accounted for more than 50% of the participants.

Table 2.1 also shows that 71.4% (*n* = 15) of studies reported that low-SES students accounted for greater than 50% of participants, one study informed that less than 50% of participants were low-SES, and 23.8% (*n* = 5) studies did not report the SES of participants. In addition, 76% of studies (*n* = 16) focused on schools located in the United States (U.S.) and 23.8% (*n* = 5) in schools outside U.S. Also, 61.2% of studies (*n* = 13) involved urban U.S. schools. Additionally, 52.4% (*n* = 11) reported that students at risk of academic failure or with low achievement in mathematics accounted for more than 50% of participants.

Descriptive results of intervention variables. Table 2.2 contains the information about some important features of the peer tutoring treatment. The majority of studies (n = 15) focused on tutoring interventions with same-grade level tutors and tutees. Six studies reported that explored the effects of cross-age peer tutoring on academic achievement in mathematics. In addition, the majority of tutoring intervention lasted from 7 to 18 weeks (54.2%). Also, the majority of studies reported 2 peer tutoring sessions per week (54.2%). Eight studies (38.1%) reported a total amount of 0.5 to 12 hours, six studies (28.6%) 13 to 24 hours, and 3 studies (14.3%) 25 to 48 hours. Four studies (19%) did not report the total time of peer tutoring intervention.

Table 2.2

*Descriptive Results of Intervention Parameters (*N *= 21)*

Variable	*n*	%
Type of peer tutoring		
Same age peer tutoring	15	71.4
Cross-age peer tutoring	6	28.6
Duration of treatment in weeks		
1 to 6 weeks	5	23.8
7 to 18 weeks	11	54.2
More than 18 weeks	5	23.8
Number of sessions peer week		
1 session	1	4.8
2 sessions	11	52.4
3 sessions	4	19.0
4 sessions	2	9.5
5 sessions	2	9.5
Unknown (not reported)	1	4.8
Total amount in hours		
0.5 to 12 hours	8	38.1
13 to 24 hours	6	28.6
25 to 48 hours	3	14.3
Unknown (not reported)	4	19.0

Note. n = number of studies

Effect Size Analysis

The weighted mean effect size for the 21 studies included in this meta-analysis was significant in both the fixed effect model (ES = .41, $p < 0.01$; 95% confidence interval (CI) [0.34, 0.49]) and random effect model (ES= .49, $p < 0.01$; 95% CI [0.34, 0.65]). The homogeneity statistics analysis (Q = 70.74, p < 0.01, $I^2 = 72\%$) indicated that Q was statistically significant at $\alpha = .05$, suggesting that the effect sizes across the studies were heterogeneous and that the variability was generated not only by sampling error but also by true differences across studies; consequently, the homogeneity assumption relating to the effect size distribution in the fixed effects model was rejected and only a random effect model were used for further analysis.

Wilson (2011b) explained that while fixed models assumes that effect size variability is generated only by sampling error, random effect models assumes that the variability of effect sizes could be attributed to sampling error plus true variability across studies, $I^2 = 72\%$ suggested that 72% of the variability across the peer tutoring studies could be explained by heterogeneity rather than by change. Consequently, as recommended by Wilson (2011b) I used a random effect model to capture both sampling error and study level variability.

Figure 2.1 summarizes the effect sizes and confidence intervals across the 21 studies included in this meta-analysis. The overall weighted effect size of peer tutoring in mathematics across all studies using the random effects model was (ES =0.49 SE = 0.08, CI [0.34, 0.65]). This confidence interval indicates that there is a 95% certainty that the true values of the effect sizes calculated in this study fell between the lower limit (LL) and upper limit (UL) of the confidence intervals.

The effect size of 0.49 means peer tutoring enhanced the academic achievement in mathematics of students who participated in these programs by approximately one half standard deviation. This result is compatible with the findings in Hattie (2009) mega meta-analysis. After synthetizing more than 800 meta-analysis that focused on achievement, he reported an overall effect size for peer tutoring of d = 0.55. Hattie stated that effect sizes greater than 0.40 can make a notable difference in improving students' academic achievement in all subjects. Consequently, the ES = 0.49 suggests a meaningful effect of peer tutoring programs on academic achievement in mathematics.

Figure 2.1 includes a Forest-Plot that provides a visual representation of the effect size results of the current meta-analysis. Each row in this graphic represents a study. The Forest-Plot shows that all effect sizes are positive and follow a consistent pattern with no evidence of outliers. Studies with the largest ES include Menesses and Gresham (2009), ES = 1.14; Sharpley, et al. (1983), ES = 1.04; Heller and Fantuzzo (1993), ES = 0.98; Bar-Eli and Raviv (1982), ES = 0.77; Ginsburg-Block and Fantuzzo (1998), ES = 0.77; Ginsburg-Block and Fantuzzo (1997), ES = 0.71. Studies with small effect sizes included Fuchs, Yazdian, and Powell (2002), ES = 0.09; Topping, et al. (2011), ES= 0.16; Cairo, Craig, & Appalachia Educational Lab (2005), ES = 0.18; Obidoa, Eskay, and Onwubolu (2013), ES = 0.22; and Sprinhall & Schoot (1989), ES = 0.26.

Study name	Hedges's g	Lower limit	Upper limit
Bar-Eli & Raviv (1982)	0.77	0.26	1.28
Cairo & Craig (2005)	0.18	-0.19	0.55
Codding, Chan-lannetta, George, Ferreira, & Volpe (2011)	0.35	-0.06	0.76
Davenport & Howe (1999)	0.51	0.02	1.00
Fantuzzo, Davis, and Ginsburg (1995)	0.68	0.19	1.17
Fantuzzo, King, and Heller (1992)	0.69	0.14	1.24
Fuchs, Fuchs, & Karns (2001)	0.37	0.06	0.68
Fuchs, Fuchs, Karns, Hamlett, Katzaroff, & Dutka (1997)	0.68	0.05	1.31
Fuchs, Fuchs, Hamlett, Phillips, Karns, & Dutka (1997)	0.36	0.01	0.71
Fuchs, Fuchs, Phillips, Hamlett, & Karns (1995)	0.29	-0.34	0.92
Fuchs, Fuchs, Yazdian,& Powell (2002)	0.09	-0.13	0.31
Ginsburg-Block & Fantuzzo (1997)	0.71	0.08	1.34
Ginsburg-Block & Fantuzzo (1998)	0.77	0.14	1.40
Greenwood, Delquadri & Hall (1989)	0.35	-0.00	0.70
Heller & Fantuzzo (1993)	0.98	0.43	1.53
Menesses & Gresham (2009)	1.14	0.55	1.73
Nazzal (2002)	0.48	-0.05	1.01
Obidoa, Eskay, & Onwubolu (2013)	0.22	0.06	0.38
Sharpley, Irvine, & Sharpley (1983)	1.04	0.82	1.26
Sprinthall & Scott, (1989)	0.26	-0.25	0.77
Topping, Miller, Murray, Henderson, Fortuna, & Conlin (2011)	0.16	-0.08	0.40
Overall Effect Size	0.49	0.34	0.65

Statistics for each study

Hedges's g and 95% CI

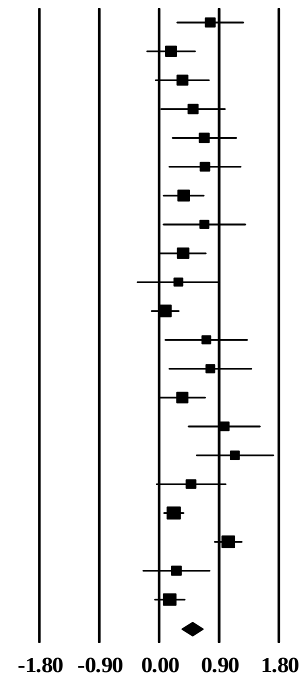

Figure 2.1: Forest Plot of Effects of Peer Tutoring on Students' Academic Achievement in Mathematics

Analysis of Moderator Variables

A homogeneity test was conducted to determine the extent to which various moderators could account for the variation in effect sizes across studies examined in this meta-analysis. I used the *Comprehensive-Meta-Analysis* software to examine various moderators under the fixed effects model. The mean effect sizes and confidence intervals of selected demographic moderators are displayed on Table 2.3. Q-between (Q_B) indicates the degree of heterogeneity between groups. Q-within (Q_W) measures the heterogeneity within the groups (Lipsey & Wilson, 2001).

Grade level. Results on Table 2.3 evidence that the level of education of tutee was not a significant moderator of achievement outcomes in mathematics ($Q_B = 3.28$, $p = 0.351$). It is important to note, however, that peer tutoring programs were more effective for students in secondary schools (ES = 0.60) than in elementary schools (ES = 0.40), or Kindergarten (ES = 0.34). Furthermore, there was heterogeneity among studies that examined tutoring interventions for elementary students ($Q_W = 67.46$, $p < 0.001$).

Race/ethnicity. Table 2.3 shows that race/ethnicity of participants was a significant moderator of mathematics achievement, yielding high heterogeneity ($Q_B = 29.90$, $p < 0.001$). Studies that reported results of peer tutoring programs for African American students generated the highest effect size (ES =0.77), followed by programs for White students (ES = 0.44), and Asian students (ES = 0.29). $Q_W = 20.36$ suggest that there is still heterogeneity among peer tutoring studies that focused on African American children. Unfortunately, I did not find studies that focus on interventions with more than 50% of Hispanic students.

Table 2.3

Homogeneity Analysis, Mean Effect Sizes, and Confidence Intervals for Selected Demographic Moderators

Variable	*k*	*Mean ES*	Q_B	Q_W	95% CI
Education level of tutee			3.28		
Kindergarten	2	0.34		0.27	0.03-0.64
Elementary (Grades 1-5)	16	0.40		67.20***	0.32-0.48
Secondary (Grades 6-12)	2	0.60		0.23	0.25-0.94
Mixed	1	0.77		0.00	0.26-1.28
Race			29.90***		
White	3	0.44		2.06	0.21-0.66
African American	7	0.73		20.36*	0.59-0.87
Hispanic	0				
Asian	1	0.29		0.00	-0.34-0.82
Mixed	2	0.20		0.17	0.07-0.33
Unknown (not reported)	8	0.34		18.2*	0.21-0.49
Location			2.84		
Urban U.S.	13	0.45		54.99***	0.36-0.54
Suburban U.S.	1	0.51		0.00	0.02-1.00
Rural U.S.	2	0.28		0.47	0.02-0.53
Outside U.S.	5	0.33		12.43*	0.16-0.50
Socioeconomic status (SES) of participants			0.65		
< 50% low SES	1	0.35		0.00	0.00-0.70
≥ 50% low SES	13	0.43		47.50***	0.34-0.52
Unknown (not reported)	7	0.37		22.60**	0.22-0.52
At risk			14.77**		
> 50% students at risk	11	0.58		37.03	0.47-0.69
≤ 50% students at risk	4	0.30		9.36	0.17-0.44
Unknown (not reported)	6	0.27		9.54	0.12-0.41

Note. A significant Q_B indicates that there are significant differences between the groups. A significant Q_W indicates heterogeneity within the groups.
CI = Confidence interval
k = number of studies
Q_B = Q-between
Q_W = Q-within
**p* < 0.05, ***p* < 0.01, ****p* < 0.001

Table 2.4

Homogeneity Analysis, Mean Effect Sizes, and Confidence Intervals for Selected Treatment Moderators

Variable	*k*	*Mean ES*	Q_B	Q_W	95% CI
Cross-age Tutoring			6.57*		
No	15	0.35		27.95*	0.26-0.44
Yes	6	0.55		36.22***	0.42-0.69
Frequency of tutoring sessions (number of sessions per week)			26.75***		
1 to 2 times a week	12	0.65		31.96**	0.53-0.77
3 to 5 times a week	8	0.25		12.03	0.16-0.35
Unknown (not reported)	1	0.68		0.00	0.19-1.17
Duration of treatment			29.01***		
1 to 6 weeks	5	0.28		6.45	0.13-0.42
6 to 12 weeks	5	0.83		11.80*	0.66-1.00
13 to 20 weeks	7	0.34		15.74*	0.21-0.46
> 20 weeks	4	0.32		7.7	0.14-0.50
Total amount of tutoring (number of hours)			15.56**		
0.5 to 12 hours	8	0.34		2.85	0.21-0.50
13 to 24 hours	6	0.55		41.76***	0.43-0.66
> 24 hours	3	0.62		3.53	0.33-0.91
Unknown (not reported)	4	0.20		7.05	0.06-0.35

Note. A significant Q_B indicates that there are significant differences between the groups. A significant Q_W indicates heterogeneity within the groups.
CI = Confidence interval
k = number of studies
Q_B = Q-between
Q_W = Q-within
**p* < 0.05, ***p* < 0.01, ****p* < 0.001

School location. Although Q_B indicated that school location was not a significant moderator ($Q_B = 2.84$, $p = 0.42$), it is important to note that peer tutoring interventions were more effective in urban (ES = 0.45) and suburban (ES = 0.51) U.S. schools compared to rural U.S. schools (ES = 0.28), and schools located in other countries (ES = 0.33). $Q_W = 54.99$ was significant for the studies that examined peer tutoring implemented in urban U.S. schools, which indicates heterogeneity in this group of studies.

Socioeconomic status (SES). Table 2.3 illustrates that the socioeconomic status of participants was not a significant moderator of academic achievement in mathematics ($Q_B = 0.65$, $p = 0.72$). However, it is important to note that the effect size of students from low SES was larger (ES = 0.43) than the SES of tutees from medium to high socio economic status (ES = 0.35). In addition, a significant Q_W for students from low socioeconomic status ($Q_B = 47.50$, $p < 0.001$) indicates high heterogeneity within this group of students.

At-risk students. The academic condition of tutees was also a significant moderator of achievement outcomes. Results evidenced significant differences between achievement of studies that focused on peer tutoring programs that enrolled more than 50% of at risk or low performing students and programs were less than 50% of students were at risk (QB = 14.77, $p < 0.01$). Studies in which more than 50% of students were considered at risk of academic failure yielded the highest effect size (ES = 0.58) compared with students equipped with better mathematics knowledge and skills (ES = 0.30).

Table 2.4 contains the results for the homogeneity analysis of selected treatment moderators. A significant Q_B indicates that there are significant differences between the effect sizes of two or more groups. A significant Qw confirms heterogeneity within a specific group of studies (Lipsey & Wilson, 2001)

Cross-age vs. same-age peer tutoring. Studies involving students in cross-age tutoring programs scored significantly higher than students enrolled in same-age tutoring interventions (QB = 6.57, $p < 0.05$). Studies that examined cross-age peer tutoring had a larger mean effect size (ES = 0.55) compared with studies that did not include cross-age tutoring (ES = 0.35). Furthermore, the QW for the two groups was significant, suggesting that there is heterogeneity inside each group.

Frequency of tutoring sessions. The number of sessions for week devoted to tutoring interventions was a significant moderator of achievement, yielded high heterogeneity (QB = 26.75, $p < 0.001$). Tutoring sessions offered one or two times a week were the most effective (ES = 0.65), while tutoring sessions that were offered three to five times a significantly lower effect size (ES = 0.25).

Duration of treatment. Table 2.4 shows that the duration of treatment was a significant moderator of academic outcome (QB = 29.01, $p < 0.001$); consequently this construct exerted a great influence on the effectiveness of a tutoring program. The highest mean effect size were generated by peer tutoring interventions that lasted from 6 to 12 weeks (ES = 0.83), followed by interventions that lasted 13 to 20 weeks (ES = 0.34), and programs that lasted more than 20 weeks (ES = 0.32). Interventions with duration from 1 to 6 weeks had the least effect size (ES = 0.28).

Total amount of treatment. Results in Table 2.4 evidences that the total amount of treatment, measured by the total of hours of peer tutoring instruction, was a significant moderator of academic performance (QB = 15.56, $p < 0.01$). Peer tutoring interventions that provided more than 24 total hours of intervention generated the highest effects (ES = 0.62) on mathematics achievement. In contrast, interventions that provided 12 or less instructional intervention yielded the lowest effect size (ES = 0.34).

Discussion

The purpose of this meta-analysis was to evaluate and summarize the effects of peer tutoring interventions on mathematics achievement in grades K-12, general education classrooms, and to analyze the effects of various key moderators for minority students. An exhaustive search of studies published between 1982 and 2015 generated only 21 relevant studies; which suggested the scarcity of research related to the effects of peer tutoring in mathematics. Clearly, more experimental studies are needed in this area.

It is important to note that after an exhaustive search of studies published between 1982 and 2015, I couldn't find any study that includes more than 50% Hispanic participants. Most studies focused on African American and White students. Evidently, there is a gap of research that explores the effects of peer tutoring on the academic outcomes for Hispanic children.

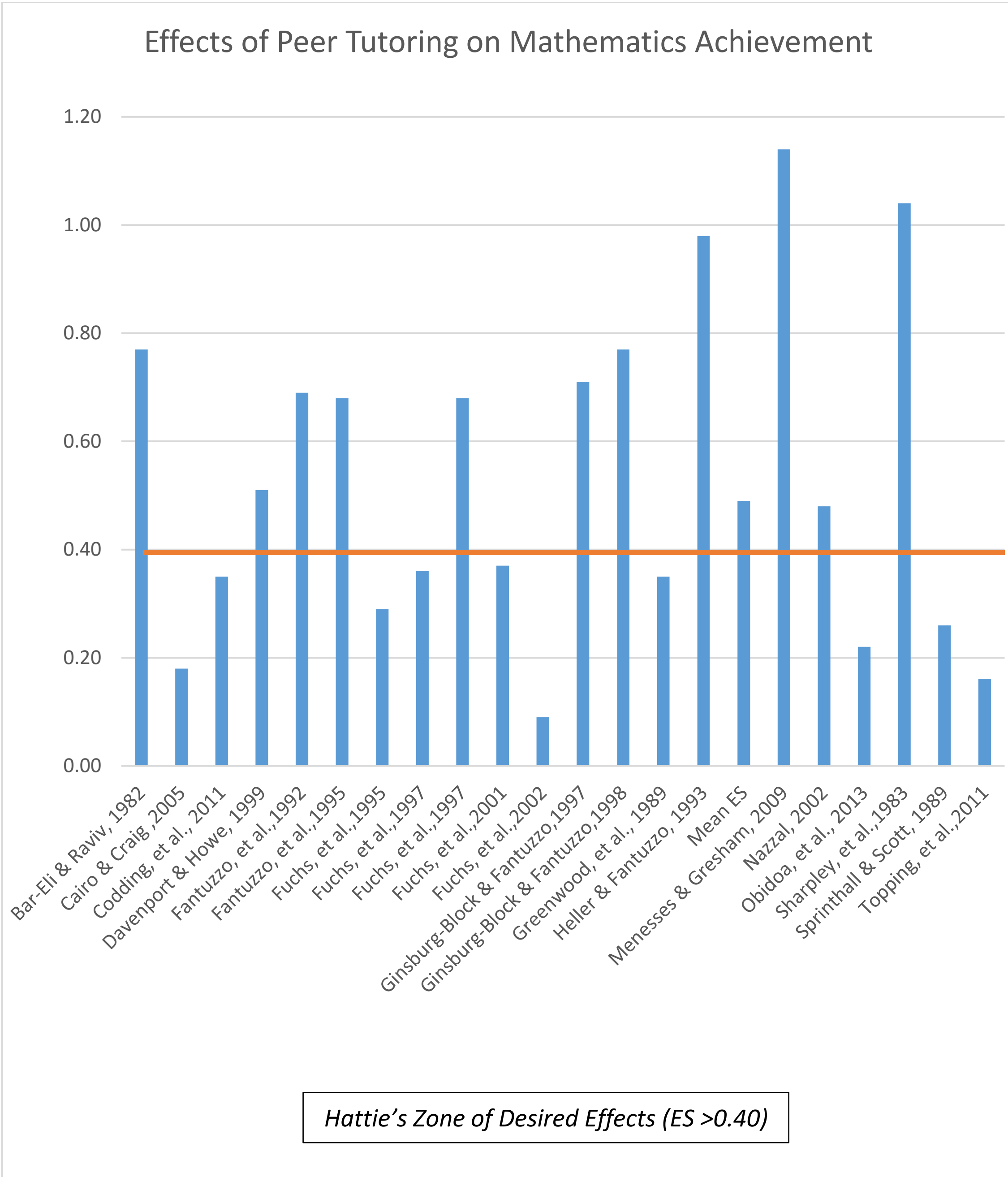

Figure 2.2. Effect Size of Studies Included in the Meta-Analysis – Comparison with Hattie's Zone of Desired Effects (*ES* > 0.40).

The results of this meta-analysis show that almost half of the studies generates effects in the area identified by Hattie (2009) as the *zone of desirable effects* for academic achievement (effect sizes greater than *ES* > 0.40) and four studies are very close to this zone (Figure 2.2). Only three studies had low effect sizes (*ES* < 0.20). The mean effect size of this meta-analysis (*ES* = 0.49) is in the *zone of desirable effects*, which suggests that, on average, tutoring interventions are effective to improve academic performance in mathematics and have the potential to accelerate the rate of learning of students who participated in these kind of programs. These features make peer tutoring especially attractive for low achieving or at risk students who need interventions that help them to learn faster and effectively.

The *unbiased standardized mean differences effect size* used to calculate the effect size for each study guarantee a more precise effect size measure in the individual studies, a better evaluation of the consistency of the effect size across studies, and a more precise effect size that summarizes the whole meta-analysis. The weighted overall effect size found in the current study (*ES* = 0.49) support findings in previous meta-analytic reviews. Kunsch, et al. (2007) reported an overall mean effect size (*ES* = 0.47) for 17 studies that focused on peer-mediated instruction in mathematics for students with learning problems. Cohen et al. (1982) found a mean effect size for tutee achievement in mathematics (*ES* = 0.60) and a mean effect size for tutors (0.62). Leung (2015) reported an effect size for mathematics of (*ES* = 0.53) analyzed as moderator under the mixed effects model.

Furthermore, the results of this meta-analysis demonstrated that peer and cross-age tutoring consistently generated positive academic outcomes in mathematics across various grade levels and demographic features of participants. The demographic moderators indicated that peer tutoring interventions were most effective for students in secondary school, African American, low socioeconomic status, at risk of academic failure, and students that were enrolled at suburban U.S. schools. In a previous meta-analysis, Rohrbeck, et al. (2003) found that peer-assisted learning interventions were more effective with low income and minority students. Unfortunately, although a great number of studies focused on predominantly African American participants, none of the studies examined tutoring interventions that enrolled more than 50% of Hispanic students.

The homogeneity analysis of treatment moderators revealed that cross-age peer tutoring programs were more effective than same-age programs. These results endorse previous meta-analytic research that reported larger effect sizes for cross-age tutoring programs on students' academic achievement than those using same-age tutoring (Cohen et al., 1982; Leung, 2015). Probably older and more knowledgeable students are better models for their younger tutees.

In my examination of treatment moderators, I found that the frequency of tutoring sessions, duration of treatment, and the total amount of tutoring were significant moderators of academic achievement. Programs that offered less frequent tutoring sessions (one or two a weeks) produced higher benefits than more frequent sessions (three to five a week). Also, programs that lasted from six to twelve weeks produced the greatest students' achievement gains. Finally, programs that offered more than 24 hours of instruction generated the largest effect size.

Implications for Research and Practice

Mathematics is fundamental to students' success; however, as reported in the 2015 Nation's Report Card (U.S. Department of Education, NCES, 2016) millions of students failed to achieve proficiency levels in mathematics. Under this critical scenario, a wise selection of instructional interventions to improve the academic achievement of all students and especially for those who are low achievers is necessary. Hattie recommended the selection of interventions that can significantly improve academic achievement, such as peer tutoring. The present meta-analysis contributes to the knowledge about research-based instructional interventions that can make a meaningful contribution to mathematics performance. The findings of this meta-analysis suggest that peer-tutoring interventions have positive effects academic achievement in mathematics. It also indicates that there is a lack of research addressing the effectiveness of peer tutoring for Hispanic students in mathematics classrooms. Future research should examine the how peer and cross-age tutoring can help to improve the academic achievement of Hispanic students in elementary and secondary schools.

A previous meta-analysis that summarized the effects of peer-mediate interventions in mathematics achievement was conducted by Kunsch et al. (2007). However, this study did not employ rigorous statistical procedures used in current meta-analytic research and included only low- achieving students and those with disabilities. Hence, the results are confounded by the inclusion of general and special education students. The present meta-analysis included low, middle, and high achieving students in general education mathematics classrooms and use current meta-analytic techniques that allow the calculation of a more precise and unbiased effect size that summarize the effectiveness of peer tutoring in K-12 mathematics classrooms.

In addition, the analysis of demographic moderators allowed me to identify the subgroups of students for whom tutoring interventions were more effective. Even though peer tutoring programs yielded positive effect sizes for all subgroups of students, the findings suggest that peer tutoring was more effective with ethnic minority, low socioeconomic status, at risk, secondary, and suburban students compared to their majority, middle and high socioeconomic status, not at risk of academic failure, elementary and students attending to urban or rural schools. This study could guide the decisions of mathematics teachers of secondary schools where this kind of intervention is seldom used despite the potential benefits of peer tutoring for students who struggle in mathematics.

Unfortunately, the lack of studies that examine the effects of peer tutoring interventions on Hispanic students prevented to include this segment of the student population in the moderator analysis. More studies about the effectiveness of peer tutoring for Hispanic children are highly needed. It is very important to know the specific effects of peer tutoring on the academic outcomes of Hispanic students in mathematics classrooms.

Furthermore, the homogeneity analysis indicated the treatment components that made tutoring intervention more effective in mathematics, including the frequency of tutoring sessions, duration of treatment, and the total amount of intervention. The findings of this meta-analysis can guide mathematics teachers to make decisions related to the kind of tutoring interventions for their students. For example, interventions were most effective for cross-age peer tutoring, interventions that were offered one of two times a week, during 6 to 12 weeks, and with a total duration of instruction greater than 24 hours.

In general, this study contributes to the knowledge of the treatment features that can generate the greatest benefits in mathematics classrooms in grades K-12 and the demographic characteristics that could make peer tutoring highly effective for some group of students. Consequently, an important implication of this study is that practitioners can use the results of this meta-analysis to make the best decisions that meet the needs of all students and improve their opportunities to learn and succeed in mathematics.

CHAPTER III

OUTCOMES OF CROSS-AGE PEER TUTORING IN MATHEMATICS IN ELEMENTARY AND MIDDLE SCHOOLS WITH PREDOMINANTLY HISPANIC STUDENTS

Overview

The present study examines the effects of a cross-age tutoring intervention on academic and nonacademic outcomes in elementary and middle school and evaluates the strongest predictors of success in this cross-age tutoring program. The majority of students who participated in this program were Hispanic from families of low socioeconomic status. Schools were located in disadvantaged urban communities of a large metropolitan area in the Southern region of the United States. The results revealed statistically significant differences between pre- and post-achievement tests in both elementary and middle school. Furthermore, this tutoring intervention had large positive effects on basic mathematics facts (*ES* = 1.39) and problem solving skills (*ES* = 1.25) among elementary school students and moderate to large effects on academic achievement of middle school students (*ES* = 0.67). Mixed results were found for enjoyment in mathematics and self-perceptions.

Introduction

One of the most critical problems of Hispanic students in the United States is their low achievement in mathematics. The 2015 Nation's Report Card informed that only 26% of Hispanic fourth-grade and 19% of eighth-grade students reached at or above proficiency levels in mathematics, compared to 51% of White fourth-graders and 43% of White eight-graders who achieved at or above proficiency in this subject in the National Assessment of Educational Progress (U.S. Department of Education, NCES, 2016).

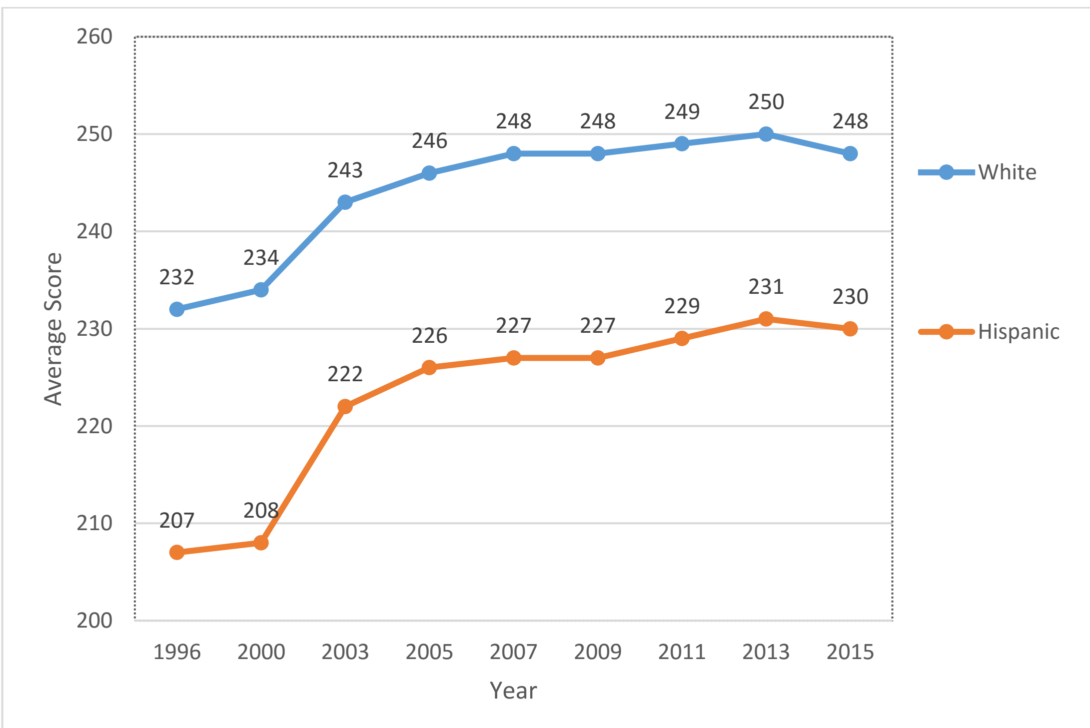

Figure 3.1. Fourth-Grade Achievement Gaps in Mathematics 1996-2015
Source: U.S. Department of Education, National Center for Education Statistics, Nation Report Card 2015

The achievement gaps in mathematics between White and Hispanic students in elementary and secondary school stated in the 2015 Nation's Report Card have remained almost unchanged in the last two decades. In 2015, Hispanic students enrolled in grade 4 scored 18 points below their White counterparts in mathematics (Figure 3.1). This achievement gap was bigger for Hispanic students enrolled in grade 8, with Hispanic eight graders scoring 22 points below their White peers (Figure 3.2).

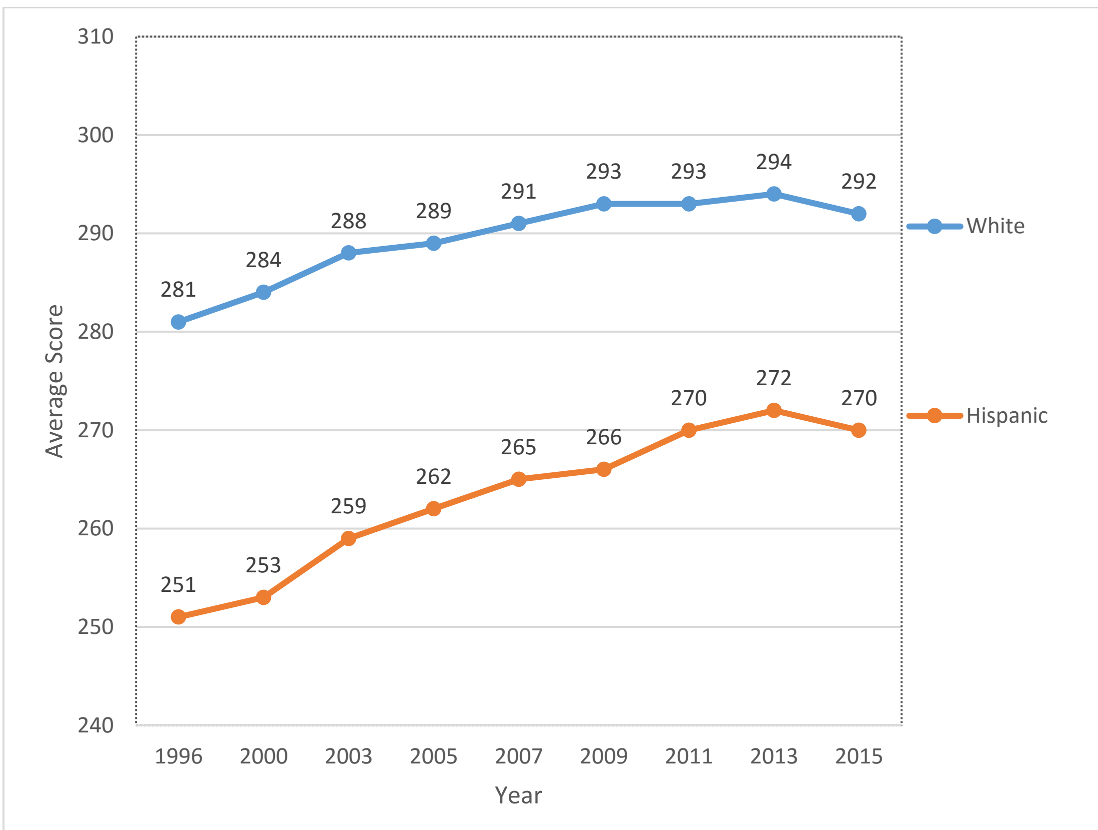

Figure 3.2. Eighth-Grade Achievement Gaps in Mathematics 1996-2015
Source: U.S. Department of Education, National Center for Education Statistics, Nation Report Card 2015

In Texas, the achievement gap in mathematics between White and Hispanic students is similar to the national panorama. In 2015, students enrolled in grade 4, scored 15 points below their White peers in the mathematics section of the National Assessment of Educational Progress (U.S. Department of Education. NCES, 2015c). This achievement gap was 21 points for students enrolled in grade 8 (U.S. Department of Education. NCES, 2015d). These results highlight an urgent need to help Hispanic students overcome their difficulties in mathematics and to take the necessary steps to close this persistent achievement gap.

Figure 3.3 shows that in 2015, only 37% of Hispanic students enrolled in fourth grade in Texas scored at or above proficiency level in mathematics, which is very low, especially if we compare this performance level with their White peers. This situation is even more critical for Hispanic middle school students since only 23% of them reached the proficiency level while 48% of White students achieved at or above proficient.

The equity principle issued by the NCTM (2000) demands that all students should have access to high-quality mathematics instruction that includes the appropriate accommodations that fit the needs of students. This means that educators need to implement effective instructional practices that meet the needs of the rapidly growing Hispanic population. Only high-quality instruction with focus on individual needs can guarantee that Hispanic students acquire the knowledge and skills to succeed as mathematics learners and to become productive members of the society in the future.

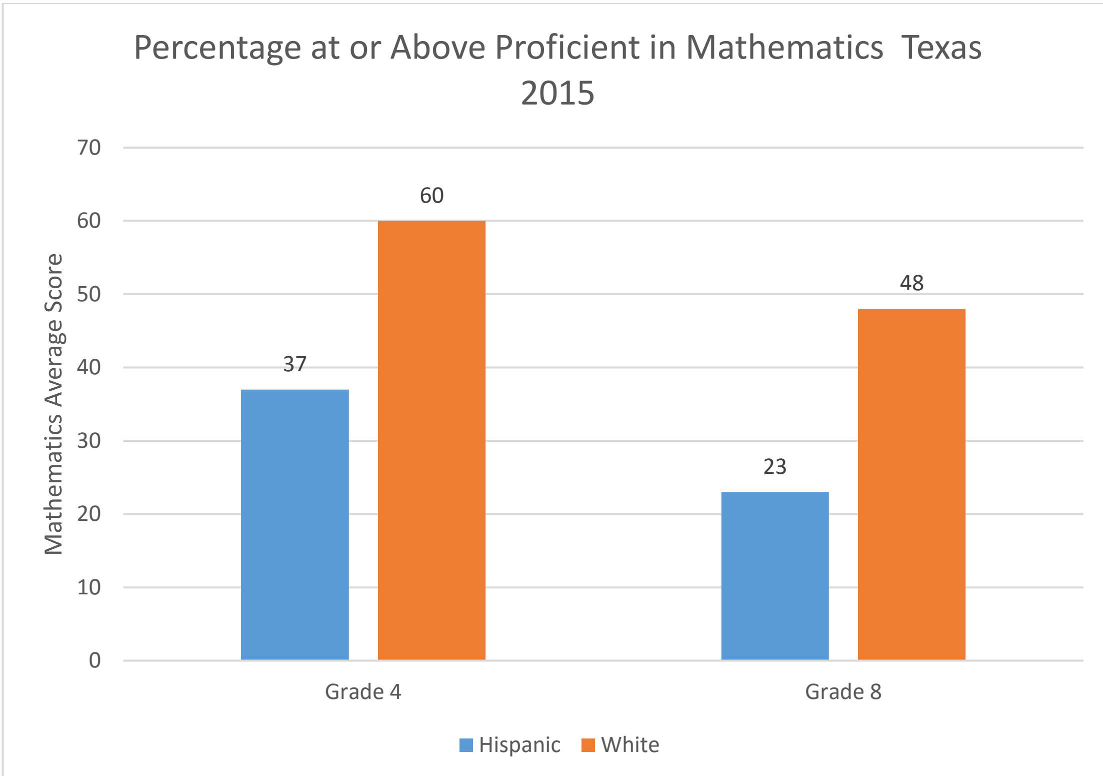

Figure 3.3. Percentage of Students at or Above Proficiency Level in Mathematics, NAEP, 2015
Source: U.S. Department of Education, National Center for Education Statistics, Nation Report Card 2015

While school districts are facing the challenge to improve the mathematics achievement for Hispanic students, the national enrollment of Hispanic students continues rising (Figure 3.4). From 2002 to 2012 the enrollment of PK-12 Hispanic children increased 41%, from 8.6 million in 2002 to 12.1 million in 2012. The U.S. Department of Education, National Center for Education Statistics (2014) projected that the number of Hispanic students will continue to grow. The number of Hispanic students enrolled in public schools is projected to increase from 12.1 million in 2012 to 15.5 million in 2024 (U.S. Department of Education, NCES, 2014). Figure 3.4 also shows that while the enrollment of White and African American students has been decreasing in the last few years, Hispanic students have been the fastest-growing racial/ethnic group at U.S. schools, and this path is projected to continue in the future.

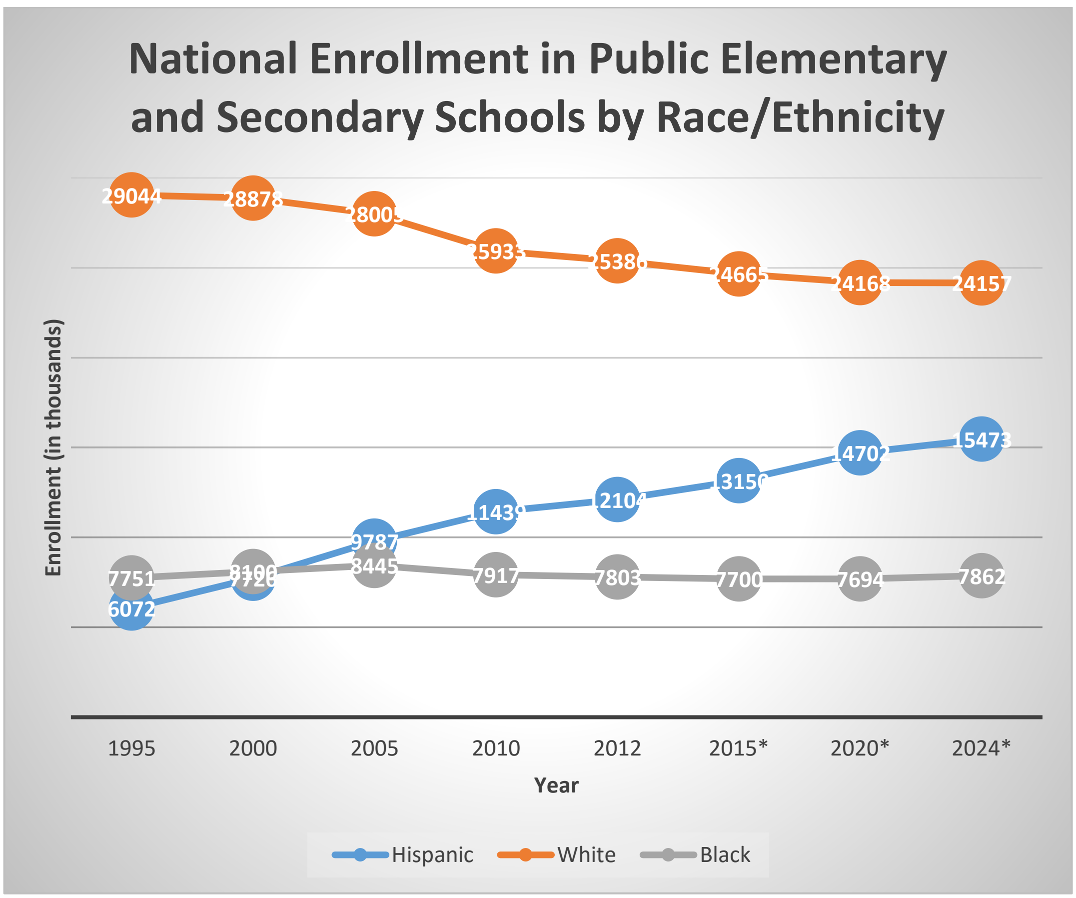

Figure 3.4. National Enrollment in Public Elementary and Secondary Schools, by Race/Ethnicity
* Projected
Source: U.S. Department of Education, National Center for Education Statistics, Digest of Education Statistics 2014

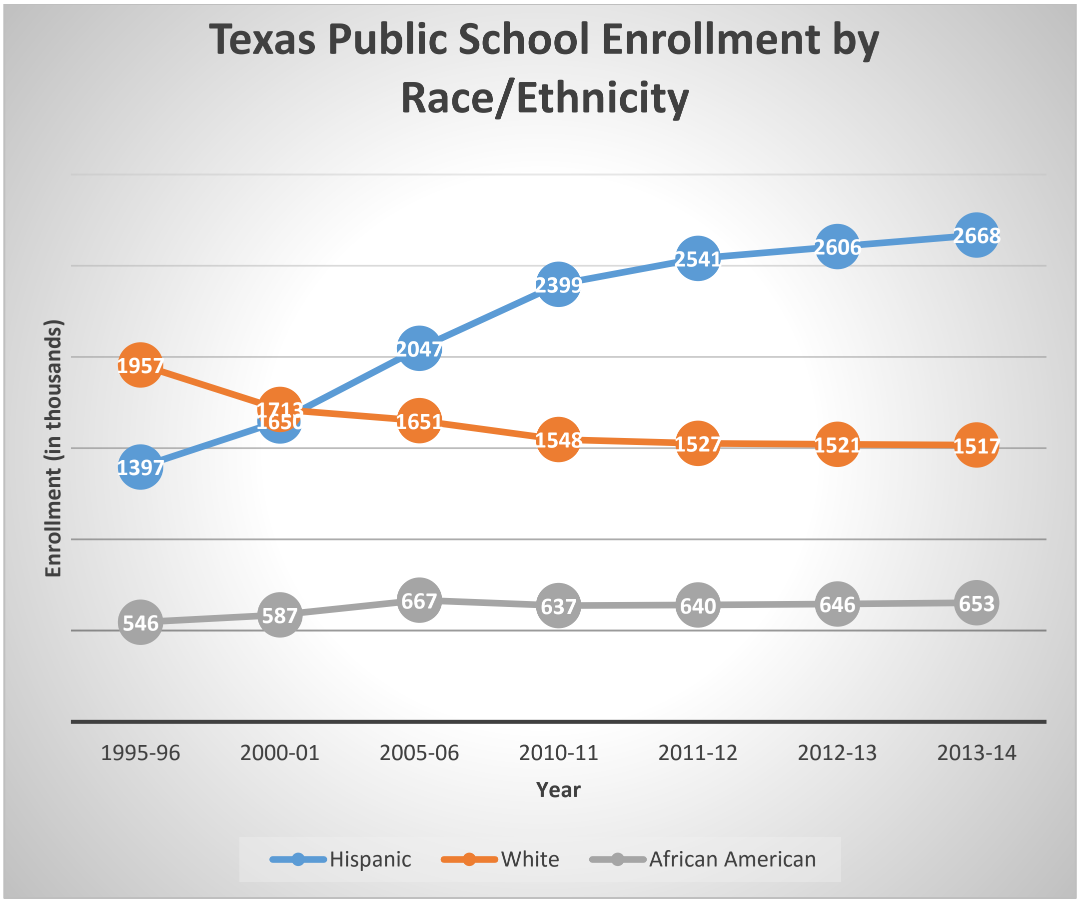

Figure 3.5. Texas Enrollment in Public Elementary and Secondary Schools, by Race/Ethnicity
Source: Texas Education Agency (2015b)

In Texas, the enrollment of Hispanic students climbed from 1.8 million in 2002 to 2.6 million in 2012. (Texas Education Agency, 2015b). This means that while at the national level the Hispanic enrollment in public schools grew 41%, in Texas the enrollment of Hispanic children increased by 44%. In addition, Hispanics represent the largest group of students enrolled in public schools in Texas. In the 2013-14 school year, Hispanic students accounted for 51.8% of all students in Texas public schools, followed by Whites (29.5%), African Americans (12.8%), and Asians (3.5%) (TEA, 2015b). Similarly to the school enrollment trend at the national level, Hispanic students are also the fastest-growing segment of the student population in the state of Texas (Figure 3.5).

As indicated by national and state statistics, the achievement of Hispanic students in mathematics remains low while this segment of the student population continues growing. This dichotomy underlines the need to search for realistic solutions that provide Hispanic students opportunities to succeed in mathematics classrooms. The NCTM (2000) stated that individuals who possess the adequate mathematical skills will have opportunities to succeed in an increasingly changing and demanding workplace. Consequently, the skills that students acquire in their mathematics classrooms will be fundamental in their future. These skills can give students access to college education and job opportunities in the competitive global labor market of the 21st century. Algebra I, for example, has been a gateway to higher-level mathematics and science courses in high school and is essential for admission in most colleges (Schachter, 2013). Furthermore, mathematics courses that students take in high school impact labor market outcomes, those who took a rigorous high school math curriculum had better employment outcomes than those who took less rigorous math courses (James, 2013).

Some researchers have suggested that the implementation of effective instructional practices in mathematics classroom can improve teaching and learning processes (Coleman & Goldenberg, 2010; Padrón, et al., 2002). Peer tutoring has been identified by empirical research as one of those effective instructional practices to improve academic achievement (Allsopp, 1997; Bowman-Perrott, et al., 2013;

Rohrbeck, et al., 2003), social, and self-concept (Robinson, et al., 2005; Ginsburg-Block, et al., 2006), and student sense of academic self-efficacy (Robinson, et al., 2005).

Considering the lack of achievement in mathematics for Hispanic students and the positive impact of peer tutoring on students' academic achievement that research has identified, it is important to determine whether peer-tutoring programs can positively enhance Hispanic students' mathematics achievement. Therefore, the purpose of this study is to evaluate the effectiveness of a peer-tutoring program implemented in elementary and secondary public schools that serve predominantly Hispanic students. The study will address the effects of the program on three key areas: (a) academic achievement in mathematics, (b) enjoyment in learning mathematics, and (c) students' self-confidence in their ability to learn mathematics.

Theoretical Framework

Research studies have found that peer tutoring can have positive effects on students' achievement (Bowman-Perrott, et al., 2013; Cohen, et al., 1982; Hartley, 1977; Kunsch, et al., 2007; Nazzal, 2002; Robinson, et al. 2005), socio-emotional outcomes such as attitudes toward the subject matter that they were being taught (Cohen, et al., 1982), self-concept (Cohen, et al., 1982; Ginsburg-Block, et al., 2006; Robinson, et al., 2005), and social and behavioral outcomes (Ginsburg-Block, et al., 2006).

In addition, researchers have found positive correlations between academic achievement, attitudes, and motivational factors. For example, the meta-analytic review of Ginsburg-Block, et al. (2006) reported that social and self-concepts were positively correlated with academic outcomes. These researchers concluded that peer tutoring interventions that focus on improvement of academic achievement can also improve students' feelings about their academic competence.

Effects of Peer Tutoring on Academic Achievement

Academic achievement has become the core of school accountability polices in education. The improvement of academic performance in content areas has become the main goal in many school districts, especially when academic outputs are linked to accountability ratings, distinction designations, and financial resources distributed by state or federal government. For example, the educational movement has emphasized school accountability in Texas in the past two decades (Rodriguez & John, 2009). The Texas Education Agency assigns schools' and districts' accountability ratings based mainly on the results of the State of Texas Assessments of Academic Readiness (STAAR) and graduation rates (TEA, 2015a; 2015c). Schools and districts in Texas attempt to obtain the highest rating possible, not only to obtain a high accountability rating but also to gain distinction designations awarded by TEA in recognition of outstanding achievement in academic areas beyond the areas evaluated under state accountability (TEA 2015a, 2015c). Some researchers also stated that academic achievement is linked to financial resources. Rodriguez and John (2009) indicated that school districts in Texas obtain federal financial resources based on accountability ratings. Given the starring role of academic achievement in educational settings, it is very important to examine the educational interventions that can help enhance students' academic outcomes.

One of the more important studies that focus on educational interventions that influence students' achievement was developed by Hattie (2009). In his book *Visible Learning,* Hattie presents a compelling explanation about the kind of educational interventions that could influence the learning curve of students. After evaluating over 800 meta-analysis that comprised 52,637 studies and about 236 million students, Hattie found that the average effect size on achievement of all various educational influences and interventions included in the 800 meta-analysis was 0.40. Using this number as a benchmark to analyze the effects on academic outcomes he stated that effective interventions should generate effect sizes above average levels ($d > 0.40$).

Hattie (2009) warned about the devastating consequences of interventions that generate small effect sizes. These kind of interventions consume valuable instructional time and involve expenditures that drain the generally limited school budget. On the other hand, educational interventions that generate above-average effect sizes on student achievement can help students reduce the achievement gaps with their peers. One educational intervention identified by Hattie as positive for student achievement is peer tutoring, which had an effect size of $d = 0.55$.

Some researchers have indicated that the quality of instruction offered to Hispanic students is limiting their opportunities for learning mathematics (Valle, et al., 2013). These researchers found that the most frequently used instructional practice in mathematics classroom is teacher-directed, whole-class instruction, which limits student participation and collaboration with other students. Valle et al. (2013), also found that students were using textbooks or worksheets almost every day. Unfortunately, these widespread educational practices promote memorization and rote learning instead of critical thinking (Padrón, et al., 2002). Mathematics requires a very dynamic type of thinking since students need a fluid, flexible, and meaningful number sense to allow them to understand the meaning of numbers, math concepts and to apply them in different scenarios (Faulkner & Cain, 2013).

Peer tutoring could be a solution to transform teacher-centered instruction to more student-centered instruction. According to Rohrbeck, et al. (2003), the effectiveness of peer-assisted learning can be linked to student-centered learning environments that empower students to become agents in the learning process. This strategy can stimulate students' cognitive development, persistence, and motivation to learn.

Effects of Peer Tutoring on Students' Nonacademic Outcomes

Students' outcomes in mathematics can be influenced not only through effective instructional interventions but also by students' attitudes, behaviors, and beliefs about the subject. Adelson and McCoach (2011) indicated that students' performance in mathematics classrooms can be influenced by children' self-perceptions as learners, the degree of enjoyment of mathematics, and their perceptions about the usefulness of mathematics.

Mathematical self-perceptions involve students' thinking about themselves as mathematics learners (Adelson & McCoach, 2011). In general, students who believe in their ability to learn and do math tend to attain better academic outcomes than those who do not believe in their academic competence. Rohrbeck, et al. (2006), for example, found a significant positive correlation between students' self-concept and academic achievement ($r = 0.57$, $p < .05$). Consequently, students' positive self-perceptions about their ability to learn mathematics may enhance their outcomes in this subject (Adelson & McCoach, 2011). Students who strongly believe in their competence in mathematics are more likely to obtain more academic gains (King-Sears & Bradley, 1995). Self-perceptions is a broad construct that includes more specific concepts such as mathematical self-efficacy and mathematical self-concept (Adelson & McCoach, 2011). These authors explained that mathematical self-efficacy refers to the student's belief in his/her capacity to successfully perform a mathematics academic task. Mathematical self-concept is the student's perception of his/her academic ability in mathematics.

Enjoyment of mathematics was defined as "the degree to which a person takes pleasure in doing and learning mathematics." (Adelson & McCoach, 2011, p. 226). Students that express their enjoyment in learning mathematics, those who believe that learning mathematics is fun, or students who can easily find interesting things to learn in math will be engaged and captivated in mathematics classrooms. Pleasure in learning mathematics may positively influence achievement (Adelson & McCoach, 2011).

A growing body of research has demonstrated that peer tutoring can influence both academic and nonacademic outcomes. For example, the meta-analysis conducted by Ginsburg-Block et al. (2006) found that peer-tutoring programs had a positive impact on self-concept, social, and behavioral outcomes. Maheady and Gard (2010) informed that class-wide peer tutoring produced improvements in all students' academic performance, classroom behavior, and participation in classroom discussions. Similarly, Cohen's (1982) meta-analysis reported positive effects of peer tutoring on academic achievement, attitudes toward the subject matter covered in the tutoring interventions, and self-esteem of tutors and tutees. The review of literature performed by Robinson, et al. (2005) reported that peer-tutoring programs had a positive impact on academic achievement, attitudes about school, self-perceptions as mathematical learners, and classroom behavior.

Although a growing body of research has examined the effectiveness of peer tutoring for general school populations or mainstream students, there is a dearth of studies about the effectiveness of peer tutoring for minority students (Robinson, et al., 2005).

Cost Effectiveness of Peer-Tutoring Program

Peer-tutoring programs not only have positive effects on the academic and non-achievement outcomes described in previous pages, but also they are cost-effective educational interventions to improve mathematics performance (Levin, et al., 1984; Yeh, 2010). Yeh (2010) conducted a meta-analysis to evaluate the cost-effectiveness of 22 approaches for raising student achievement. Yeh reported a cost-effectiveness ratio of 0.001746 for cross-age tutoring programs in mathematics. This ratio was greater than the ratio calculated for other alternatives such as computer-assisted instruction (0.000504), lengthening the school day by 60 minutes (0.000188), hiring teachers with a master's degree (0.000313) or with more experience (0.000256), class size reduction (0.000065), 10% increase in expenditures per pupil (0.000027), voucher programs (0.000008), among other alternatives.

Giving that cost-effectiveness indexes are calculated by dividing the effect size of any educational intervention by the cost necessary to implement it, a high cost effectiveness ratio means that every dollar invested in peer-tutoring program generates a high educational productivity. According to the cost-effectiveness ratios reported by Yeh (2010), cross-age peer tutoring generates more educational gains for each dollar spent than the majority of educational approaches included in his meta-analysis. For example, cross-age tutoring is approximately 27 times more cost effective than 10% increase in expenditures per pupil and 218 more cost effective than voucher programs.

In summary, research has been reporting positive academic and nonacademic outcomes with peer tutoring. Considering that the effect size of this instructional intervention (d = 0.55) calculated by Hattie (2009) was in the zone of desired effects—where educational interventions make a meaningful contribution in students' learning—and that effect size is a very cost-effective instructional strategy, the implementation of peer tutoring in public schools could be the answer to solve the academic difficulties faced by Hispanic students.

Therefore, the terms self-perceptions, self-concept, and self-efficacy in mathematics can be used interchangeably since they measure the same construct.

Purpose of the Present Study

A growing body of research has reported the effectiveness of peer tutoring in mainstream classrooms (Cohen, et al., 1982; Hartley, 1977; Robinson, et al., 2005) and in special education classrooms (Bowman-Perrott, et al., 2013; Bowman-Perrot, et al., 2014). Research studies have found that peer tutoring had positive effects on students' mathematics achievement (Bar-Eli and Raviv, 1982; Davenport and Howe, 1999; Fuchs, Fuchs, Hamlett, Phillips, Karns, and Dutka, 1997; Fuchs, Fuchs, and Karns, 2001; Ginsburg-Block and Fantuzzo 1997; Heller and Fantuzzo 1993; Menesses and Gresham, 2009; Sharpley et al., 1983; Sprinthall and Scott, 1989; Topping, et al., 2011). Furthermore, some researchers found that peer tutoring interventions were effective to improve attitudes toward the subject matter that they were being taught (Cohen, et al., 1982; Robinson, et al., 2005), academic motivation, academic self-concept, and social competence (Ginsburg-Block and Fantuzzo, 1998), and behavioral outcomes (Bowman-Perrott, et al., 2014; Ginsburg-Block, et al., 2006). Furthermore, researchers have found that social competence and self-concept were positively correlated with academic achievement (Ginsburg-Block, et al., 2006). However, there is still a dearth of studies about the effectiveness of peer tutoring on academic performance, motivation, and attitudes of Hispanic students.

The purpose of this study was to examine the effects of a cross-age peer-tutoring intervention on students' mathematics achievement, enjoyment of mathematics, and self-perceptions as mathematics learners of students in at-risk urban elementary and middle schools that serve predominantly Hispanic students. In addition, the present study investigates what are the strongest predictors of success in this cross-age tutoring program.

Research Questions

The following research questions will be addressed:

1. Are there significant changes in students' math achievement scores following participation in the peer-tutoring program?

2. Are there significant changes in students' enjoyment of mathematics following participation in the peer-tutoring program?

3. Are there significant changes in students' self-perceptions of ability in math following participation in the peer-tutoring program?

Method

Participants

Participants included 132 students enrolled in one elementary and three middle public urban schools within two large urban districts located in the southern central region of the U.S. Figure 3.6 and Table 3.1 shows that the majority of participants were enrolled in middle school (78.8%), 50.8% of students were tutors and 41.2% were tutees.

Table 3.1 also shows that the majority of students (71.2%) reported that they speak Spanish at home. This number suggest a strong tendency among Hispanic students to use Spanish as their preferred language. Figure 3.7 indicates that the majority of participants were Hispanic (79.5%), followed by African American (12.9%), White (3%), Asian (3%), and other race (3%).

Table 3.1

Demographics of Participants (N= 132)

Variables	***n***	**%**
Education Level		
Elementary	28	21.2
Middle School	104	78.8
Grade		
Third grade	14	10.6
Fifth grade	14	10.6
Sixth grade	51	38.6
Eight grade	53	40.2
Gender		
Male	68	51.5
Female	64	48.5
Role		
Tutor	67	50.8
Tutee	65	49.2
Race/Ethnicity		
Asian	4	3.0
White	4	3.0
African American	17	12.9
Hispanic	105	79.5
Other	2	1.5
Language speaks at home		
Spanish	94	71.2
English	34	25.8
No response provided	4	3.0

Note. *n* = number of participants, % percentage

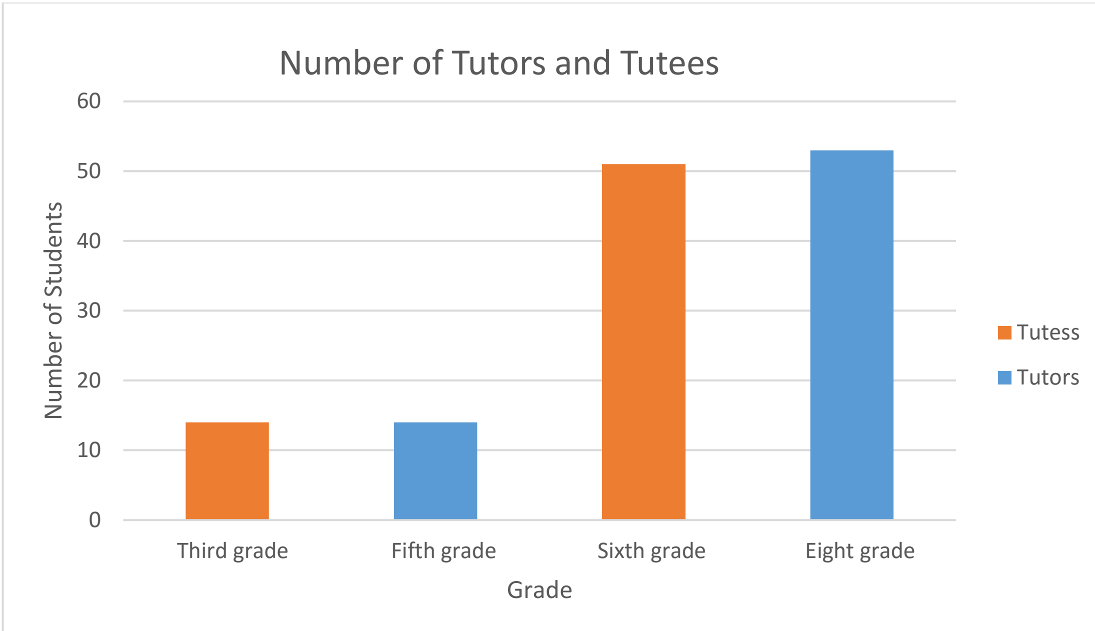

Figure 3.6. Number of Tutors and Tutees Enrolled in the Tutoring Program

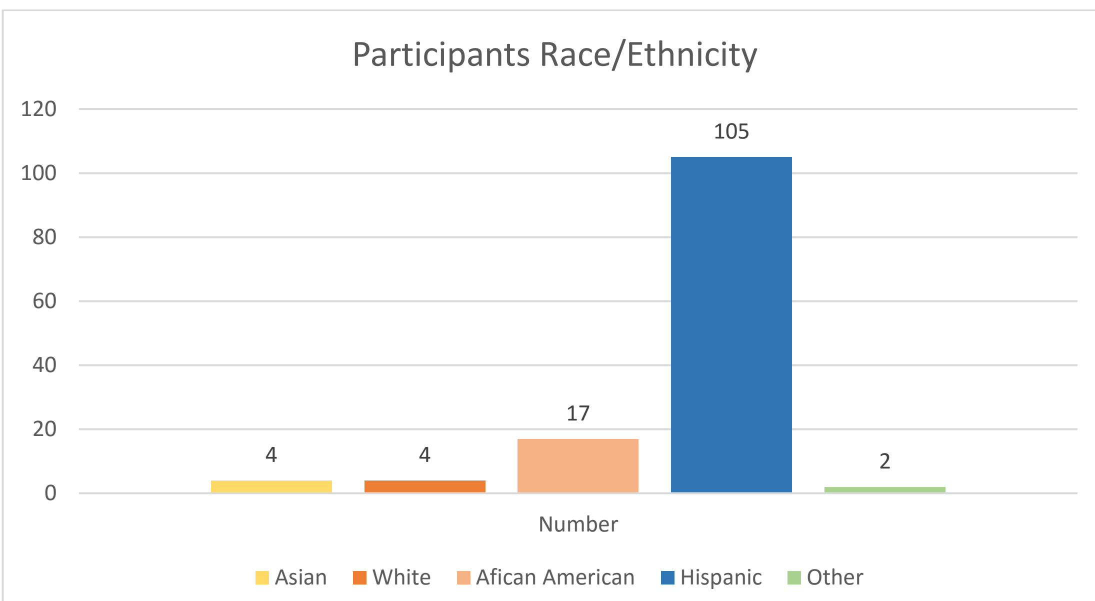

Figure 3.7. Race/Ethnicity of Students Enrolled in the Tutoring Program

Procedures

The procedures for this study were divided into three phases. Phase 1 consisted in the selection of tutors and tutees in elementary and middle schools. Phase 2 involved the training of teachers, administrators, and facilitators. Phase 3 was the implementation stage which included tutor training, called *Tutors' Academy,* and the actual tutoring sessions. This program offered two sessions per week, one involving tutor training and the other the actual tutor-tutee sessions. Each tutoring session consisted of 60 minutes for an approximately of 26 weeks.

Selection of tutors and tutees. Tutors and tutees in the elementary and middle schools were selected by their mathematics teachers using the following criteria: (a) students who struggle in mathematics classrooms and who have the potential to achieve a higher level of performance with additional help, (b) students categorized as "bubble", which means that they are no more than one year behind their peers. In general, "bubble" students could improve their mathematics skills and reach grade level proficiency in mathematics through intervention programs. It was hypothesized that selecting tutors who struggle in mathematics was that their participation in the program would have a positive impact on their academic, emotional, and social development. Tutors were at least one grade level above tutees.

Each tutor was matched with a tutee to work with for the entire program. In the elementary school tutors were in fifth grade, while tutees were in third grade. In middle school, tutors were in eighth-grade and tutees were in sixth-grade. Teacher/facilitators were assigned to work with students during the weekly tutoring sessions. All facilitators held a bachelor's degree, although not all were certified in mathematics. All facilitators participated in a two full-day workshops where the purpose and procedures of the peer-tutoring program were extensively explained, the curriculum was reviewed, and materials were provided.

Teachers, administrators, and facilitators training. Teachers and administrators from the schools that have decided to implement the tutoring program were invited to participate in this training as well as facilitators who work for the non-profit organization that was sponsoring the program, and independent researchers who were in conducting the evaluation of this initiative. The training was developed and conducted by the non-profit organization during two full days. During the training, instructors explained the purpose and procedures of the cross-age peer-tutoring program as well as the content of the curriculum. The training also included a comprehensive review of several mathematics lessons. Participants were asked to play the role of tutors and tutees to create the environment of real cross-age tutoring sessions. In addition, participants had the opportunity to watch short videos from previous reading tutoring programs. The videos portrayed numerous positive experiences of principals, teachers, coordinators, and students who have participated in previous peer-tutoring programs. Notably, in these videos students who have served as tutors expressed feelings of fulfillment and personal satisfaction while discussing how they helped their tutees.

The majority of the training was devoted to a comprehensive review of the curriculum developed for this program. Participants received a package that contained a detailed curriculum, a tutor guidebook, tutee activity book, whiteboard, tutor journal, math manipulative materials, markers, color pencils, calculator, and other materials needed for the tutoring sessions. The content of the tutor guidebook and tutee activity book was thoroughly explained by an expert instructor to all participants. The lessons were scripted to facilitate tutor's instruction. After whole group discussions, participants worked in pairs to play the role of tutors and tutees. Participants reviewed all steps in the lessons.

Tutors' academy. Tutors were trained by facilitators in weekly sessions of 45 to 60 minutes. During these meetings, facilitators modeled how to teach the weekly lesson. Facilitators reviewed with tutors the materials, instructional strategies and the fundamental steps in the tutor-tutee session: (1) warm-up activities, (2) review of math concepts, (3) read a story, (5) problem solving (6) journal writing, and (7) tutor debriefing.

During the kick-off event that marks the beginning of this tutoring intervention, the program coordinators used several warm-up activities to motivate students and enhance their participation in classroom discussions. One of these activities, for example, was called the "The Tangled Web." The facilitators asked students to make a circle; then, one facilitator shared something about herself while holding a large ball of colorful yarn; then, she threw the ball of yarn to a student without letting go of the end of the yarn. The student who caught the yarn said his/her name and something about himself/herself and then threw the ball of yarn to another student keeping the end of the yarn. This process continued until everyone had had the opportunity to talk. When the last student spoke, the circle looked like a colorful tangled web. Students loved this activity

During each tutor preparation session, teachers started the lesson with a warm-up activity like the Tangled Wed described above. After the warm-up activity, the teacher introduced several math facts related to the lesson. For example, during a "measurement of length" lesson, students explored non-standard and standard units for measuring length such as teaspoon, cup, gallon, meter, centimeter, kilometer, etc. Next, the students read a story that included some mathematics information. Then, students wrote in their own words a problem related to the story and solved it.

After the whole group discussion, teachers asked tutors to work in pairs to simulate the actual peer-tutoring session, one student played the role of tutor and the other the role of tutee. Tutors followed all the steps in the lesson and asked for clarification when they did not understand the meaning of math vocabulary, new concepts, problem solving, or specific strategies that they were supposed to use during the tutor-tutee sessions.

Tutor-tutee sessions. Tutors and tutees met once a week for 45 to 60 minutes. During the session, tutors followed each step in the scripted lesson that they rehearsed during the tutor's preparation session. After warm-up activities, tutor and tutee took turns reading a story. After reading the story, the tutors asked tutees to examine the mathematical problem generated by the passage, analyze the data, and find the solution. Tutors provided feedback to tutee's responses. Facilitators monitored tutor-tutees interactions and provided feedback as needed.

The peer-tutoring curriculum. The curriculum included 30 weekly lessons. Pre- and post-assessments were scheduled for the beginning and end of the school year. As stated before, every tutoring session included the following elements: (1) warm-up activities, (2) review of math concepts, (3) reading a story, (5) solving problems (6) journal writing, and (7) tutor debriefing.

One feature that makes this tutoring program unique is the integration of mathematics with reading and social studies. Every lesson in the peer-tutoring curriculum included a reading passage that was shared by tutors and tutees. After the reading, tutors asked tutees to find information in the passages to develop mathematical problems. Additionally, the content of the passage was used to make connections between mathematics and other content areas.

Key Features of the Cross-Age Tutoring Program

This tutoring program was part of a bigger project for several urban school districts in large metropolitan area in Texas. In order to help students who struggled in mathematics, this program was implemented in one elementary school and three middle schools that enroll predominantly Hispanic students. Students in fifth grade (tutors) were teamed up with third grade students (tutees). Likewise, students in eight grade (tutors) were paired with sixth grade students (tutees). They were instructed to work together one day per week during the time scheduled by each school.

Instruments

The instruments used to evaluate the effectiveness of the tutoring program were an Attitudes/Motivation Survey and a Mathematics Skill Test administered at the beginning and end of the tutoring treatment. The characteristics of each one of these instruments are described below.

Pre-and post- attitudes/motivation survey. The Mathematics Attitudes/Motivation Survey included 20-item Likert-type psychometric scale that measures twenty variables grouped into three constructs of interest: (a) enjoyment of mathematics, (b) mathematical self-perceptions, and (c) perceived usefulness of mathematics. Questions in the survey were adapted from the Adelson and McCoach's (2011) *Math and Me* Survey and from the Trends in International Mathematics and Science Study (U.S. Department of Education, NCES, 2015f). Students responded by circling one of the following options: 1= strongly agree, 2=disagree, 3=agree, and 4= strongly agree). Adelson and McCoach (2011) reported that the results for the reliability analysis, Cronbach's alpha, was .920 for the *Enjoyment of Mathematics* subscale, .874 for the *Mathematics Self-Perceptions* subscale, and .729 for the *Perceived Usefulness of Mathematics* subscale.

The Enjoyment of Mathematics subscale contains 6 items that measure the extent to which a student enjoys learning and doing mathematics. Examples of items in this subscale are: *I enjoy math, math is fun, I like math, and I learn many interesting things in math*. The Mathematics Self-perception subscale contains items that measure how confident a student feels about his/her ability to learn and perform mathematics well. Examples of items are: *I am really good at math, I learn things quickly in math, and I usually do well at math.* Finally, the Value of Mathematics subscale contains items that measure the extent to which a student believes that math is important and useful.

Examples of items are: *Math is useful, I will use math in many ways when I grow up, and knowing math will help me get a good job when I grow up*. During the survey administration, the facilitators read each one of the questions of the survey aloud to ensure that deficiencies in reading proficiency did not obstruct the accuracy of students' responses.

Mathematics achievement assessments. Tutors and tutees in elementary school completed the pre- and post-achievement tests to evaluate their performance in mathematics. These assessments were designed by Learning Together, a private company offering educational interventions for below-level learners (Learning Together, 2015). The *Math M2 Together Elementary* test contains 30 fill-in-the-blank questions to assess how well they are able to solve three basic mathematics operations: addition, subtraction, and multiplication. The second part of the test includes 10 problem solving questions. Students needed to read, analyze, and find the solution to each problem. Questions on the pre-and post-test are aligned to the lessons provided through the tutoring program. The pre- and post- *Get Ready 4 Algebra* assessments include 50 short answer and problem-solving questions that evaluate the academic performance of tutors and tutees in middle school. The questions of the test cover the content of the lessons.

Results

Effects of Peer Tutoring on Achievement for Elementary School Students

The elementary school tutors and tutee s completed pre- and post-achievement tests that were designed to evaluate their academic achievement in mathematics. The first part of the test contained 30 fill-in-the-blank questions to assess how well the students were able to solve three basic mathematics operations: addition, subtraction, and multiplication. The second part of the test involved 10 problem-solving questions that evaluated the students' knowledge and skills of content standards included in this peer tutoring program, such as number and operations, measurement, and data analysis.

Table 3.2 shows the means and standard deviations of pre-and post-tests for all elementary school students who participated in the program and completed both the pre and post assessments. A paired t-test was used to analyze the differences between pre- and post-test scores. The results revealed significant increases from the students' performance for both areas from fall 2014 to spring 2015 ($p = 0.008$). Figure 3.8 illustrates that tutees were the group that achieved greater gains in mathematics facts. Figure 3.9 shows that tutors increased their problem-solving performance from 2.67 to 5.42 points, which represents an improvement of 103%. Tutees advanced from 0.5 to 3.2 points.

It is important to note that the maximum score for the mathematics facts section of the exam was 30. Consequently, the score achieved in spring ($M = 29.18$) suggests an excellent level of performance in the three basic operations included in this section: addition, multiplication, and subtraction of whole numbers.

Table 3.2

T-Test Results for Elementary School Mathematics Achievement Scores

Math Achievement Tests	***M***	***SD***	***t***	***p***
Mathematics Facts				
Pre-test (n=11)	24.91	4.206	3.338**	0.008
Post-test (n=11)	29.18	1.079		
Problem Solving Skills				
Pre-test (n=11)	1.68	1.521	3.414*	0.011
Post-test (n=11)	4.41	2.663		

Note. ** $p < .01$; * $p < .05$

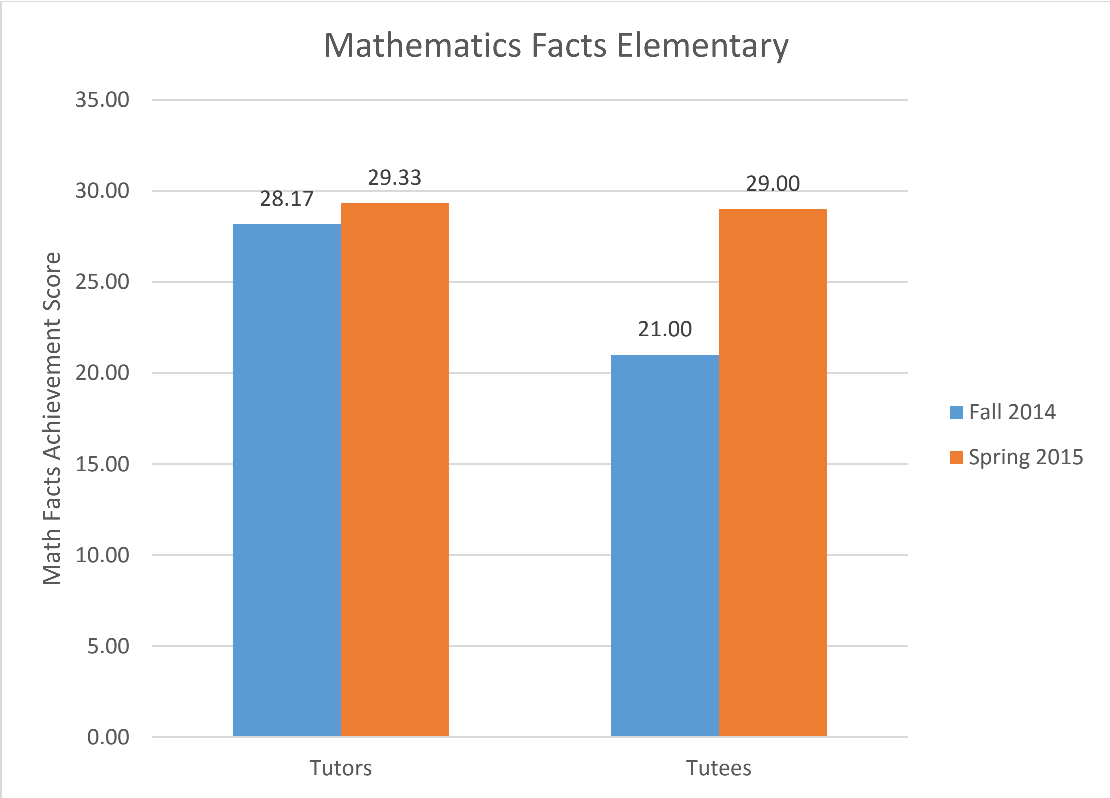

Figure 3.8. Mathematics Facts Elementary School

On the other hand, although tutors and tutees achieved significant score gains between pre-and posttests, the maximum possible score for problem solving was 10 points; consequently, Figure 3.9 shows that the tutees' ability to solve problems is still low. The average of the posttest is only 3.2 points.

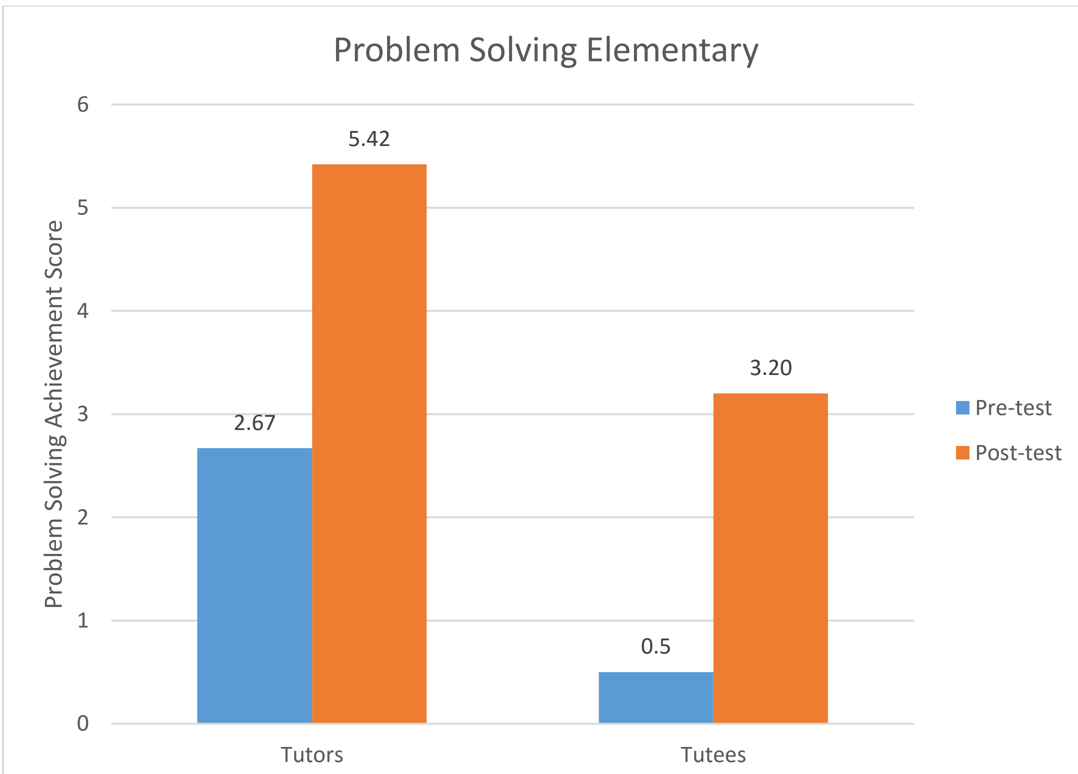

Figure 3.9. Problem Solving Elementary School

The effect size (ES) was calculated to measure the effect of this cross-age tutoring program on academic achievement in mathematics. Cohen's *d* and confidence intervals were computed using the statistical software STATA for pre-post-tests comparison. Table 3.3 shows a large effect size on mathematics facts of elementary students (d = 1.39). In the same way, the effect of peer tutoring was large for problem-solving (d = 1.25). Using Hattie (2009) benchmark to evaluate the contribution of the tutoring program to the academic outcomes of elementary students, these effect sizes are outstanding.

Table 3.3

Effect Size of Peer Tutoring on Mathematics Achievement for Elementary School Students

Effect Size	**Estimate**	**[95% Confidence Interval]**	
Mathematics Facts			
Cohen's *d*	1.39	.44	2.32
Problem Solving			
Cohen's *d*	1.25	.32	2.16

Effects of Peer Tutoring on Achievement for Middle School Students

Tutors and tutees in the middle school program completed an achievement test that included 50 short answer and problem-solving questions that covered the content standards included in the curriculum designed for this peer-tutoring program. Table 3.4 displays the means and standard deviations for the pre-and post-tests for all middle school students who participated in the program and completed both the pre-and posttests. A paired t-test revealed significant improvements in the middle school students' performance from the beginning to the end of the program (*t = 4.95*, *p* = 0.0001). The average achievement scores increased from 5.81 to 8.32 points or 43%.

Table 3.4

T-Test Results for Middle School Mathematics Achievement Scores

Math Achievement Tests	***M***	***SD***	***t***	***P***
Pre-test (n=49)	5.81	3.030	4.950***	.00001
Post-test (n=49)	8.32	4.153		

*Note: *** p < .001*

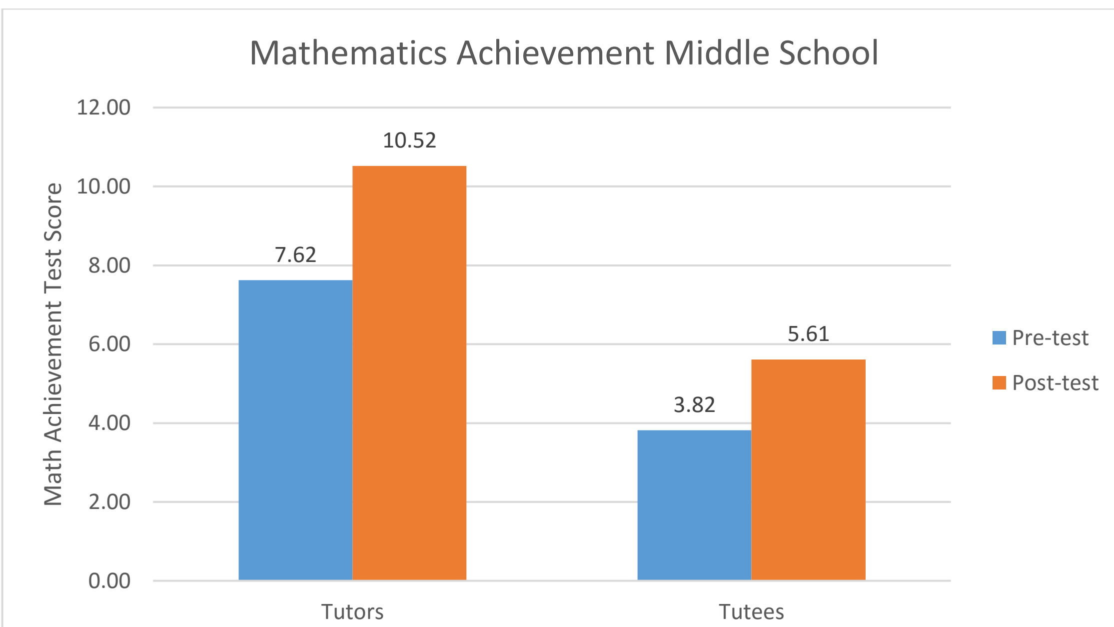

Figure 3.10. Mathematics Achievement Middle School

Figure 3.10 shows that both tutors and tutees improved; however, these results should be interpreted with caution. Although significant gains were observed, the means of the pre- and post-tests remained low. The mean of the pre-test (*M*= 5.81) displayed in Table 3.4, indicates that tutors and tutees on average answered only 11.6% of the questions correctly in the pre-test and the mean of the posttest (*M*= 8.32) suggests that, on average, tutors and tutees answered only 16.64% of the questions correctly. The low score in the pre- and post-tests could in part be attributed to the short amount of time scheduled for this test. Students had to answer 50 questions in about one hour.

Table 3.5

Means and Standard Deviations of Pre-and Post-Mathematics Achievement Test for Middle School Students

Middle Schools	***Mean Pre-Test***	***SD Pre-Test***	***Mean Post-Test***	***SD Post-Test***
Middle School 1	5.57	3.24	9.29	4.59
Middle School 2	7.07	2.52	8.75	2.77
Middle School 3	5.80	3.03	7.27	3.92

Note. SD = standard deviation

Table 3.5 contains the means and standard deviation of pre-and post-achievement tests for middle school students. The results show academic gains for all schools. An analysis of covariance (ANCOVA) was conducted to examine the mathematics achievement scores in the three middle schools with post-test scores as the dependent variable and pre-test scores as the covariate (Table 3.6). The results show middle schools participant in this cross-age tutoring program did not have significant differences in the mean achievement post-test scores when we controlled for pre-test scores.

Table 3.6

ANCOVA Results for Middle School Mathematics Achievement by Campus

Source	**Partial Sum of Squares**	***df***	**Mean Square**	***F***	***p***
Model	301.55	3	100.52	8.59	0.001
Pre-test	256.73	1	256.73	21.95	0.0000*
School	51.55	1	256.73	21.95	0.1221
Residual	526.30	45	11.69		
Total	827.85	48	17.25		

Note. **p*<.001, *df* = degrees of freedom

The results in Table 3.7 show that the effect of peer tutoring on mathematics academic achievement ($d = 0.67$). According to Hattie (2009), effect sizes greater than $d = 0.40$ are located within the zone of desired effects; consequently, these results suggest that peer tutoring interventions made a significant contribution to student achievement.

Table 3.7

Effect Size of Peer Tutoring in Mathematics Achievement for Middle School Students

Effect Size	Estimate	[95% Confidence Interval]	
Cohen's *d*	0.67	0.26	1.07

Mathematics Attitudes/Motivation Survey

A factor analysis was conducted in SPSS to explore the underlying constructs comprised in the responses to the items in the Attitudes/Motivation Survey administered at the beginning and end of the tutoring intervention. Negative items were reversed and recoded values were used in the factor analysis and further analysis involving data from this survey. Results of the factor analysis are displayed in Table 3.8.

The results of factor analysis with Varimax rotation revealed that two constructs summarize the items in the survey for the present study: (a) Self-perceptions for mathematics, and (b) Enjoyment of mathematics. The two variables captures 60.2% of the variance. The factors' loadings that show how the items of the survey clustered under two constructs are displayed on Table 3.8. Cronbach's alpha reliability for the first construct, self-perceptions for mathematics, is 0.874 and the alpha reliability for the second construct, enjoyment of mathematics, is 0.872. These results indicate a good reliability for the two constructs.

Table 3.8

Factor Analysis Results of the Attitudes Motivation Survey

Survey Item	**Self-perceptions**	**Enjoyment of mathematics**
I am really good at math	.818	
I learn things quickly at math	.804	
I usually do well in math	.781	
Doing math is easy for me	.714	
Math is harder for me than for many of my classmates	.686	
Math is harder for me than any other subject	.656	
I can solve difficult math problems	.537	
I enjoy learning math		.763
Math is boring		.755
I like math		.737
I use math in other subjects at school		.687
Math is fun		.657
I would like to have a job that involves math		.632
I learn many interesting things in math		.614
Cronbach's alpha	.874	.872
Variance Explained (%)	48.779	11.428
Cumulative Variance Explained (5)	48.779	60.207

Enjoyment of Mathematics Elementary School Students

Two t-tests were conducted to examine if significant differences existed between the levels of enjoyment of mathematics of tutors and tutees from the beginning to the end of the program. The results in Table 3.9 show a statistically significant decline of enjoyment for tutors in elementary school (p = .006). Tutors' enjoyment declined from a mean of 3.76 to a mean of 3.24.

Table 3.9

T-Test Results for Enjoyment Elementary School Tutors

	M	***SD***	***t***	**Sig**
Pre- Enjoyment Tutors	3.76	.23	4.568	.006
Post- Enjoyment Tutors	3.24	.45		

Note. Scores based on a 4-point Likert-type scale

Table 3.10

T-Test Results for Enjoyment Elementary School Tutees

	M	***SD***	***t***	**Sig**
Pre- Enjoyment Tutees	3.42	.89	1.082	.340
Post- Enjoyment Tutees	3.89	.19		

Note. Scores based on a 4-point Likert-type scale

In contrast, the results of paired-samples t-test on Table 3.10 show that peer tutoring has a positive impact in enjoyment of mathematics for elementary school tutees. However, there were no statistically significant differences between the levels of enjoyment from the beginning to the end of the program. Figure 3.11 shows these mixed results of mathematics enjoyment for tutors and tutees in elementary school.

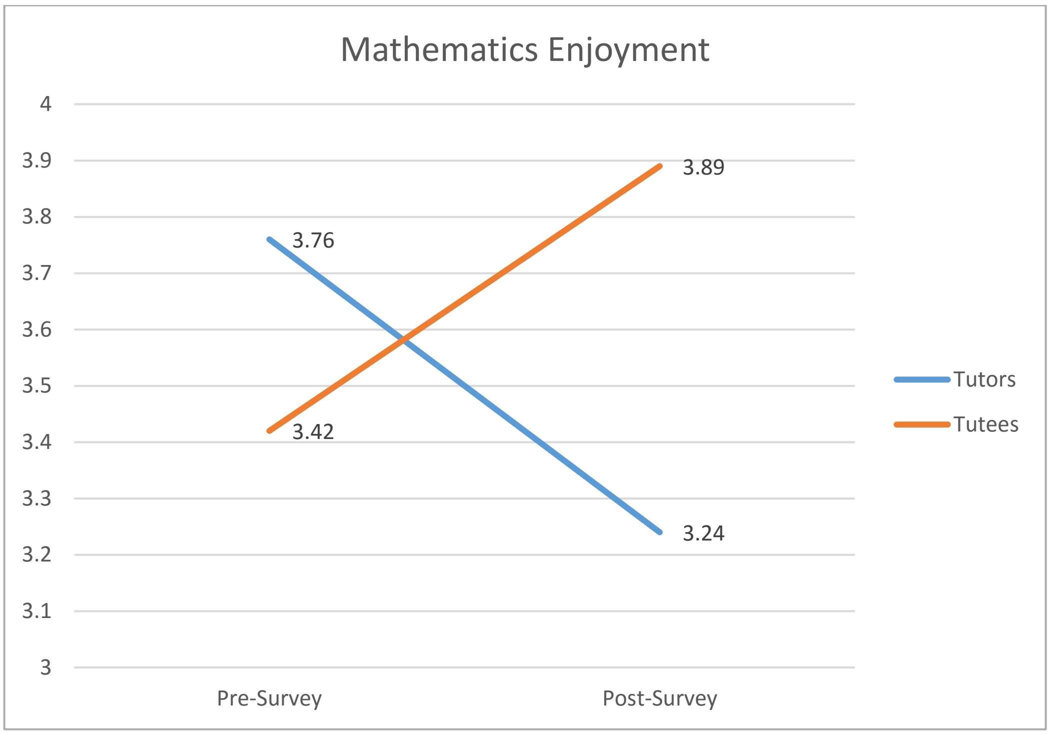

Figure 3.11. Mathematics Enjoyment Tutors and Tutees Elementary School

Table 3.11 displays the effect size of peer tutoring on students' enjoyment of mathematics. A large negative effect size was generated for elementary school tutors (*d* = - 1.46). In contrast, a positive effect size was generated for tutees (*d* = .71).

Self-Perceptions as Mathematics Learners Elementary School Students

Paired-Samples t-tests were conducted to determine if significant differences existed between self-perceptions as mathematics learners of tutors and tutees from the beginning of the program to the end. The results of the t-test show that there are no significant differences in tutors' self-perception in elementary school (Table 3.12).

Table 3.11

Effect Size of Peer Tutoring on Enjoyment of Mathematics for Elementary School Students

Effect Size	Estimate	[95% Confidence Interval]	
Tutors Cohen's *d*	-1.46	-2.73	-.14
Tutees Cohen's *d*	.71	-.60	1.98

Table 3.12

T-Test Results for Self-perceptions Elementary School Tutors

	M	***SD***	***t***	**Sig**
Pre- Self-perceptions Tutors	3.19	.51	.863	.428
Post- Self-perceptions Tutors	3.02	.79		

Note: Scores based on a 4-point Likert-type scale

The results of paired-samples t-test on Table 3.13 suggest that although peer tutoring had a positive impact in self-perceptions for elementary school tutees, there are not statistically significant differences in tutees' perceptions from the beginning to the end of the tutoring program.

Table 3.13

T-Test Results for Self-perceptions Elementary School Tutees

	M	***SD***	***t***	**Sig**
Pre- Self-perceptions Tutees	3.07	.75	.762	.489
Post- Self-perceptions Tutees	3.37	.58		

Note. Scores based on a 4-point Likert-type scale

The effect size of peer tutoring on students' self-perceptions as mathematical learners was negative for tutors (g = - .25). In contrast, the effect size for self-perceptions for school tutees was positive (g = .45).

Table 3.14

Effect Size of Peer Tutoring on Self-Perceptions for Elementary School Students

Effect Size	Estimate	[95% Confidence Interval]	
Tutors			
Cohen's *d*	-.25	-1.38	.89
Tutees			
Cohen's *d*	.45	-.82	1.70

Figure 3.12 shows that while the self-perceptions score in mathematics of tutees increased, this value decreased for tutors. Further investigation is needed to determine the reasons of decline in the self-perceptions as mathematics learners experienced by tutors.

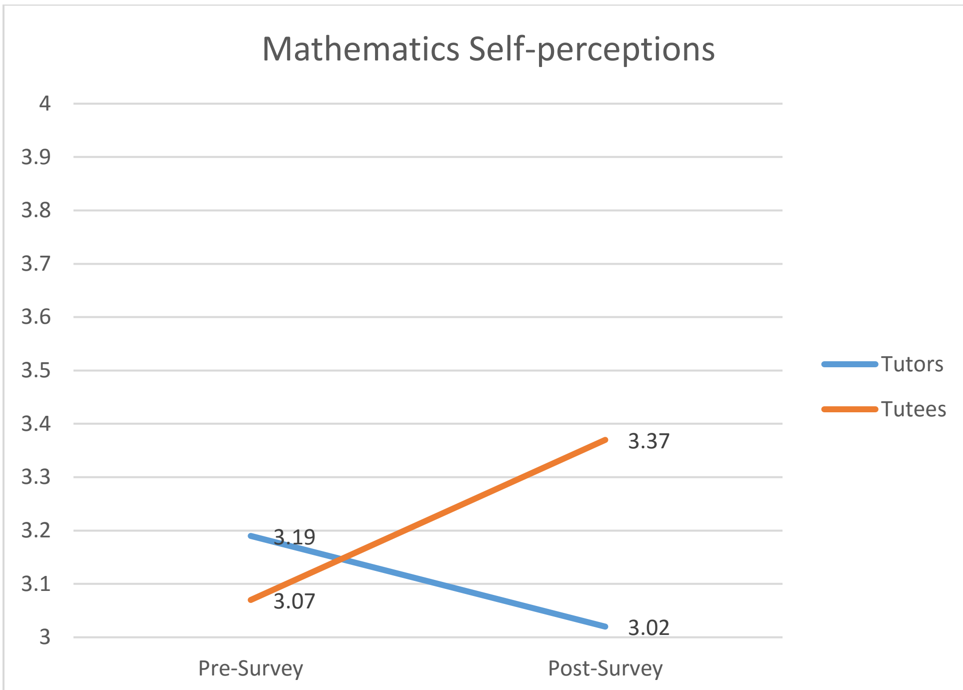

Figure 3.12: Self-Perceptions as Mathematics Learners Tutors and Tutees Elementary School

Enjoyment of Mathematics Middle School Students

Paired-samples t-tests were conducted to examine if significant differences existed between the levels of enjoyment of mathematics of tutors and tutees from the beginning of the program to the end. The results of the t-test (Tables 3.15 and 3.16) show that although the enjoyment level slightly declined, there were not statistically significant differences between the levels of enjoyment from the beginning to the end of the program.

Table 3.15

T-Test Results for Enjoyment Middle School Tutors

	M	***SD***	***t***	**Sig**
Pre- Enjoyment Tutors	2.86	.44	1.65	.112
Post- Enjoyment Tutors	2.69	.53		

Note. Scores based on a 4-point Likert-type scale

Table 3.16

T-Test Results for Enjoyment Middle School Tutees

	M	***SD***	***t***	**Sig**
Pre- Enjoyment Tutees	2.86	.81	.333	.743
Post- Enjoyment Tutees	2.80	.74		

Note. Scores based on a 4-point Likert-type scale

Table 3.17 shows small negative effect sizes of peer tutoring on enjoyment of mathematics for middle school tutors and tutees. The effect size for tutors was (*d* = -.21) while the effect size for tutees was (*d* = -.11).

Table 3.17

Effect Size of Peer Tutoring on Enjoyment for Middle School Students

Effect Size	Estimate	[95% Confidence Interval]	
Tutors			
Cohen's *d*	-.21	-.76	.35
Tutees			
Cohen's *d*	-.11	-.73	.50

Table 3.18

ANCOVA Results for Middle School Enjoyment Tutors/Tutees

Source	**Partial Sum of Squares**	***df***	**Mean Square**	***F***	***p***
Model	5.27	2	2.63	8.97	0.0006
Pre-survey	5.11	1	5.11	17.42	0.0002
Tutor/Tutee	0.11	1	0.11	0.37	0.5460
Residual	11.44	39	.29		
Total	16.70	41	0.41		

ANCOVA was conducted to explore the differences in enjoyment between tutors and tutees who participated in the program. Table 3.18 shows that there was no statistically significant differences in the level of enjoyment between these two groups of participants at the end of the program when we controlled for enjoyment pre-survey scores (p = 0.5460).

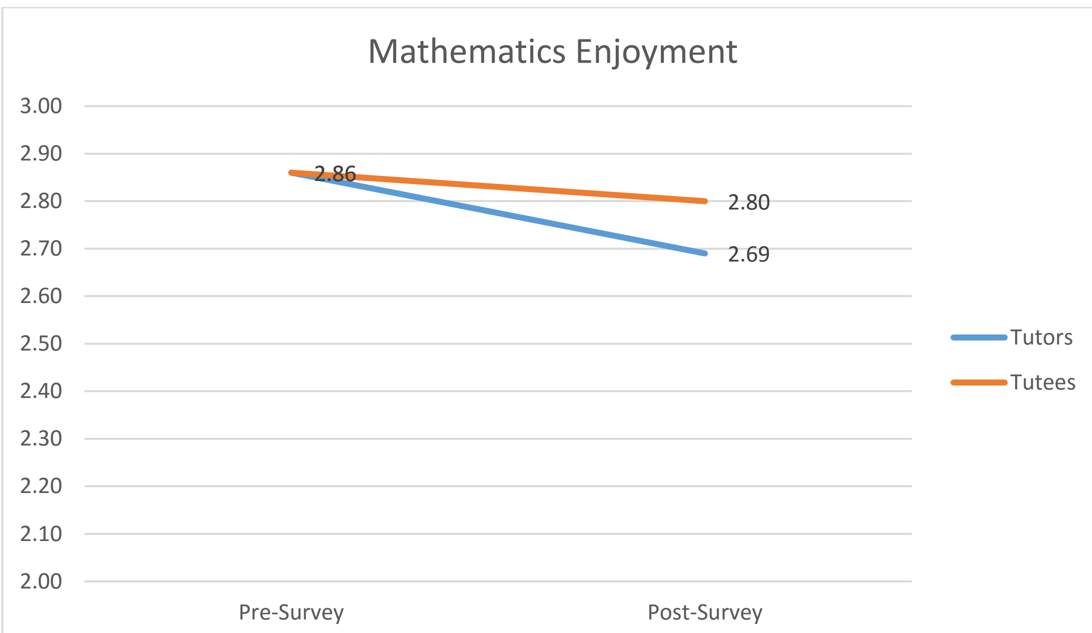

Figure 3.13. Mathematics Enjoyment Tutors and Tutees Middle School

Figure 3.13 illustrates how the level of enjoyment declined for both tutors and tutees. While the decline of enjoyment was small for tutees, it was steeper for tutors.

Self-Perceptions of Middle School Students

Paired-Samples t-tests were conducted to determine if significant differences existed between self-perceptions as mathematics learners of tutors and tutees from the beginning of the program to the end. The results of the t-test show that there are no significant differences in middle school tutors' self-perceptions in mathematics (Table 3.19).

Table 3.19

T-Test Results for Self-perceptions Elementary School Tutors

	M	***SD***	***t***	**Sig**
Pre- Self-perceptions Tutors	2.51	.59	.746	.463
Post- Self-perceptions Tutors	2.43	.58		

Note. Scores based on a 4-point Likert-type scale

Table 3.20

T-Test Results for Self-perceptions Elementary School Tutees

	M	***SD***	***t***	**Sig**
Pre- Self-perceptions Tutees	2.43	.65	-1.403	.178
Post- Self-perceptions Tutees	2.66	.65		

Note. Scores based on a 4-point Likert-type scale

Likewise, the results of paired-samples t-test on Table 3.20 show that although peer tutoring has a positive impact in self-perceptions of middle school tutees, there are no statistically significant differences between the levels of self-perceptions from the beginning to the end of the program.

Table 3.21

Effect Size of Peer Tutoring on Self-Perceptions for Middle School Students

Effect Size	Estimate	[95% Confidence Interval]	
Tutors Cohen's *d*	-.28	-.84	.27
Tutees Cohen's *d*	.44	-.19	1.1

Table 3.21 shows that the effect size of the tutoring program on students' self-perceptions as mathematics learners was negative for middle school tutors (*ES* = -.28) and positive for middle school tutees (*ES* = .44).

ANCOVA was conducted to explore the differences in the level of self-perceptions as mathematics learners between tutors and tutees. Table 3.22 indicates that there are no statistically significant differences between these two groups of students in the level of self-perceptions at the end of the program ($p = 0.0968$) when controlled by self-perceptions scores at the beginning of the program.

Table 3.22

ANCOVA Results for Middle School Self-Perception Tutors/Tutees

Source	**Partial Sum of Squares**	***df***	**Mean Square**	***F***	***p***
Model	4.44	2	2.22	7.60	0.0016
Pre-survey	3.96	1	3.96	13.54	0.0007
Tutor/Tutee	0.85	1	0.85	2.90	0.0968
Residual	11.40	39	.29		
Total	15.84	41	0.39		

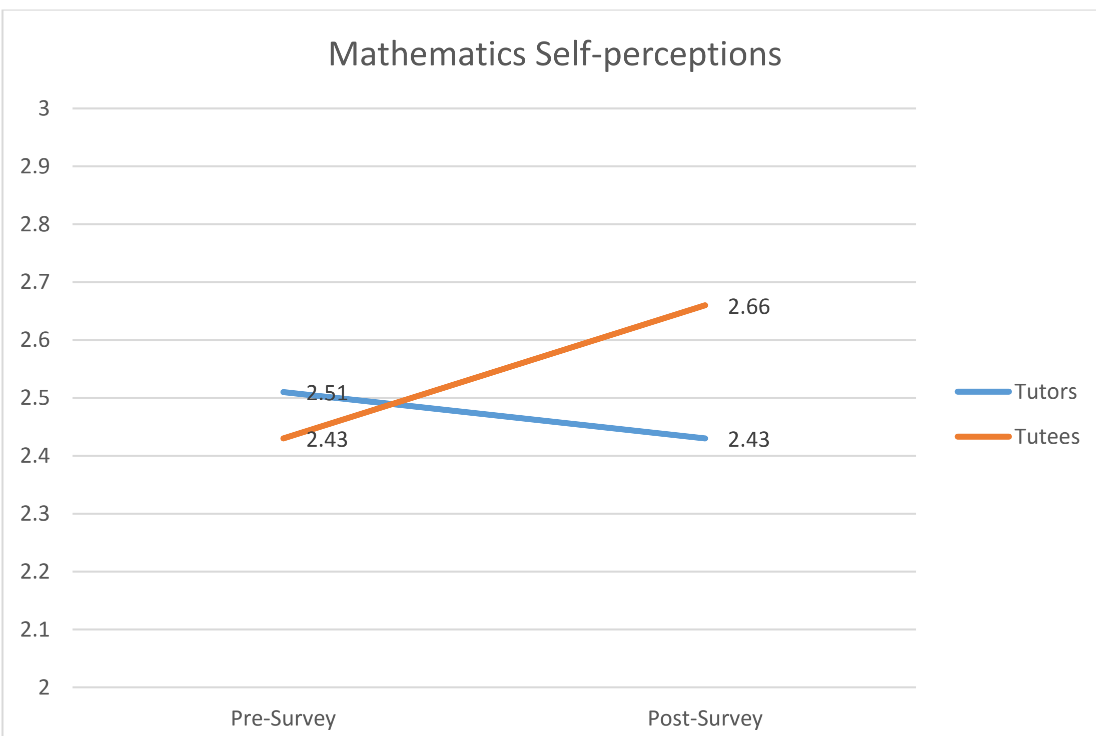

Figure 3.14: Mathematics Self-Perceptions Tutors and Tutees Middle School

Figure 3.14 portraits positive effects of the tutoring program on mathematics self-perceptions for middle school tutees. In contrast, small negative effects can be observed for tutors. Further investigation is needed to determine the reasons of decline in the self-perceptions as mathematics learners experienced by tutors.

Regression Commonality Analysis

Commonality analysis is an alternative regression model that can be used to decompose the explained variance of a dependent variable or R^2 from multiple regression into constituent, nonoverlapping parts that explain the unique and common explanatory power of the predictors (Thompson, 2006; Warne, 2011). I used commonality analysis to examine the explanatory power of achievement, enjoyment of mathematics, and self-perception at the beginning of the program on the dependent variable, achievement at the end of the tutoring program.

Using Commonality Analysis to Understand R^2 Results for Students in Elementary School

Table 3.23 contains the results of the multiple regression R^2 values for the three independent variables: mathematics achievement, enjoyment of mathematics, and self-perception as mathematical learners as well as four possible combinations of these variables. The dependent variable was mathematics achievement measured at the end of the program.

Table 3.23

Multiple Regression R^2 Values Elementary School

Predictor variables	**Variable number**	R^2
Pre-achievement	1	9.03%
Pre-enjoyment	2	4.70%
Pre-self-perceptions	3	8.26%
Pre-achievement, pre-enjoyment	1,2	11.32%
Pre-achievement, pre-self-perception	1,3	15.23%
Pre-enjoyment, pre self-perceptions	2,3	8.27%
Pre-achievement, pre-enjoyment, pre-self-perceptions	1,2,3	15.38%

After the R^2 values were obtained, I used the following formulas to calculate the unique and common components of the shared variance. These equation were recommended by Thompson (2006) for three independent variables.

$U_1 = R^2(123) - R^2(23)$

$U_2 = R^2(123) - R^2(13)$

$U_3 = R^2(123) - R^2(12)$

$C_{12} = R^2(13) + R^2(23) - R^2(3) - R^2(123)$

$C_{13} = R^2(12) + R^2(23) - R^2(2) - R^2(123)$

$C_{23} = R^2(12) + R^2(13) - R^2(1) - R^2(123)$

$C_{123} = R^2(123) + R^2(1) + R^2(2) + R^2(3) - R^2(12) - R^2(13) - R^2(23)$

The sum of all seven partitions of R^2 in Table 3.24 equals the R^2 of the three predictors with achievement at the end of the peer tutoring program. Consequently, 7.11% + 0.15% + 4.06% – 0.14% – 0.49% + 2.14% + 2.55% = 15.38% (See Table 3.23). The results on Table 3.24 suggests that the academic pre-achievement was the strongest predictors of academic achievement of elementary school students at the end of the program ($Unique_{pre\text{-}achievement}$ = 7.11%). Pre-achievement alone explained 46% of the R^2 = 15.38%. Furthermore, when pre-achievement was added to other predictors, explained 58.7% of R^2 = 15.38%. (9.03% / 15.38% = 58.71%).

The degree of enjoyment of mathematics at the beginning of the program was a weak predictor of academic achievement ($Unique_{pre\text{-}enjoyment}$ = 0.15%). Alone explained less than one percent of R^2 = 15.38%. In concert with the other predictors ($Common_{pre\text{-}enjoyment}$ = 4.55%) explained about one-third of R^2 = 15.38%.

Self-perceptions uniquely contribute about one-fourth of the R^2 = 15.38% (4.06% / 15.38% = 26.4%). Moreover, when other common predictors were working with self-perceptions, it explained about one half of R^2 = 15.38% (8.26% / 15.38% = 53.71%).

Table 3.24

Unique and Common Components of the Shared Variance (R^2) Elementary School

Predictors/partitions	**Predictors**		
	Pre-achievement	Pre-enjoyment	Pre-self-perceptions
Pre-achievement	7.11%		
Pre-enjoyment		0.15%	
Pre-self-perceptions			4.06%
Pre-achievement, pre-enjoyment	-0.14%	-0.14%	
Pre-achievement, pre-self-perception	-0.49%		-0.49%
Pre-enjoyment, pre self-perceptions		2.14%	2.14%
Pre-achievement, pre-enjoyment, pre-self-perceptions	2.55%	2.55%	2.55%
Unique	7.11%	0.15%	4.06%
Common	1.92%	4.55%	4.20%
Total	9.03%	4.70%	8.26%

Using Commonality Analysis to Understand R^2 Results for Students in Middle School

Table 3.25

Multiple Regression R^2 Values Middle School

Predictor variables	**Variable number**	R^2
Pre-achievement	1	30.20%
Pre-enjoyment	2	0.20%
Pre-self-perceptions	3	0.71%
Pre-achievement, pre-enjoyment	1,2	30.46%
Pre-achievement, pre-self-perception	1,3	31.07%
Pre-enjoyment, pre self-perceptions	2,3	6.37%
Pre-achievement, pre-enjoyment, pre-self-perceptions	1,2,3	33.38%

Table 3.25 displays the results of the multiple regression R^2 values for the three independent variables examined in middle school: mathematics achievement, enjoyment of mathematics, and self-perception as mathematical learners as well as four possible combinations of these variables. The dependent variable was mathematics achievement measured at the end of the program. After the R^2 values were calculated, I computed the

unique and common components of the shared variance using the formulas recommended by Thompson (2006) described above.

Table 3.26

Unique and Common Components of the Shared Variance (R^2) Middle School

Predictors/partitions	**Predictors** Pre-achievement	Pre-enjoyment	Pre-self-perceptions
Pre-achievement	27.01%		
Pre-enjoyment		2.31%	
Pre-self-perceptions			2.92%
Pre-achievement, pre-enjoyment	3.35%	3.35%	
Pre-achievement, pre-self-perception	3.25%		3.25%
Pre-enjoyment, pre self-perceptions		-2.05%	-2.05%
Pre-achievement, pre-enjoyment, pre-self-perceptions	-3.41%	-3.41%	-3.41%
Unique	27.01%	2.31%	2.92%
Common	3.19%	-2.11%	-2.21%
Total	30.20%	0.20%	0.71%

The results on Table 3.26 indicates that the strongest predictor for academic achievement at the end of the program is the achievement at the beginning. The scores of the pre-test of academic achievement uniquely explained 80.92% of R^2 (27.01% / 33.38% = 80.92%). In concert with the other predictors ($\text{Common}_{\text{pre-achievement}}$ = 3.19%) explained 90.47 of R^2 (30.20% / 33.38% = 90.47%).

The degree of enjoyment of mathematics at the beginning of the program was a weak predictor of academic achievement alone or combined with other predictors. Likewise, students' self-perceptions as mathematics learners at the beginning of the program was a weak predictor of the achievement scores at the end of the program.

Discussion

The purpose of this study was to evaluate the effects of a cross-age peer tutoring on academic achievement, enjoyment of mathematics, and self-perceptions about ability in mathematics of elementary and middle school students who participated in this tutoring program and to explore the extent to which the initial levels of academic performance, enjoyment, and self-perceptions were predictors of students' academic performance in mathematics at the end of the program. The intervention was conducted in a school setting and included two weekly sessions, one for tutoring training and one for tutor-tutee sessions, for an average of 26 weeks. Pre-test and post-test were administered at the beginning and end of the program to tutors and tutees to measure their academic achievement in mathematics. In addition, a pre-and post-survey provided information about students' enjoyment for mathematics and self-perceptions about their ability to learn and perform in this content area.

The results of this study indicate that tutors and tutees who participated in this cross-age tutoring intervention in elementary and middle schools had statistically significantly gains in academic achievement in mathematics. This tutoring intervention yielded a large positive effect on mathematics facts of elementary school students (d = 1.39) and problem solving skills (d = 1.25). Furthermore, the program generated a moderate to large effect on academic achievement of middle school students (d = 0.67). In both cases, the effect size were within the zone of desired effects described by Hattie (2009). Consequently, this program had a great influence academic achievement in mathematics in both elementary and secondary levels.

The findings support previous studies that reported positive effects of cross-age peer tutoring on mathematics performance for low-achieving students (Bar-Eli & Raviv, 1982; Sharpley, et al., 1983). For example, Bar-Eli & Raviv (1982) found that both underachieving fifth- and sixth- grade (tutors) and second grade (tutees) showed significant improvement in mathematics after participating in a cross-age tutoring program. Sharpley, et al., (1983) reported that a cross-age tutoring program in mathematics yielded significant increase mathematics achievement for low achieving participants. The findings in this study are also compatible with previous literature that reported that cross-age peer tutoring and other peer-assisted learning interventions generated greatest academic benefits for urban, low socioeconomic status, and minority students (Rohrbeck, et al., 2003).

Mixed results were found on students' enjoyment in mathematics. Tutors in elementary school experienced a strong decline in enjoyment of mathematics (ES = -

1.46). This drop was statistically significant. In contrast, tutees experienced an increase of enjoyment in mathematics (*ES* = .71). Among middle school students, the level of enjoyment slightly declined for tutors (*ES* = - .21) and tutees (*ES* = - .11). Results of t-test showed that this drop was not statistically significant. Further investigation is needed to determine the reasons of decline in this construct. I hypothesize that some of the reasons that could have prevented the achievement of significant positive effects on students' enjoyment in mathematics could be attributed to problems in the implementation of the program, lack of adherence to the original goals of the peer tutoring plan, lack of skills and experience of the instructors who are not professional educators, and lack of appropriate training and support to this new group of instructors during the implementation of the program.

Mixed results were also found on students' self-perceptions as mathematical learners. Self-perceptions declined among tutors in elementary school (*ES* = -.21) and middle school (*ES* = - .28). In contrast, peer tutoring impacted positively on the self-perceptions of tutees in elementary school (*ES* = .45) and middle school (*ES* = .44). Previously, Bar-Eli and Raviv (1982) found that cross-age peer tutoring did not generate significant improvement in tutors' self-perceptions. Futures studies need to investigate the effects of peer tutoring in self-perceptions and enjoyment of mathematics since these constructs could influence academic achievement. Greater gains in these two constructs could lead to improve academic achievement results.

Furthermore, regression commonality analysis revealed that the level of academic achievement at the beginning of the cross-age tutoring program was the strongest predictor for the level of academic performance at the end of the program for elementary school students. The scores on academic achievement at the beginning of the program for elementary school students uniquely contributed 46% of R^2. In concert with the other predictors, the achievement at the beginning of the program explained 58.7% of R^2.

Likewise, the academic achievement level at the beginning of the program was the strongest predictor for the academic achievement at the end of the program. The scores of the pre-test of academic achievement uniquely explained 80.92% of R^2 and acting with other common predictors explained 90.47% of R^2.

One explanation for these results could be that elementary and middle school students needed a strong mathematics background to assimilate new mathematical content. This is even more challenging if we consider that instruction is provided by students during tutoring sessions limited to 45 to 60 minutes a week.

The results of commonality analysis also suggested that students' enjoyment of mathematics at the beginning of the program was a weak predictor for further academic performance in elementary and middle school.

Conclusions

Enhancing academic achievement in mathematics for Hispanic students involves overcoming barriers in instructional classroom practices, student motivation, and other nonacademic factors. The effectiveness of cross-age peer tutoring in elementary and secondary school has been demonstrated by individual studies and major meta-analytic reviews.

Research studies have found that peer tutoring can have positive effects on students' achievement (Cohen, et al., 1982; Hartley, 1977; Robinson, et al., 2005), socio-emotional outcomes such as attitudes toward the subject matter that they were being taught (Cohen, et al., 1982), self-concept (Cohen, et al., 1982; Robinson, et al., 2005), and their academic self-perceptions (Robinson, et al., 2005). The results in the present study suggest that peer tutoring helped Hispanic students overcome some of the academic challenges in mathematics classrooms and enhance their academic achievement, which was reflected in the statistically significant increase of their academic performance between the beginning and end of the program.

Findings related to the effects of this cross-age tutoring program on nonacademic outcomes revealed different directions for tutors and tutees. Small gains in enjoyment of mathematics and self-perceptions as mathematical learners were experienced by tutees in elementary school. In contrast their tutors experienced a decline in these two constructs, although these changes were not statistically significant. At the same time, the levels of enjoyment of mathematics slightly dropped for tutors and tutees in middle school. The only nonacademic construct that showed a slight increase among middle school students was their self-perceptions as mathematics learners.

As stated before the lack of professional teaching qualification and experience of facilitators could have prevented the achievement of greater enjoyment and self-perceptions outcomes. Padrón, et al. (2002) indicated that one of the key factors in the development of effective educational programs for Hispanic students is the appropriate teacher qualification. All facilitators held a bachelor's degree, but none of them had the

Texas professional teaching certification in mathematics. We all know that the route for professional certification includes training in vital topics for a teacher. These topics include educational psychology, classroom management, pedagogy, mathematics methods, and field experiences. Lack of training in this critical areas could have prevented the use of strategies that improve students' motivation and self-perceptions.

A regression analysis revealed that the strongest predictor of academic achievement in elementary and middle school was the level of mathematics knowledge and ability that students brought to the class from the beginning of the program. Self-perceptions as mathematics learners was the second more important predictor of the academic achievement of elementary students but was a weak predictor for middle school students.

Implications for Practice and Future Research

Academic achievement in mathematics of Hispanic students is critical. Effective instructional practices are needed to close the deep and persistent achievement gap between Hispanic and White students. One effective instructional practice supported by research is peer tutoring. Unfortunately, research about the impact of peer tutoring on Hispanic students is rare. Consequently, more research that focuses on the specific effects of several types of peer-tutoring interventions with Hispanic students in elementary and secondary school is greatly needed.

Significant positive effects of cross-age tutoring programs such as the ones found in this study and previous research should encourage mathematics teachers to implement peer tutoring in their classroom to help Hispanic students that are already behind of their peers. The mixed effects on students' self-perceptions and enjoyment of mathematics suggested that teachers will need more information, training and support about cross-age tutoring programs and how to implement it in mathematics classrooms.

CHAPTER IV

EVALUATING THE IMPLEMENTATION OF A CROSS-AGE PEER-TUTORING MATHEMATICS PROGRAM IN ELEMENTARY AND MIDDLE SCHOOLS THAT SERVE PREDOMINANTLY HISPANIC STUDENTS

Overview

A growing body of research has shown the positive effects of peer tutoring on academic achievement, self-concept, attitude, social, and behavioral outcomes. However, there is a paucity of research that focuses on how peer-tutoring interventions are implemented for Hispanic students. The current study examined classroom practices, as well as teachers' and students' behaviors within a cross-age peer-tutoring program implemented in elementary and middle schools that serve predominantly Hispanic students. Classroom observations and face-to-face interviews with facilitators were used to evaluate the implementation of the program. This study was conducted in one elementary and three middle schools that offered cross-age tutoring interventions for low achieving students in mathematics. The program's strengths included the development of positive emotions and relationships among students and evidence of a classroom environment that fostered warm and supportive relationships. Weaknesses included flaws in the implementation of the program. Several features of this peer-tutoring intervention included in the program design were not fully implemented. For example, most of the instructional strategies that were included in the original plan were not used during tutoring sessions. In addition, teachers seldom provided positive reinforcement, and they rarely encouraged critical thinking skills. Findings from this study can be used to improve the effectiveness of future peer-tutoring programs in mathematics.

Introduction

The achievement level in mathematics for Hispanic students in elementary and secondary U.S. schools is in a critical state. National statistics show a chronic underperformance in mathematics among Hispanic students (U.S. Department of Education, NCES, 2015b). Educational problems among Hispanic students have been attributed to social, economic, and educational conditions, including very limited household income, scarce social services, lack of educational resources, language barriers, and low-quality education (Gándara, 2008, 2015). Hispanic and African American are over represented in the groups that endure severe poverty in the United States. Poverty among minority students has been associated with low academic performance in mathematics (Berliner, 2006).

Padrón, et al. (2002) also indicated that some socioeconomic, cultural, and political factors have placed Hispanic children at-risk of academic failure. Many children live in communities of concentrated poverty and attend schools with limited resources and without political support that helps teachers to implement instructional programs that fit the needs of this group of students. Furthermore, Padrón et al. (2002) identified three key school-based factors that can be altered. These factors are the shortage of qualified teachers prepared to fulfill the diverse needs of Hispanic students, at-risk school environments, and inappropriate teaching practices.

Considering these factors, it is critical to improve the academic outcomes of Hispanic students in mathematics by implementing the most effective instructional strategies to help them overcome persistent academic problems. Some researchers have suggested that peer tutoring has positive effects in classrooms that educate minority, low-income, and urban children. For example, the meta-analytic reviews conducted by Rohrbeck, et al. (2003) and Ginsburg-Block, et al. (2006) found that peer-assisted learning interventions were more effective with low-income, urban, and minority students than higher income, suburban, and nonminority children.

Theoretical Framework

Mathematics achievement of Hispanic students in elementary and middle school is critically low. The 2015 Nation's Report card indicated that only 26% of Hispanic fourth-grade students and 19% of eighth-grade students reached at or above proficiency levels in mathematics, compared to 51% of White fourth-graders and 43% of White eight-graders who achieved at or above proficiency (U.S. Department of Education, Nacional Center of Education Statistics, 2016). In Texas, results show that 37% of Hispanics in fourth grade and 23% in eight grade reached proficiency level in mathematics in 2015 (U.S. Department of Education, National Center of Education Statistics, 2016). While the academic achievement remains low, the enrollment of Hispanic student continues growing. In 2012, Hispanic students comprised 24.3% of the total enrollment in elementary and secondary U.S. schools (U.S. Department of Education, National Center for Education Statistics, 2014) and 52.0% of the students enrolled in Texas public schools during the school year 2014-15 (Texas Education Agency, 2015b).

Educational problems among Hispanic students was attributed to social, economic, and educational factors that limit the educational opportunities of this group of students (Gándara, 2008). Schools that educate predominantly Hispanic students, do not have the necessary resources to offer them the quality of education they need to achieve higher levels of academic performance. Padrón, et al. (2002) stated that economic, social, cultural, and political factors might compromise the low educational attainment of Hispanic students. These factors include poverty among Hispanic households and communities, limited resources in schools located in Hispanic neighborhoods, and lack of political support for programs that support the needs of these students.

Furthermore, Padrón et al. (2002) identified three alterable factors associated with the critical condition of Hispanic achievement. These factors are the shortage of qualified teachers prepared to fulfill de academic needs of this group of students, inappropriate teaching practices in schools that serve Hispanic students, and at-risk school environments. These researchers found that the most common classroom practice was direct instruction, where the majority of instructional time was devoted to lecture, seatwork, drill, and memorization. Padrón et al. (2002) suggested the careful selection of research-based teaching practices that significantly improve the academic success of Hispanic students.

Several studies that focused on peer-tutoring programs found that such programs have a positive impact on academic achievement in mathematics (Bar-Eli & Raviv, 1982; Cohen, et al., 1982; Fantuzzo, Davis, & Ginsburg, 1995; Menesses & Gresham, 2009; Sharpley, et al., 1983). In addition, several researchers have reported positive effects of peer tutoring for minority, low-income, and urban students (Rohrbeck, et al., 2003; Ginsburg-Block, et al., 2006). Furthermore, peer tutoring is a teaching practice that can help transform teacher-centered instruction to student-centered learning (Cole, 2014). Ginsburg et al. (2006) stated that the effectiveness of peer-assisted learning can be linked to student-center learning environments since they promote gains in achievement and self-esteem. Topping, et al. (2003) found that peer tutoring improved cooperation among students since tutor and tutee have multiple opportunities to discuss and work together.

Research on peer-tutoring programs has also found that peer tutoring is a cost-effective way to improve math performance (Yeh, 2010). Yeh (2010) found that cross-age tutoring is more cost-effective with regard to student achievement than many other alternatives such as computer-assisted instruction, lengthening the school day by 60 minutes, hiring teachers with a master degree or with more experience, and increasing teacher salaries. Considering that research has reported positive effects of peer tutoring on academic and nonacademic outcomes and that peer tutoring is a very cost-effective instructional strategy, the implementation of peer tutoring in public schools could help to alleviate the academic difficulties in mathematics faced by Hispanic students.

According to Greenwood, Terry, Arreaga-Mayer, and Finney (1992), the strength and fidelity of treatment are key to the success and effectiveness of a tutoring program. Strength has been associate to the duration and intensity of the tutoring sessions (e.g. 20 weeks, 60 minutes a week). Fidelity involves the accuracy and consistency of the different components of the tutoring program. Implementation problems can affect students' outcomes (Greenwood, et al., 1992). Important elements in the program implementation include teacher training, tutor training and the one-to-one instruction provided by tutors to tutees.

Tutor training has been identified as an important element of success in a tutoring program (Wepner, 1985). Wepner (1985) indicated that tutors have to be prepared to address the diverse instructional needs of tutees and deliver lessons using a variety of instructional approaches or strategies. An effective tutor training is necessary because mathematics instruction could be a difficult task for tutors, especially if they are inexperienced elementary or middle school children. Tutors need to know not only the content to be taught but also strategies to help enhance comprehension, provide helpful feedback, and help tutees improve cognitive and affective areas (Wepner, 1985).

Cross-age peer tutoring involves a one-to-one teaching and learning process in which older students in higher-grade levels tutor younger students in lower grade levels (Robinson et al., 2005). Peer tutoring incorporates teaching, learning, and emotional factors generated by the unique dyad partnership where the tutor assumes the role of teacher and the tutee learns from the tutor (Cohen, 1986). Since the responsibility of teaching is transferred from teachers to tutors, tutor training is a key factor in the success of a peer tutoring program in mathematics (Greenfield & Neil, 1987).

Although tutor training and one-to-one instruction in the dyads is very important to ensure the effectiveness of any tutoring program, research has generally focused on the effects of tutoring interventions on academic outcomes, leaving aside the study of instructional practices and process during tutor training and tutoring sessions. Consequently, more research about the instructional practices and behaviors within the tutoring sessions is needed.

Purpose of this Study

Research on peer tutoring has been typically been used to explore the students' academic outcomes. Empirical research, however, has been less frequently used to describe the implementation of peer-tutoring programs. Therefore, the purpose of this study is to examine the implementation of a cross-age peer-tutoring in mathematics through classroom observations and teacher surveys.

More specifically, classroom observations were uses to investigate classroom practices, instructional strategies, teachers' and students' behaviors in a peer-to-peer tutoring program implemented in one elementary and three secondary urban schools that enroll predominantly low-income minority students. Teacher interviews were used to investigate the teachers' perceptions about the benefits of this program for tutors and tutees as well as the potential strengths and weaknesses of the program.

Research Questions

Did classroom practices, instructional strategies, teachers' and students' behaviors during the tutoring sessions suggest that this cross-age tutoring program was implemented as designed? This general question encompassed the following specific questions:

1. What were the instructional practices during tutor training and tutoring sessions?
2. What were facilitators' and students' behaviors during tutoring sessions?
3. What were the facilitators' perceptions about the strengths and weaknesses of this tutoring program?

Method

This study used secondary data collected as part of a larger investigation on peer tutoring in mathematics implemented in elementary and secondary schools located in a large, urban city in the southwest region of the United States. The majority of children in these schools come from families with a disadvantaged socio-economic status. A non-profit organization provided materials and other resources necessary for the implementation of the program.

Participants

Participants in the current study were students enrolled in one elementary and three public middle schools in Texas. Figure 4.1 shows that 105 children were Hispanic, 17 African American, 4 Asian, 4 White, and 2 other race/ethnicity. The majority of participants (71.2%) indicated that they speak Spanish at home. In addition, 51.5% of participants were male and 48.5% were female. All tutors and tutees were underachieving students in mathematics, 67 students had the role of tutors and 65 had the role of tutees. In secondary schools, one tutor in eight grade worked the entire program with one tutee in sixth grade. In elementary schools, one tutor in fifth grade worked with one tutee in third grade during the whole program.

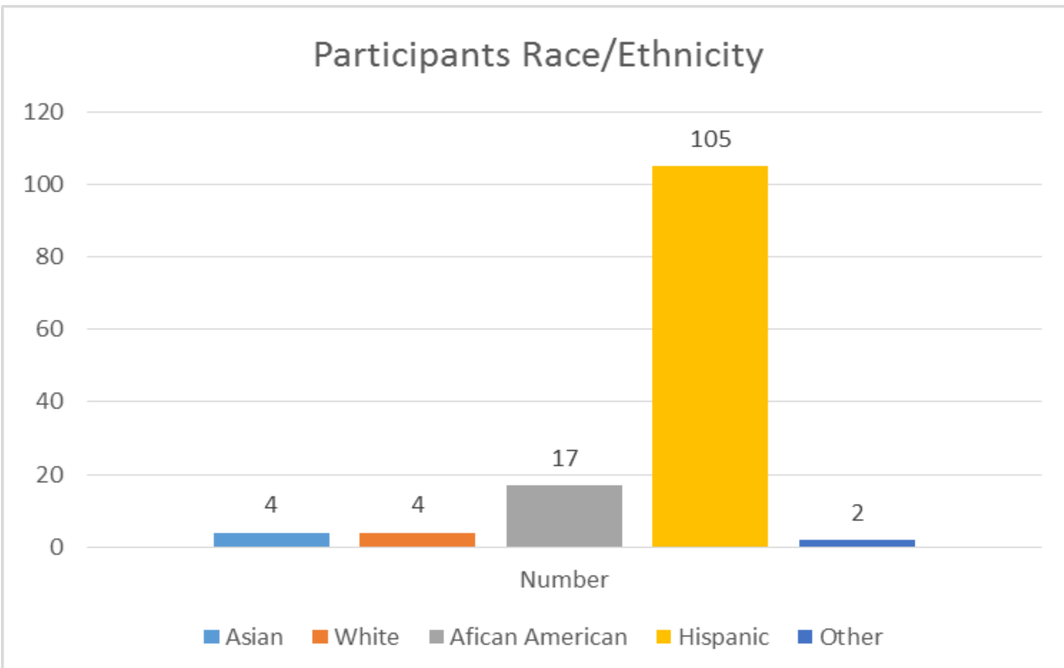

Figure 4.1. Participants Race/Ethnicity

All tutors and tutees were low achieving students. The reason for selecting students who struggle in mathematics was the expectation that their participation in the program could have a positive impact on their academic, emotional, and social development. Tutors were two grade levels above tutees. Each tutor was matched with a tutee to work with for the entire program. In the elementary school, tutors were in fifth grade and the tutees were in third grade. In middle school, tutors were in eighth-grade and tutees were in sixth-grade.

A total of six facilitators were hired by a nonprofit organization that provided the funds for the implementation of this cross-age tutoring program. These facilitators were in charge of the supervision of the implementation of the program, they provided training to tutors during weekly tutoring sessions and monitored the tutor-tutee sessions. All facilitators held a bachelor's degree. However, none of them had the Texas professional teaching certification in mathematics. All facilitators participated in a two-day workshop where the purpose and procedures of the peer-tutoring program were extensively explained, the curriculum was reviewed, and materials were provided.

Instruments

This study incorporated several forms of data collection. First, classroom observations were conducted to document classroom practices as well as facilitator and student behaviors during classroom instructional-learning settings. Second, field notes were created by researchers during and after the observations to describe relevant classroom practices, behaviors, attitudes, emotions, events, and activities observed during tutoring sessions. Finally, face-to-face teacher interviews were conducted to capture the teacher's perceptions about important features of the tutoring program.

The Overall Classroom Observation for the Tutor Preparation Session (OCOTPS). This instrument was designed to collect specific information about classroom behaviors and educational practices during the tutor preparation sessions in the following areas: (a) *knowledge and skills addressed in the lesson*, (b) *instructional strategies used by the teacher or facilitator*, (c) *teacher activities*, (d) *student activities*, (e) *classroom management and environment*, (f) *student engagement*, (g) *positive/negative relationships between the teacher and students*, (h) *student's accomplishment*, and (i) *reinforcement and feedback*. The instrument was completed after the training session.

The OCOTPS contains a 3-point scale to record the extent to which certain classroom behaviors, instructional strategies, and teacher-tutor or tutor-tutee interactions are evident during the tutor training sessions. The codes for this 3-point scale are 1 for not observed at all, 2 for observed in some extent, and 3 observed in great extent. The inter-rater reliability for the OCOTPS for this study was 77%. This percentage was calculated as the number of agreements divided by the total numbers of items in the observation instrument.

The Overall Classroom Observation for the Tutor-Tutee Session (OCOTTS). During the whole session, researchers use the OCOTTS to collect information about the following areas: (a) knowledge and skills covered in the lesson, (b) instructional strategies used by the tutor, (c) tutor math activities, (d) tutee math activities, (e) classroom management/environment, (f) positive/negative emotions of tutees toward their tutors, (g) tutee engagement, (h) existence of positive/negative relationships between tutors and tutees, (i) tutee accomplishments during the session, and (j) reinforcement and feedback provided by tutors.

Researchers use the OCOTTS at the end of the tutoring session. This instrument contains a 3-point scale that will help observers record the extent to which certain classroom behaviors, instructional strategies, and teacher-tutors or tutor-tutees interactions are evident during the lesson. The codes for this 3-point scale are 1 for not observed at all, 2 for observed in some extend, and 3 observed in great extent. The inter-rater reliability for the OCOTTS for this study was 79%. This percentage was calculated as the number of agreements divided by the total numbers of items in the observation instrument.

The two instruments described above were adapted to the characteristics of the tutoring program from previous research and classroom observations instruments (Alford, Rollins, Stillisano, & Waxman, 2013; Padrón, Waxman, Yuan-Hsuan, Meng-Fen, & Michko, 2012; Ross & Smith, 1996); Valle, et al., 2013).

Field notes. These documents were designed to provide researcher(s) with the opportunity to expand on the information recorded on the observation instruments, describe relevant behaviors or classroom procedures, explain how classroom activities addressed the students' academic deficits, and how the classroom environment influence social and emotional skills of students. In general, researchers used field notes to describe the teachers/facilitators and students behaviors and attitudes, activities that students are working on, the materials being used, the physical setting of the classroom, patterns of teacher-students interactions, verbal and non-verbal communication, and classroom environment.

Field notes contained the two following questions: (a) *How do the activities address the student's academic deficits and improve achievement in math?* (b) *How do the activities build the social and emotional skills of students?* Researchers answered the two questions and add any other comment about what their ideas, impressions, and thoughts about the tutoring sessions.

In addition, *Field Notes* prompted observers to write about the following features observed within the tutoring sessions: (a) *Describe the teachers/volunteers/facilitators/tutors and their roles,* (b) *Describe the tutees' behaviors and attitudes,* (c) *Physical setting,* (d) *Social environment,* (e) *Description of activity,* and (f) *Reflections.* Besides writing notes related to the above topics, researchers recorded any relevant thought about the facilitator-tutor-tutee interactions.

Facilitator interviews. Researchers conducted face-to-face interviews at the end of the tutoring program. The purpose of the interviews was to gather information of facilitator's perceptions about the following characteristics of the program: (a) strengths and challenges of the tutoring program, (b) improvements in students' achievement, leadership skills, enjoyment of learning mathematics, academic self-efficacy, and believes about the usefulness of mathematics, (c) how the his/her participation in the program impacted their lives, and (d) what they learned about education as a result of their participation in the program.

Procedures

Figure 4.2 shows the duration of the peer- tutoring program in weeks. On average the length of the tutoring program was 26 weeks. The elementary school offered the peer-tutoring instruction during 27 weeks. The program in the three middle schools lasted 27, 26, and 22 weeks respectively.

Classroom observations of tutor training were conducted at the beginning, middle and end of the peer-tutoring program. There was a total of 14 classroom observations conducted by trained researchers in both the elementary and middle schools that offered the peer-tutoring program. Each tutor training session lasted approximately 45 to 60 minutes. The researchers observed classroom practices and behaviors using the two observations instruments described above.

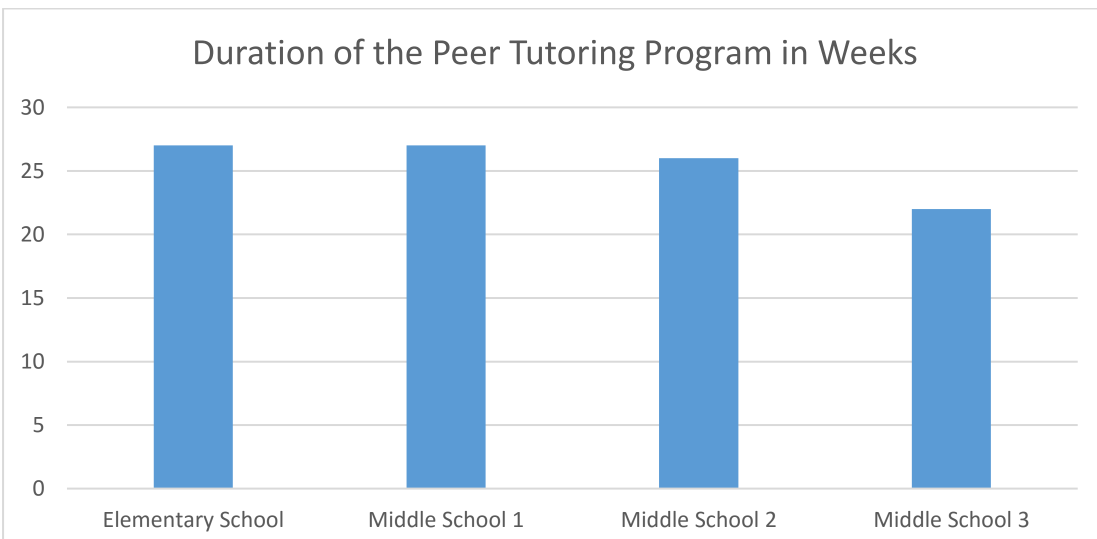

Figure 4.2. Duration of the Peer Tutoring Program in Weeks

Selection of tutors and tutees. Mathematics teachers were in charge of selecting tutors and tutees using the following criteria: (a) they selected fifth grade underachievers as tutors of third grade underachievers in elementary school, (b) they selected eighth grade underachievers as tutors of sixth grade underachievers in middle school, (c) teachers nominated students categorized as “bubble”, which meant that they were no more than one year behind their peers (in general, “bubble” students are expected to improve their mathematics skills and reach grade level proficiency in mathematics through intervention programs), and (d) teachers nominated underachieving students only when they believed that the student had the potential to improve his/her academic outcomes with additional help.

Teachers, administrators, and facilitators training. Teachers and administrators from the schools that have decided to implement the tutoring program were invited to participate in this training as well as facilitators who work for the non-profit organization that is sponsoring the program, and independent researchers who were in charge of conducting the evaluation of this initiative. The training was developed and conducted by Learning Together (2014), a private company offering educational interventions for below-level learners. This training was provided during two full days, or sixteen hours before the implementation of the program.

During the training, instructors explained the purpose and procedures of the cross-age peer-tutoring program as well as the content of the curriculum. The training also included a comprehensive review of several mathematics lessons. Participants were asked to play the role of tutors and tutees to create the environment of real cross-age tutoring sessions. In addition, participants had the opportunity to watch short videos from previous reading tutoring programs. The videos portrayed numerous positive experiences of principals, teachers, coordinators, and students who have participated in previous peer-tutoring programs. Notably, in these videos students who have served as tutors expressed feelings of fulfillment and personal satisfaction while discussing how they helped their tutees.

The majority of the training was devoted to a comprehensive review of the curriculum developed for this program. Participants received a package that contained a detailed curriculum, a tutor guidebook, tutee activity book, whiteboard, tutor journal, math manipulative materials, markers, color pencils, calculator, and other materials needed for the tutoring sessions. The content of the *Tutor Guidebook* and *Tutee Activity Book* was deeply and thoroughly explained by an expert instructor and examined by all participants. The lessons were scripted to facilitate tutor's instruction. After whole group discussions, participants worked in pairs to play the role of tutors and tutees while they reviewed every step in the lessons contained in the curriculum.

Features of the Tutoring Program

This program was designed to provide one-to-one peer-tutoring instruction to underachieving students in mathematics. The purpose of the program was to integrate mathematics with other content areas, teach students fundamental mathematics skills, promote critical thinking skills, and foster problem-solving abilities in one-on-one environments (Learning Together, 2014). The goals of this program were aimed at enhancing students' academic achievement, social, and motivational factors, including self-confidence in mathematics, social relationships, intrinsic motivation, critical thinking, analytic skills, career readiness, and study skills conducive to lifelong success (Learning Together, 2014).

One of the major goals of this program was to integrate mathematics with other content areas. For example, after reading passages about U.S. history, students extracted information from the reading to solve problems (Learning Together, 2014). Research supports content area integration since it helps students make connections between mathematics ideas and concepts to real life situations, promotes critical thinking, improves analytical skills, enhances motivation, and helps students find meaning and purpose in mathematical ideas and concepts included in the lesson (Kinniburgh & Byrd, 2008). Lim and Chapman (2015) examined the effects of using history as a tool to teach mathematics and found that this strategy had a significant positive effect on students' achievement and extrinsic motivation. Their findings suggest positive benefits of the integration of mathematics with other content areas.

The current cross-age tutoring program also proposed the creation of a low-anxiety classroom environment conducive for learning (Learning Together, 2014). Classroom environments that minimize the level of math anxiety enhance students' comprehension of the content being taught and improve academic achievement. Some researchers, for example, found that low anxiety settings may improve the learning process of young children (McQuarrie, Siegel, Perry, & Weinberg, 2014). Peer tutoring helps build a classroom environment where students display appropriate behaviors, enhance positive social interactions with their peers, improve social skills, and increase academic engagement (Bowman-Perrot, et al., 2014).

In summary, the objectives of the program were the following: (a) to integrate mathematics with other content areas, (b) to teach students fundamental mathematical skills, (c) to enhance critical thinking skills, (d) to improve problem-solving ability, (e) to develop academic language, (f) to increase students' self-confidence as mathematics learners, (g) to enhance students motivation, and (f) to encourage students to investigate math conjectures (Learning Together, 2015).

Furthermore, the program design included the implementation of instructional strategies that could help students improve understanding, explore concepts, and construct meaning. The strategies proposed for this program were the following: (a) use of manipulative materials, (b) visual representations, (c) use of calculators, and (d) the problem-solving heuristic model (SOLVE), which guides students through five steps to solve a problem.

The mnemonic strategy SOLVE stands for <u>S</u>tudy the problem, <u>O</u>rganize the facts, <u>L</u>ine up plan, <u>V</u>erify, and <u>E</u>xamine the answer (Freeman-Green, O'Brien, Wood, & Hitt, 2015; National Training Network [NTN], 2016). This strategy can help low-achieving students to remember the logic steps to solve word problems. When students use the SOLVE strategy, they use the following procedure: (a) Study the problem – students read the problem, review the information, and underline the question they need to answer, (b) Organize the facts – students eliminate unnecessary facts and list only the necessary facts, (c) Line up a plan – they select the operation(s) they need to use, and (d) Verify – students carry out the plan and find the answer to the problem, and (e) Examine the answer – students ask if the answer is accurate and makes sense.

A complete description of the SOLVE strategy can be found in the National Training Network website, http://www.ntnmath.com/video%20index/SOLVE/SOLVE.html.

The NTN is a professional development company specializing in training to mathematics teachers. This website contains a series of lessons that explain how students can learn and practice the five steps of the SOLVE strategy. They use world problems to model how mathematics teachers could deliver the lesson to students. The videos included in this website provide examples for each step of the SOLVE strategy.

Peer-tutoring Curriculum

The curriculum was designed by Learning Together. It was aligned to Common Core State Standards that define the knowledge and skills students should achieve in mathematics (Learning Together, 2014). The peer-tutoring curriculum included instruction targeted to enhance students' abilities in the following standards: (a) number and operations, (b) algebra, (c) measurement, (d) geometry, and (e) data analysis and probability. These standards were outlined and recommended by the NCTM (2000) to ensure excellence in instructions provided in K-12 mathematics classrooms.

The program included 30 regular lessons, 4 optional review lessons, four quizzes, one pre-test and one post- test. Each lesson had eight basic components: (a) warm-up activities designed to motivate students and prepare them for the new math lesson, (b) activating prior knowledge, (c) exploring and practicing math facts, (d) modeling, (e) shared reading, (f) problem-solving, (g) journal writing, and (h) debriefing (Learning Together, 2015). Each lesson lasted approximately 60 minutes.

Tutor Training

Tutors were trained by facilitators in weekly sessions of 45 to 60 minutes that took place before tutors provided instruction to tutees. During this training sessions, facilitators explained how to deliver the mathematics lessons, reviewed materials, and instructional strategies. Tutors were instructed to follow these steps when teaching each lesson to their tutees: (a) start with some warm-up activity, (b) review math concepts, (c) read a story, (d) solve problems, and (e) write a reflection about the lesson.

Facilitators explained the content of lessons and the sequence in which the lesson should be delivered. Tutors followed the explanations in his/her individual *Tutor Guidebook* that contained the scripted lessons for each session. Facilitators also modeled peer-tutoring procedures for the students. After each training session, tutors met with tutees and delivered the lesson that they reviewed with facilitators.

Results

Results are presented in four sections. The first section reports the results of classroom observations during tutor training sessions. The second part presents the findings of classroom observations in one-to-one dyads tutoring instruction. The third section includes findings from the field notes related to classroom observations. The last section describes the results of the face-to-face facilitator interviews.

Results of the Tutor Training Sessions

This section reports the results of the overall classroom observations during the tutoring training sessions. At the end of each observation period, the observers recorded classroom behaviors on a three-point scale (1 for not observed at all, 2 for observed in some extend, and 3 observed in great extent). The mean values calculated for each section ranged from 1 to 3 with a mean value of 3 indicates that the instructional strategy or behavior was observed most of the time, whereas a mean value of 1 indicates that the instructional strategy or behavior was not observed at all.

Table 4.1

Overall Classroom Observations for the Tutor Preparation Session: *Knowledge and Skills*

Instruction	*M*	*SD*
Number and operations	2.50	0.67
Algebra	1.17	0.39
Geometry	1.17	0.58
Measurement	1.08	0.29
Data analysis and probability	1.00	0.00

Note. 1 = not observed at all, 2 = observed to some extent, and 3 = observed in great extent

Table 4.1 and Figure 4.3 show the content standards observed during tutor training instruction. Table 4.1 displays the overall descriptive statistics for the mathematics knowledge and skills that facilitators addressed during the tutor training sessions. The results indicate that facilitators emphasized the development of *number and operations* of tutors (*M* = 2.5, *SD* = 0.67). In contrast, they neglected to develop other important national standards for school mathematics, such *algebra* (*M* = 1.17, *SD*

= 0.39), *geometry* (*M* = 1.17, *SD* = 0.58), *measurement* (*M* = 1.08, *SD* = 0.29). The means are very close to one, suggesting that instruction for these standards was rarely provided. Finally, Table 4.1 shows a mean of 1.0 for *data analysis and probability*, which means that instruction related to this standard was never evident during classroom observations.

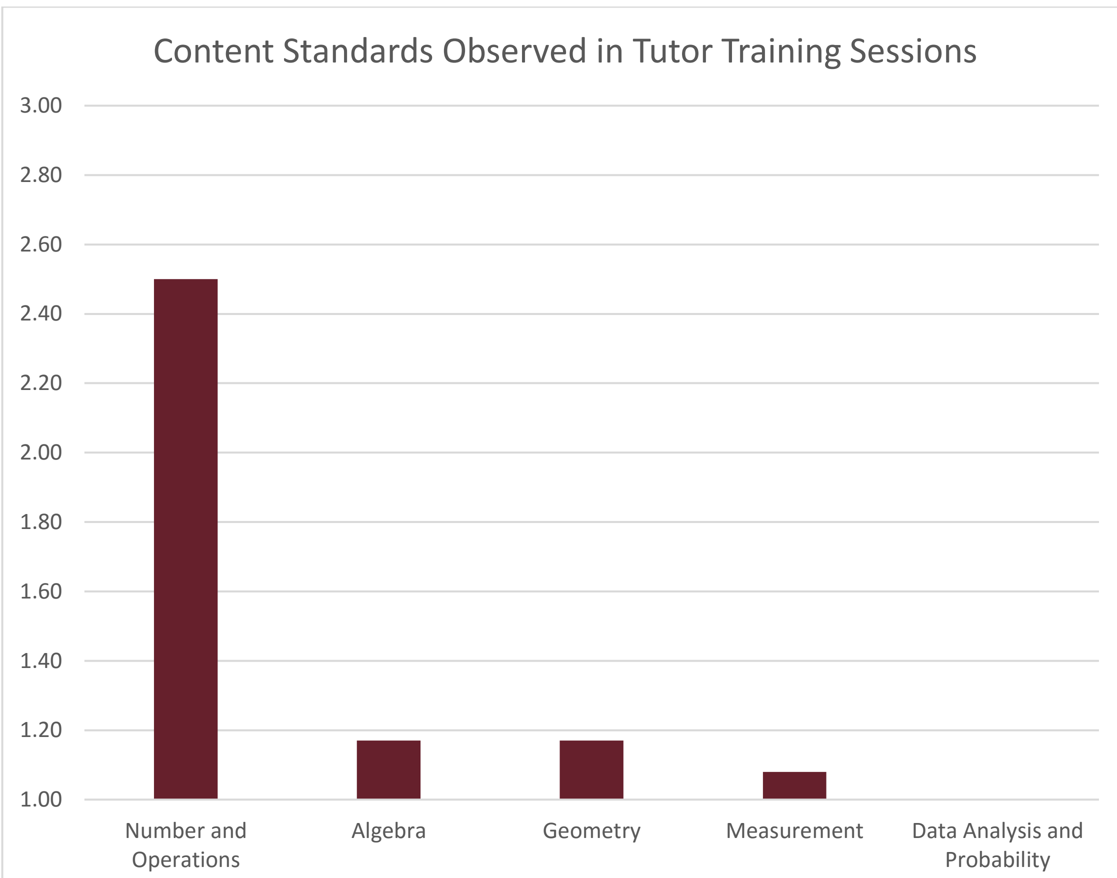

Figure 4.3: Content Standards Observed During Tutor Training

Table 4.2 and Figure 4.4 contain the instructional strategies observed during tutor training sessions. The strategies most frequently used were: a*sking questions to monitor comprehension* (*M* = 2.25, *SD* = 0.45), *modeling how to analyze information and solve problems* (*M* = 2.08, *SD* = 0.67), *providing timely feedback* (*M* = 2.08, *SD* = 0.67), *providing ample waiting time for student responses* (*M* = 1.83, *SD* = 1.58), and *relating math to real-world experiences* (*M*= 1.83, *SD* = 0.39). Instructional strategies seldom used included: *helping students build connections between mathematical ideas and visual representations* (*M* = 1.58, *SD* = 0.67), *encouraging students to think critically and creatively to solve problems* (*M* = 1.50, *SD* = 0.52), *motivating students to solve problems in more than one way* (*M* = 1.42, *SD* = 0.67), *assisting students to connect mathematical ideas with content areas* (*M* = 1.17, *SD* = 1.39), and *using manipulatives to help students understand mathematical ideas and concepts* (*M* = 1.08; *SD* = 0.29).

Table 4.2

Overall Classroom Observations for the Tutor Preparation Session: *Instructional Strategies*

Instructional Strategies	*M*	*SD*
Activating prior knowledge	1.75	0.45
Relating math to real-world experiences	1.83	0.39
Helping students build connections between mathematical ideas and visual representations	1.58	0.67
Assisting students to connect mathematical ideas with content areas	1.17	0.39
Modeling how to analyze information and solve problems	2.08	0.67
Asking questions to monitor comprehension	2.25	0.45
Providing ample waiting time for student responses	1.83	0.58
Providing timely feedback	2.08	0.67
Using manipulatives to help students understand mathematical ideas and concepts	1.08	0.29
Promoting academic language development	1.67	0.65
Motivating students to solve problems in more than one way	1.42	0.67
Encouraging students to think critically and creatively to solve problems	1.50	0.52
Encouraging students to think aloud when solving problems and have students give oral explanations of his/her thinking	1.42	0.51
Emphasizing calculator use	1.67	0.78

Note. 1 = not observed at all, 2 = observed to some extent, and 3 = observed in great extent

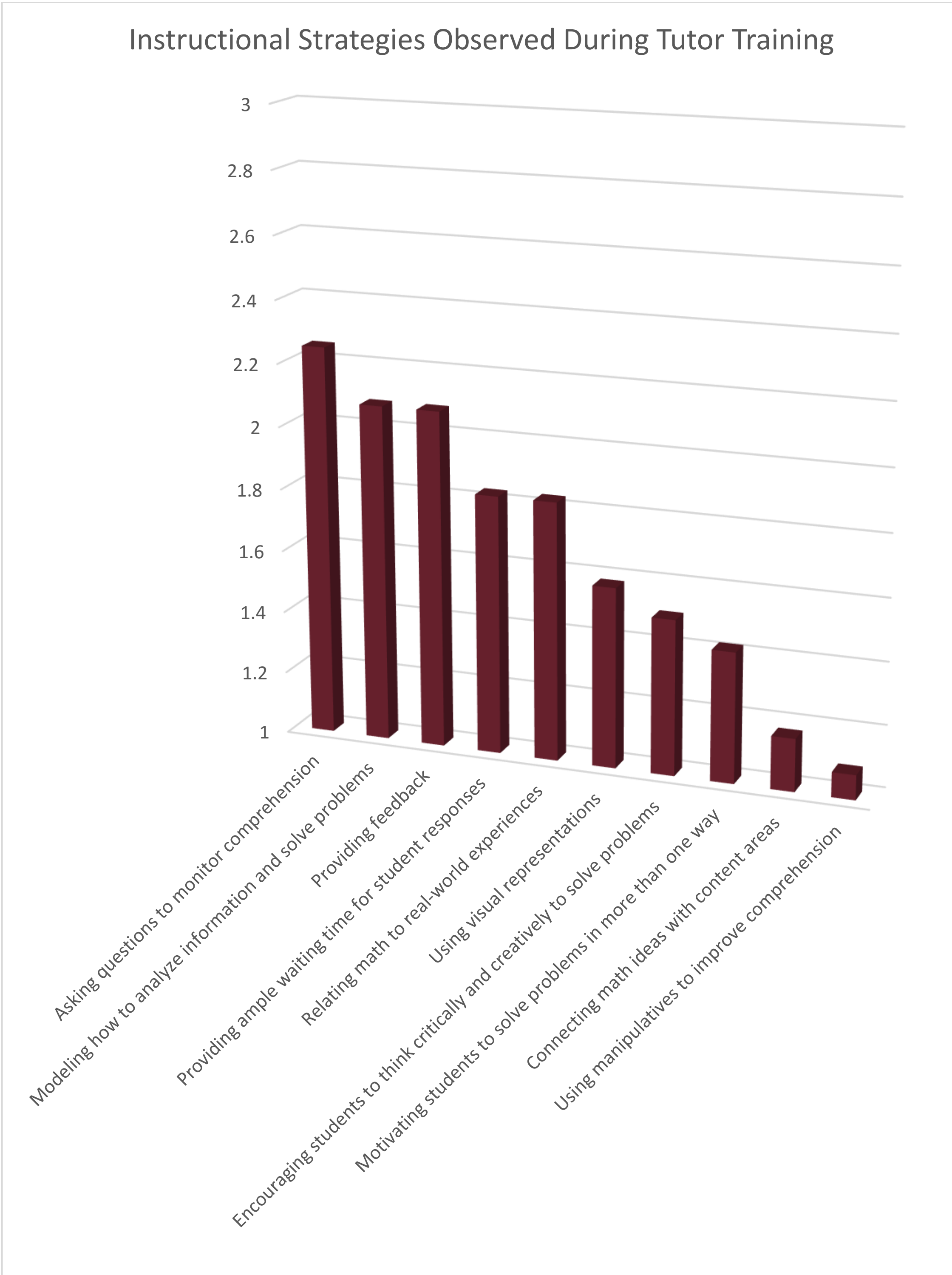

Figure 4.4: Instructional Strategies Observed During Tutor Training

Table 4.3

Overall Classroom Observations for the Tutor Preparation Session: *Student Activities*

Students Activities	*M*	*SD*
Connecting what they already knew to new ideas	1.46	0.52
Relating math to real-world experiences	1.46	0.52
Building connections between mathematical ideas and visual representations	1.46	0.66
Connecting mathematical ideas with other content areas	1.15	0.38
Asking clarification questions	1.46	0.52
Answering questions from teacher	2.08	0.64
Using visual as a tool to represent mathematical ideas and solve problems	1.77	0.60
Using manipulatives materials to make connections between concrete and abstract ideas	1.15	0.38
Exploring several ways to solve a problem	1.23	0.44
Communicating his/her thinking orally while solving problems and gave oral explanations of his/her thinking	1.54	0.52
Engaging in listening to the teacher	2.15	0.55
Asked for clarification of unfamiliar words during math activities or problem solving	1.15	0.38
Using calculator as a tool to solve problems	1.00	0.00
Reading aloud	2.00	0.71

Note. 1 = not observed at all, 2 = observed to some extent, and 3 = observed in great extent

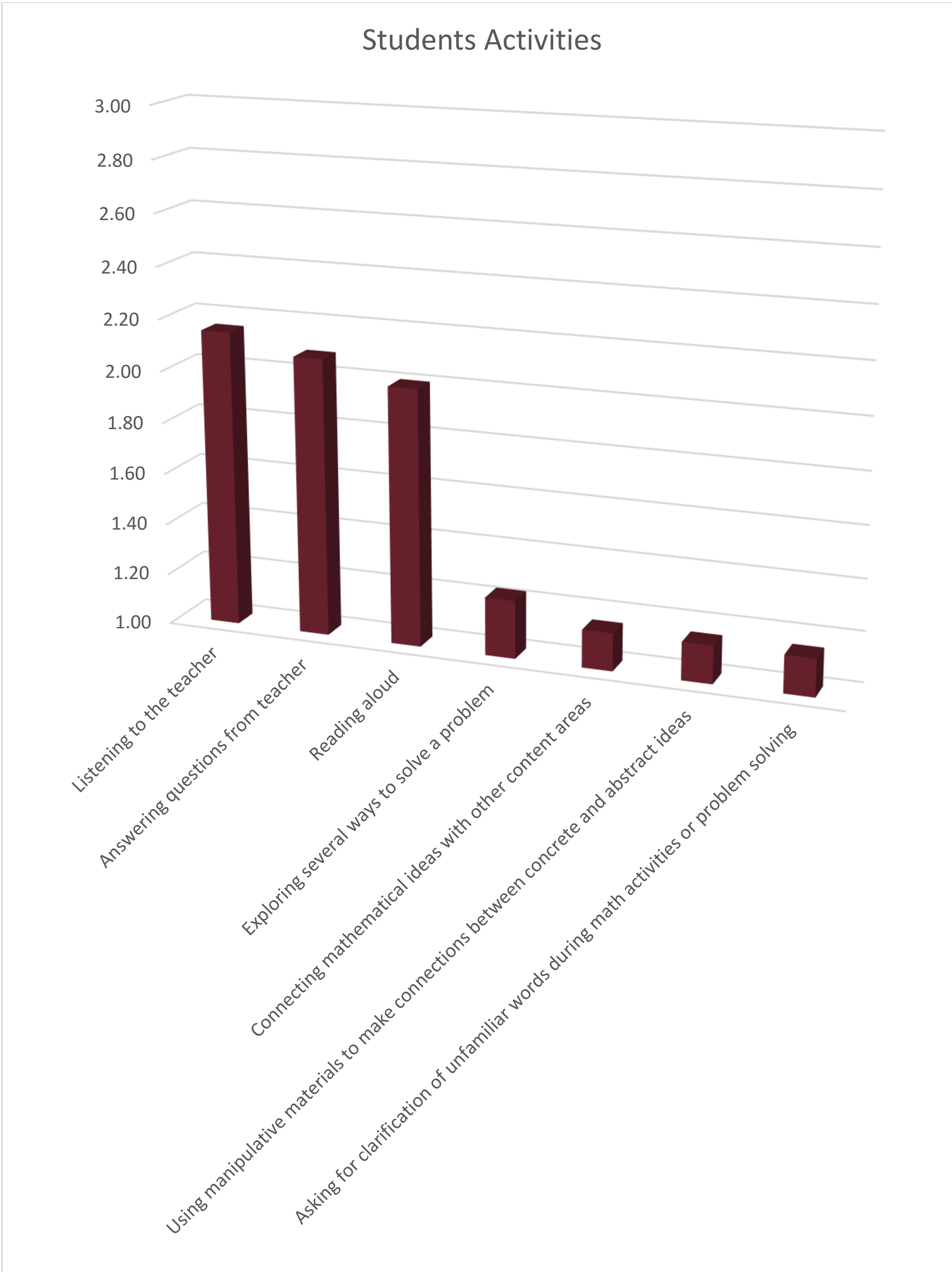

Figure 4.5: Students Activities Observed During Tutor Training

Table 4.3 and figure 4.5 show that the most frequently observed student activities were *answering questions from the teacher* (*M* = 2.08, *SD* = 0.64), *listening to the teacher* (*M* = 2.15, *SD* = 0.55), and *reading aloud* (*M* = 2.0, *SD* = 0.71). The least frequent student behaviors were *connecting mathematical ideas with other content areas* (*M* = 1.15, *SD* = 0.38), *using manipulative materials to make connections between concrete and abstract ideas* (*M* = 1.15, *SD* = 0.38), *asking for clarification of unfamiliar words during math activities or problem solving* (*M* = 1.15, *SD* = 0.38), and *exploring several ways to solve a problem* (*M* = 1.23, *SD* = 0.44). It is interesting to note that students were not observed using calculators to solve problems, even though calculators were part of the tool box that they received at the beginning of the tutoring program and the use of calculators was one of the objectives proposed by the program.

Table 4.4 informs that in terms of classroom management and environment teachers had *materials and/or manipulative available* (*M* = 2.23, *SD* = 0.60), *activities started on time* (M = 2.38, SD = 0.87), and *transitions were quick and efficient* (*M* = 2.38, *SD* = 0.65). Comparing the results in Tables 4.2, 4.3, and 4.4 we can see that even though manipulative materials were frequently available, teachers and students rarely used them during classroom activities.

Table 4.4

Overall Classroom Observations for the Tutor Preparation Session: *Classroom Management*

Classroom management/environment	*M*	*SD*
Materials and/or manipulatives were available	2.23	0.60
Activities started on time	2.38	0.87
Transitions were quick and efficient	2.38	0.65

Note. 1 = not observed at all, 2 = observed to some extent, and 3 = observed in great extent

Table 4.5

Overall Classroom Observations for the Tutor Preparation Session: *Positive Emotions and Relationships*

Positive Emotions and Relationships	*M*	*SD*
Students displayed positive affect toward the teacher	2.23	0.44
Students appeared to be happy in the class	2.15	0.55
Students appeared to enjoy being in this class	2.15	0.55
Teacher enjoyed teaching this class	2.31	0.48
Teacher appeared to have warm, supportive relationships with students	2.15	0.38

Note. 1 = not observed at all, 2 = observed to some extent, and 3 = observed in great extent

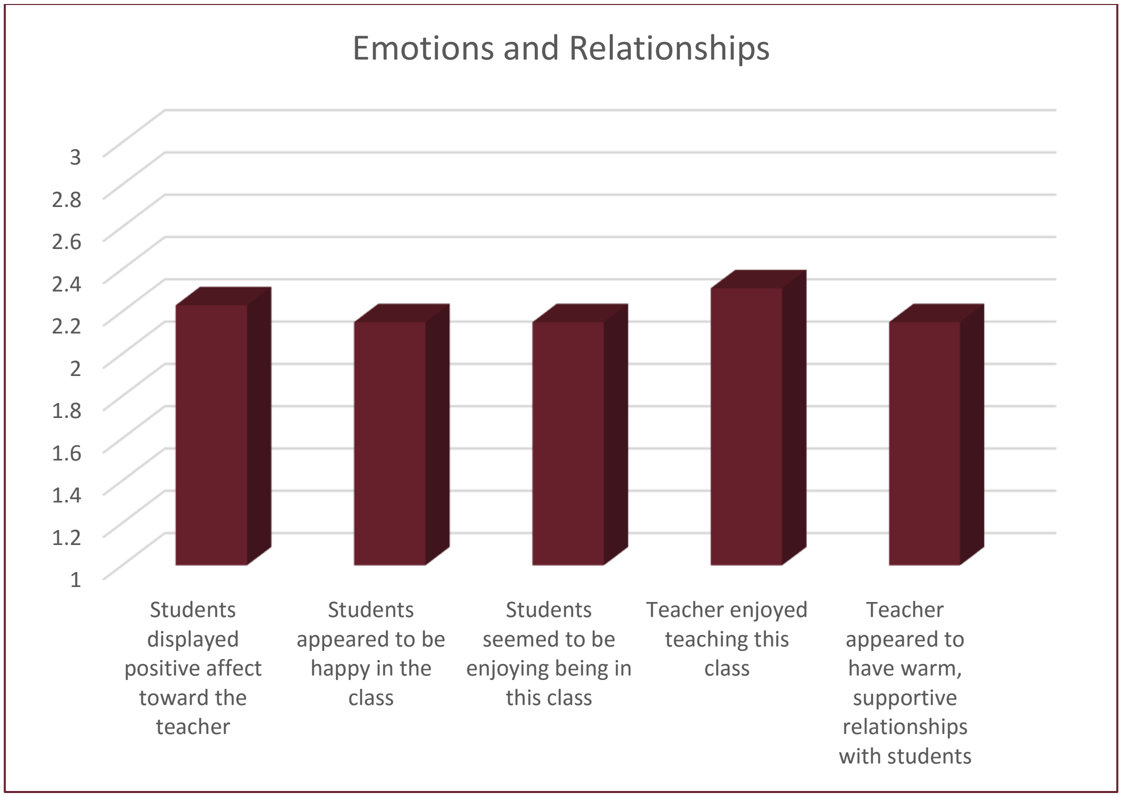

Figure 4.6. Emotions and Relationships Observed During Tutor Training

Results in Figure 4.6 and Table 4.5 suggest that a positive learning environment was created during the tutor training sessions. The following behaviors were frequently observed: *students displayed positive affect toward their teachers* (*M* = 2.23, *SD* = 0.44), *teacher enjoyed teaching in this class* (*M* = 2.31, *SD* = 0.48), *students appeared to be happy in this class* (*M* = 2.15, *SD* = 0.55), *students appeared to enjoy being in the class* (*M* = 2.15, *SD* = 0.55), *teachers appeared to have warm, supportive relationships with tutors* (*M* = 2.15, *SD* = 0.38).

Table 4.6

Overall Classroom Observation for the Tutor Preparation Session: *Engagement and Meaning*

Engagement and Meaning	*M*	*SD*
Students were engaged in math activities	2.15	0.55
Students were eager to answer questions	1.62	0.65
Students were absorbed by exploring math ideas and searching for multiple paths to solve problems	1.08	0.28
Students concentrated on activities	1.69	0.63
Students enjoyed solving problems	1.54	0.52
Teacher related concepts to student's lives	1.46	0.52

Note. 1 = not observed at all, 2 = observed to some extent, and 3 = observed in great extent.

Results for *Engagement* and *Meaning* displayed in Figure 4.7 and Table 4.6 indicate that *students were engaged in math activities* (*M* = 2.15, *SD* = 0.55); however, they rarely *were absorbed by exploring math ideas and searching for multiple paths to solve problem*s (*M* = 1.08, *SD* = 0.28). There is little evidence that *teacher related concepts to student's lives* (*M* = 1.46, *SD* = 0.52), students *enjoyed solving problems* (*M* = 1.54, *SD* = 0.52), *were eager to answer questions* (*M* = 1.62; *SD* = 0.65), *or concentrated on activities* (*M* = 1.69, *SD* = 0.63).

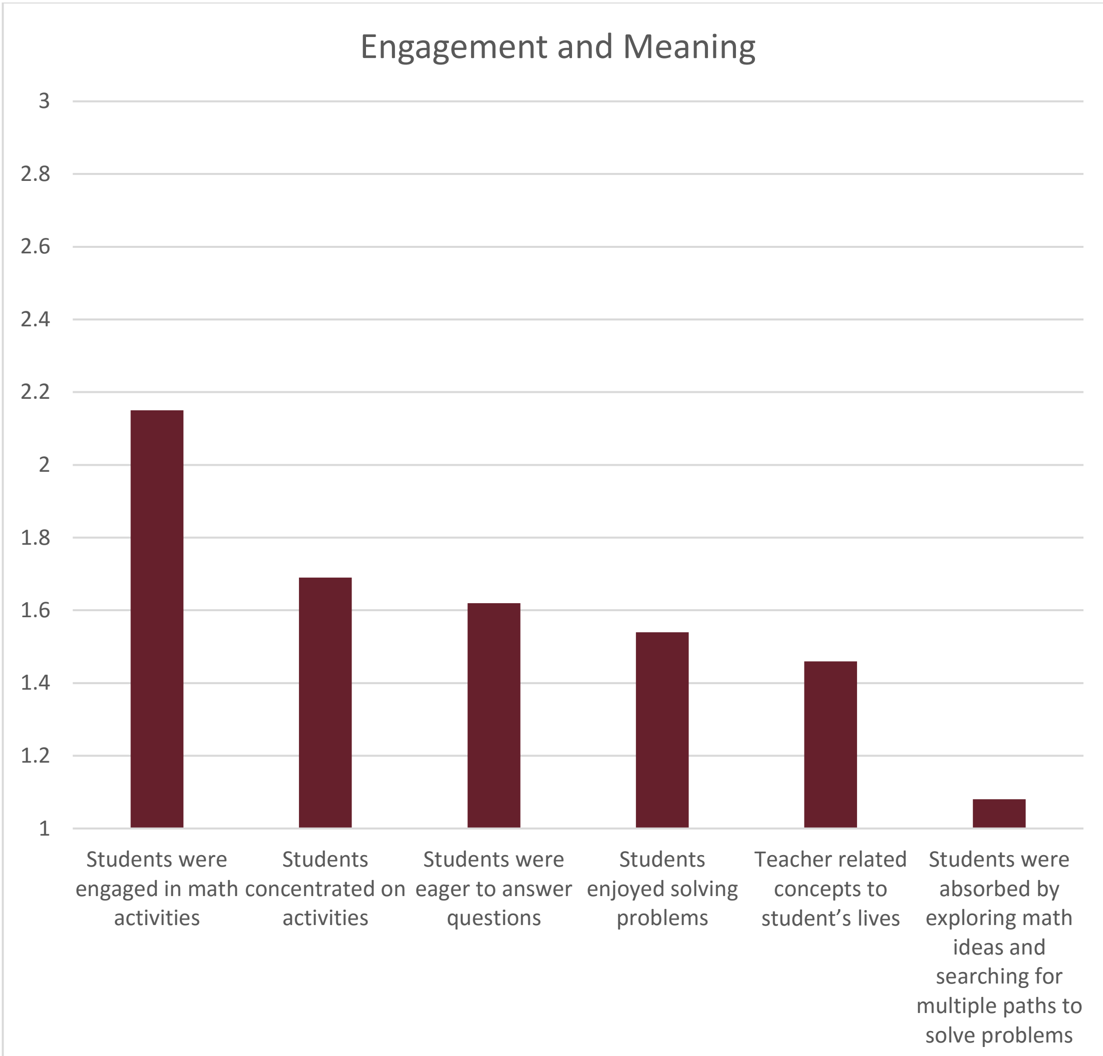

Figure 4.7. Engagement and Meaning Observed During Tutor Training

Table 4.7

Overall Classroom Observations for the Tutor Preparation Session: *Accomplishment and Growth-Mindset*

Accomplishment and Growth-Mind Set	*M*	*SD*
Students initiated and assumed responsibility for learning activities	1.31	0.63
Teacher provided opportunities for students to be creative and/or generate his/her own ideas and/or products	1.15	0.38
Teacher provided opportunities for the student to assume responsibility in activities	1.62	0.51
Students focused on accomplishing the assigned work	1.77	0.83
Teacher provided feedback to student that he/she is smart.	1.00	0.00
Teacher let student know that he/she had worked hard	1.54	0.66
Teacher encouraged students to keep trying to answer questions and solve problems	1.54	0.66
Teacher encouraged students' persistence on learning activities	1.38	0.51

Note. 1 = not observed at all, 2 = observed to some extent, and 3 = observed in great extent

The results of accomplishment and growth-mindset displayed in Table 4.7 and Figure 4.8 indicate that students *focused on accomplishing the assigned work* in some extent (*M* = 1.77, *SD* = 0.83). Furthermore, the following teacher and students behaviors suggest that accomplishment and growth-mindset during tutor training were rarely evident during tutor training sessions: *teacher provided opportunities for the student to* *assume responsibility in activities* (*M* = 1.62, *SD* = 0.61), *students initiated and assumed responsibility for learning activities* (*M*= 1.31, *SD* = 0.51), *teacher provided opportunities for students to be creative and/or generate his/her own ideas and/or products* (*M*= 1.15, *SD* = 0.38).

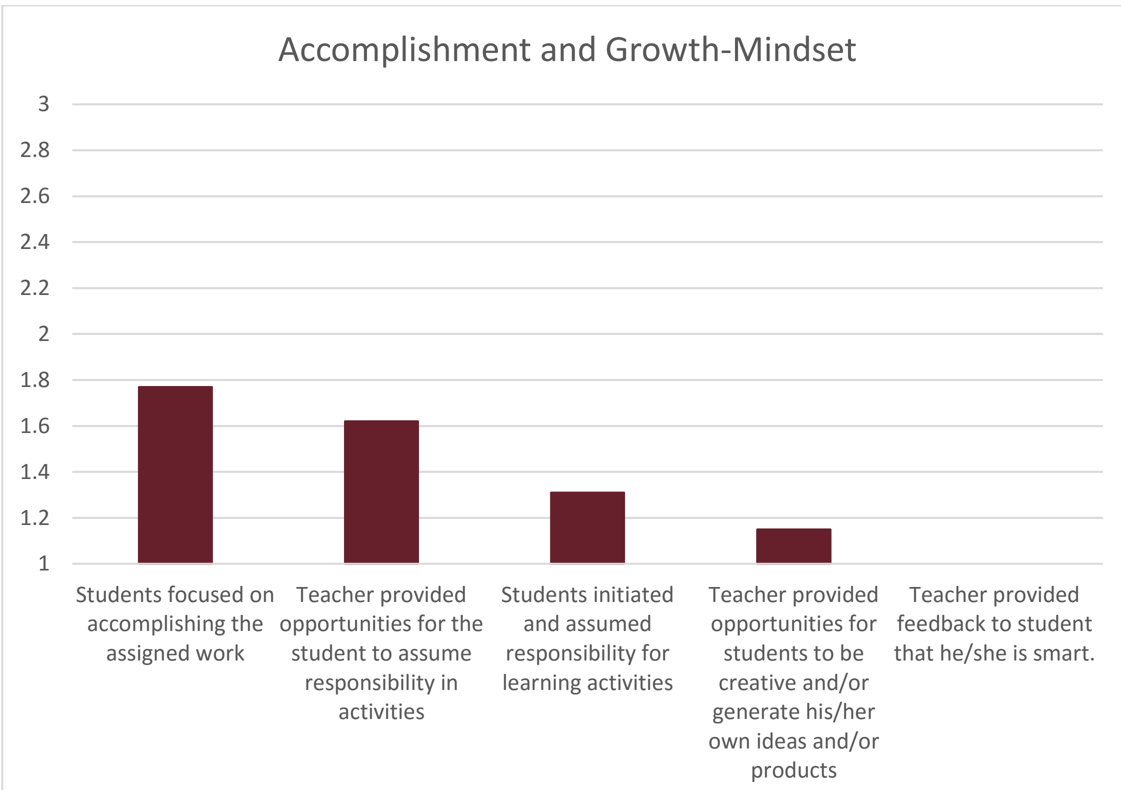

Figure 4.8. Tutor Training Accomplishment and Growth-Mindset

Results of the Tutor-Tutee Sessions Observations

This section reports the results of the overall classroom observations during the tutor-tutee sessions**.** The mean values for each scale range from 1 to 3. A mean scale close to the value of 3 indicates that a behavior or interaction was observed to a great extent, a mean value of 2 indicates that it was observed to some extent, and a mean score of 1 indicates that a behavior or interaction was not observed at all.

The content standards covered during instruction provided by tutors during tutoring interventions are shown in Table 4.8 and Figure 4.9. Tutors focused on number and operations. Instruction on geometry and measurement was rarely observed. Instruction related to algebra and data analysis and probability was never observed. The focus on number and operations in tutor-tutee session followed the same pattern as the one observed during tutor training sessions.

Table 4.8

Overall Classroom Observations for the Tutor-Tutee Session: *Content Standards Included in Instruction*

Instruction	*M*	*SD*
Number and operation	2.50	0.67
Algebra	1.00	0.00
Geometry	1.17	0.58
Measurement	1.17	0.59
Data analysis and probability	1.00	0.00

Note. 1 = not observed at all, 2 = observed in some extend, and 3= observed in great extent

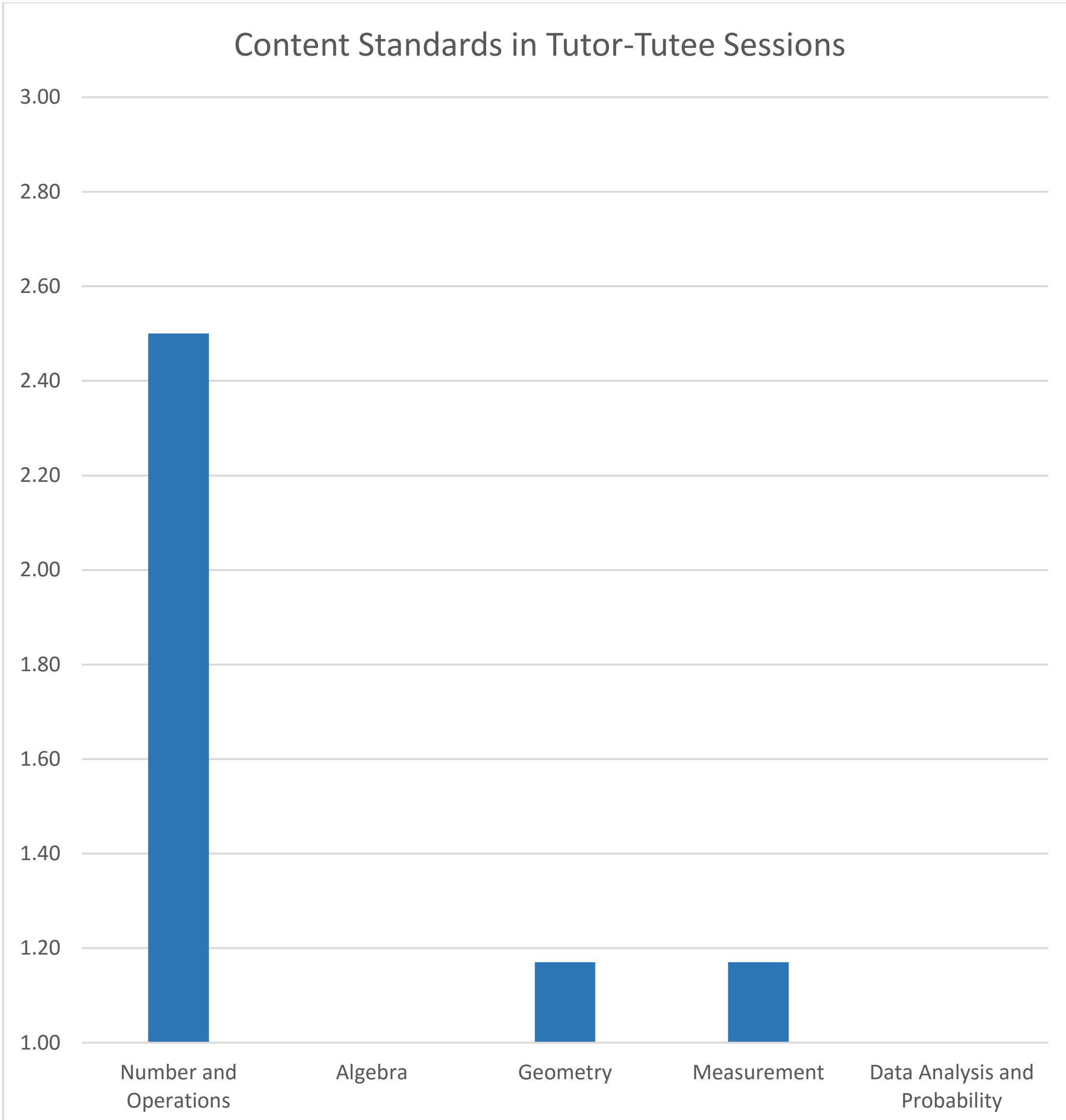

Figure 4.9: Content Standards Observed During Tutor-Tutee Sessions

Table 4.9

Overall Classroom Observations for the Tutor-Tutee Session: *Instructional Strategies used by Tutors*

Instructional Strategies	*M*	*SD*
Peer tutoring	2.83	0.67
Activating prior knowledge	1.00	0.00
Relating math to real-world experiences	1.25	0.62
Helping tutee build connections between mathematical ideas and visual representations	1.33	0.65
Assisting students to connect mathematical ideas with content areas	1.08	0.29
Modeling how to analyze information and solve problems	1.67	0.49
Asking literal questions	1.75	0.45
Encouraging tutee to talk or respond	1.75	0.45
Providing timely feedback	1.42	0.67
Using manipulatives to help tutees to understand mathematical ideas and concepts	1.08	0.29
Using visual materials to explore concepts and construct meaning	1.25	0.62
Promoting academic language development	1.00	0.00
Clarifying unfamiliar words during math activities	1.00	0.00
Modeling how to make connections from reading to math	1.08	0.29
Encouraging tutees to think aloud when solving problems and have tutees give oral explanations of his/her thinking	1.25	0.45
Emphasizing calculator use	1.00	0.00

Note. 1 = not observed at all, 2 = observed in some extend, and 3= observed in great extent

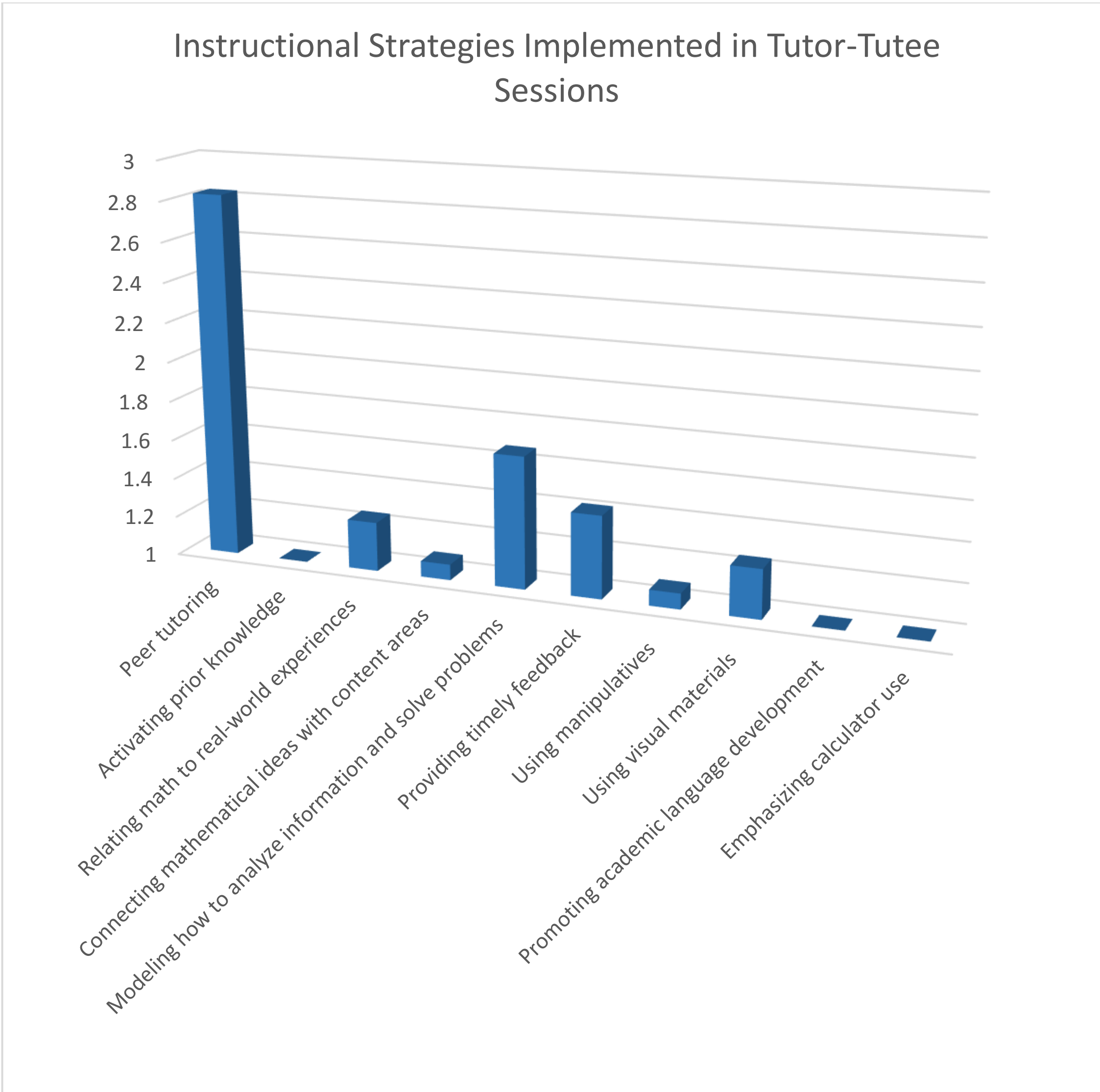

Figure 4.10. Instructional Strategies Used in Tutor-Tutee Sessions

Table 4.9 and Figure 4.10 shows that the instructional strategy most frequently used during tutor-tutee sessions was *peer tutoring* (M = 2.83, SD = 0.67). This result was expected because of the focus of this intervention program. The majority of instructional strategies that could have helped minority students to succeed in mathematics were rarely used, such us: *relating mathematics with real-world experiences* (M = 1.25, SD = 0.62), *helping tutee build connections between mathematical ideas and visual representations* (M = 1.33, SD = 0.65), *providing timely feedback* (M = 1.42, SD = 0.67), *using manipulatives to help tutees to understand mathematical ideas and concepts* (M = 1.08, SD = 0.29), *assisting tutee to connect mathematical ideas with content areas* (M = 1.08, SD = 0.29). Furthermore, some instructional strategies including in the initial plan of the program were never observed such as *promoting academic language development, clarifying unfamiliar words during math activities, and using calculators.*

The results of classroom observations of the tutee activities are shown in Table 4.10 and Figure 4.11. Tutee activities more frequently observed were: *listening to the tutor*, *responding orally or discussing,* and *answering questions from tutor.* Tutee activities seldom observed included *relating math to real-world experiences, building connections between mathematical ideas and visual representations, connecting mathematical ideas with other content areas, using manipulative materials to make connections between concrete and abstract ideas, using visuals as a tool to represent mathematical ideas and solve problems, communicating his/her thinking orally while solving problems and gave oral explanations of his/her thinking, and making connections from reading to math activities.* Moreover, observers never saw tutees *connecting what they already knew to new ideas, exploring several ways to solve a problem, asking clarification of unfamiliar words during math activities,* and *using calculators as tools to solve problems.*

Table 4.10 *Overall Classroom Observations for the Tutor-Tutee Session*: *Tutee Activities*

Instructional Strategies	*M*	*SD*
Responding orally or discussing	2.00	0.00
Listening to tutors	2.58	0.51
Connecting what the student already knew to new ideas	1.00	0.00
Relating math to real-world experiences	1.17	0.39
Building connections between mathematical ideas and visual representations	1.25	0.62
Connecting mathematical ideas with other content areas	1.17	0.39
Modeling how to analyze information and solve problems	1.67	0.49
Asking clarification questions	1.58	0.51
Answered questions from tutor	1.92	0.29
Using manipulative materials to make connections between concrete and abstract ideas	1.08	0.29
Using visuals as a tool to represent mathematical ideas and solve problems	1.50	0.67
Exploring several ways to solve a problem	1.00	0.00
Communicating his/her thinking orally while solving problems and gave oral explanations of his/her thinking	1.25	0.45
Asking clarification of unfamiliar words during math activities and problem solving	1.00	0.00
Engaging in writing activities	1.50	0.52
Using calculator as a tool to solve problems	1.00	0.00
Making connections from reading to math activities	1.17	0.39

Note. 1 = not observed at all, 2 = observed in some extend, and 3 = observed in great extent

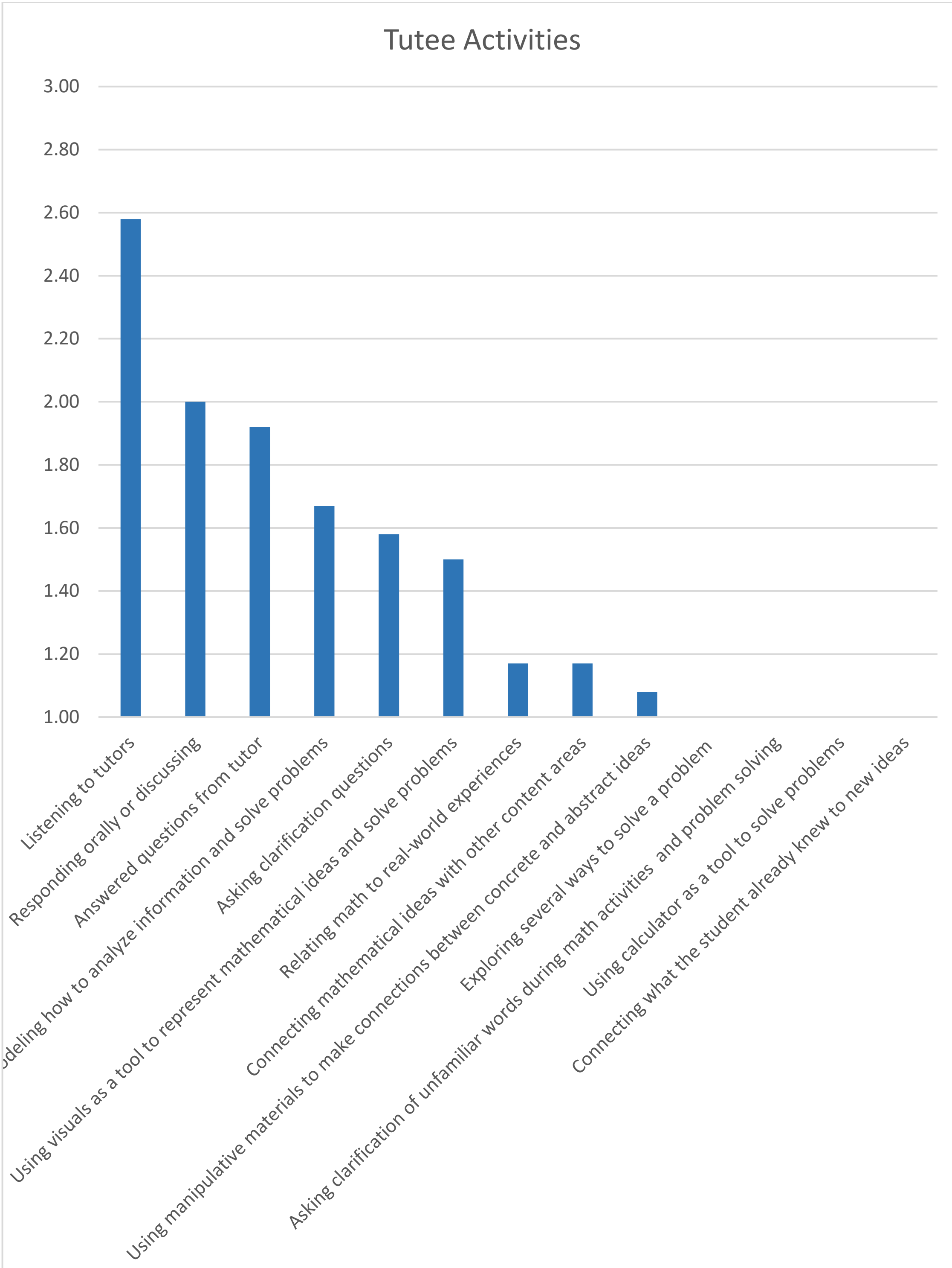

Figure 4.11. Tutee Activities Observed During Tutor-Tutee Sessions

Table 4.11. *Overall Classroom Observations for the Tutor-Tutee Sessions*: *Classroom Management*

Classroom management/environment	*M*	*SD*
Materials and/or manipulatives were available	1.92	0.79
Activities started on time	2.08	0.79
Transitions were quick and efficient	2.17	0.83

Note. 1 = not observed at all, 2 = observed in some extend, and 3 = observed in great extent

Table 4.11 shows the results of classroom management observed during tutor-tutee sessions. Results indicate that in general materials and manipulative materials were available to students, activities started on time, and transitions were quick and efficient. These observations suggest that during the tutor-tutee sessions, the classroom environment were conductive to learning.

The results of emotions and relationships observed during tutor-tutee sessions are shown in Table 4.12 and Figure 4.12. The following behaviors were observed in some extend: *tutors appeared to have warm supportive relationships with tutees* (M = 2.08, SD = 0.51), *tutors enjoyed teaching in this class* (M = 2.08, SD = 0.51), *tutees appeared to be happy in this class* (M = 2.08, SD = 0.51), *tutees enjoyed being in the clas*s (M = 2.17, SD = 0.58), and *tutees displayed positive affect toward tutors* (M = 2.25, SD = 0.62).

Table 4.12.

Overall Classroom Observations for the Tutor-Tutee Sessions: *Positive Emotions and Relationships*

Positive Emotions and Relationships	*M*	*SD*
Tutee displayed positive affect toward the tutor	2.25	0.62
Tutee displayed positive engagement with tutor	2.17	0.58
Tutee appeared to be happy in the class	2.08	0.51
Tutee enjoyed being in this class	2.17	0.58
Tutor enjoyed teaching in this class	2.08	0.51
Tutor appeared to have warm, supportive relationships with tutee	2.08	0.51

Note. 1 = not observed at all, 2 = observed in some extend, and 3 = observed in great extent

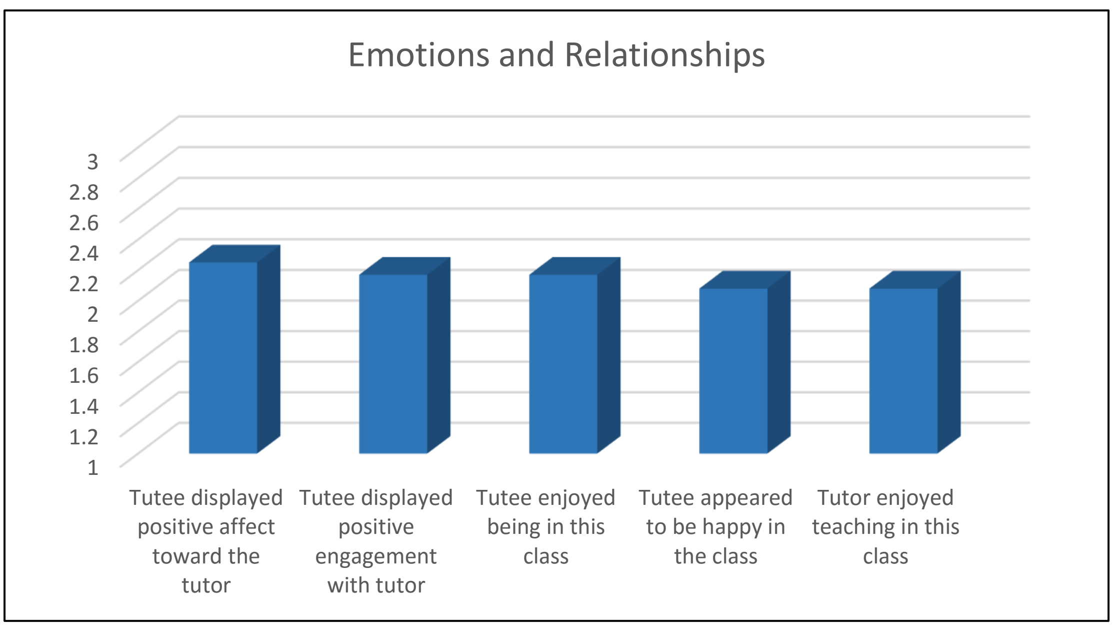

Figure 4.12. Emotions and Relationships Observed During Tutor-Tutee Sessions

Table 4.13.

Overall Classroom Observations for the Tutor-Tutee Session: *Engagement and Meaning*

Engagement and Meaning	*M*	*SD*
Tutees were engaged in math activities	2.08	0.29
Tutees were eager to answer questions	1.08	0.29
Tutees were absorbed by exploring math ideas and searching for multiple paths to solve problems	1.00	0.00
Tutees concentrated on activities	1.83	0.58
Tutees enjoyed solving problems	1.17	0.39
Tutor related concepts to tutee's lives	1.00	0.00

Note. 1 = not observed at all, 2 = observed in some extend, and 3 = observed in great extent.

Results for engagement and meaning are illustrated in Table 4.13 and Figure 4.13. Tutees *were engaged in math activities*, however, they were rarely *eager to answer questions* or *enjoyed solving problems*. Furthermore, tutees were never appeared to be *absorbed by exploring math ideas and searching for multiple paths to solve problems*. Tutors never *related concepts to tutee's lives*.

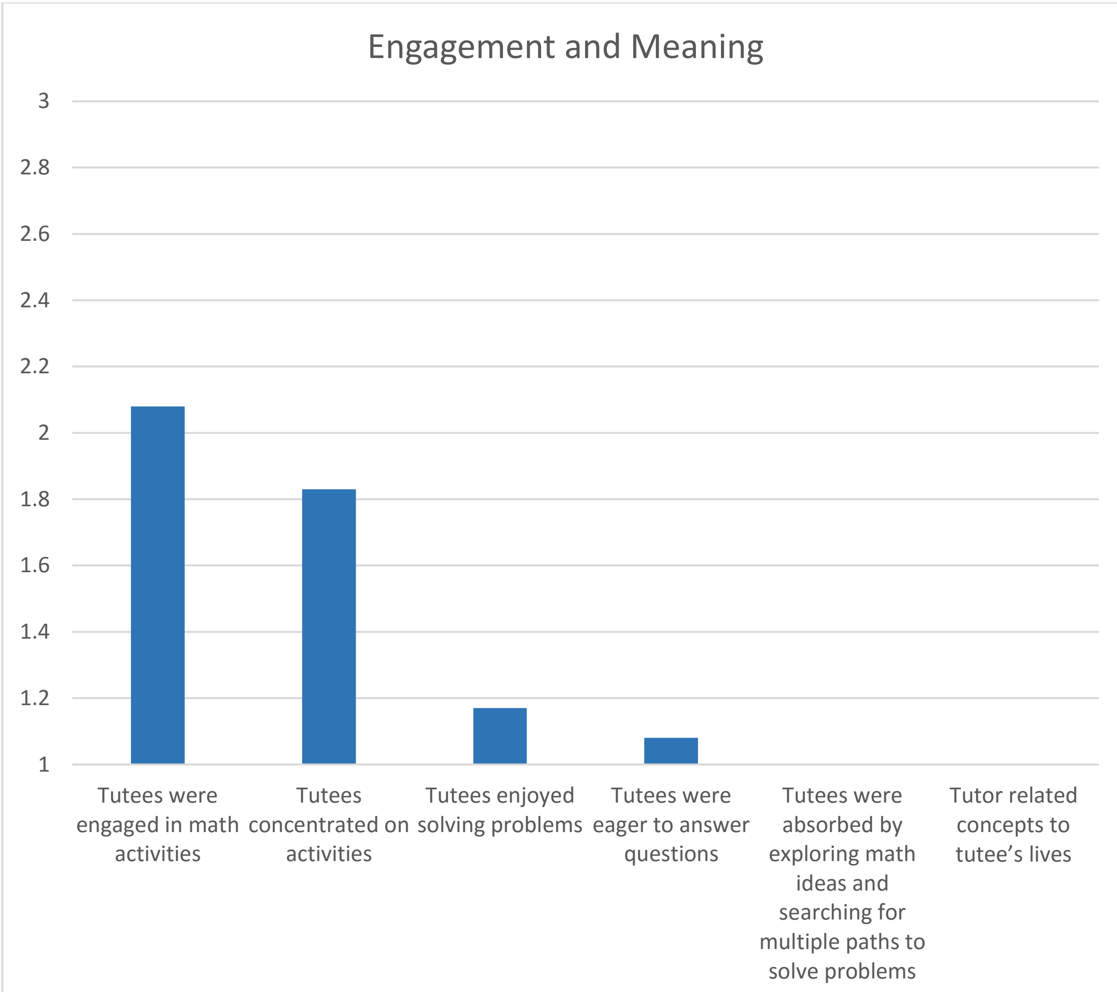

Figure 4.13. Engagement and Meaning Observed During Tutor-Tutee Sessions

Table 4.14 and figure 4.14 show low levels of accomplishment and among tutees. They seldom *assumed responsibility for learning activities* (M = 1.42, SD = 0.67), or *focused on accomplishing the assigned work* (M = 1.67, SD = 0.65). Tutors rarely *provided opportunities for tutees to be creative and/or generate his/her own ideas and products* (M = 1.08, SD = 0.29). Furthermore, tutors seldom *provided opportunities for the tutee to assume responsibility in activities* (M = 1.58, SD = 0.67), or *let tutees know* *that he/she had worked hard* (M = 1.25, SD = 0.45). Furthermore, tutors never *encouraged tutee's persistence on learning activities or to keep trying to answer questions and solve problems* (M = 1.0, SD = 0.00).

Table 4.14.

Overall Classroom Observations for the Tutor-Tutee Session: *Accomplishment and Growth-Mindset*

Accomplishment and Growth-Mind Set	*M*	*SD*
Tutees initiated and assumed responsibility for learning activities	1.42	0.67
Tutor provided opportunities for tutees to be creative and/or generate his/her own ideas and/or products	1.08	0.29
Tutor provided opportunities for the tutee to assume responsibility in activities	1.42	0.51
Tutee focused on accomplishing the assigned work	1.67	0.65
Tutee assumed responsibility for learning activities	1.58	0.67
Tutor provided feedback to student that he/she is smart	1.00	0.00
Tutor let student know that he/she had worked hard	1.25	0.45
Tutor encouraged tutees to keep trying to answer questions and solve problems	1.00	0.00
Tutor encouraged tutee's persistence on learning activities	1.00	0.00

Note. 1 = not observed at all, 2 = observed in some extend, and 3 = observed in great extent

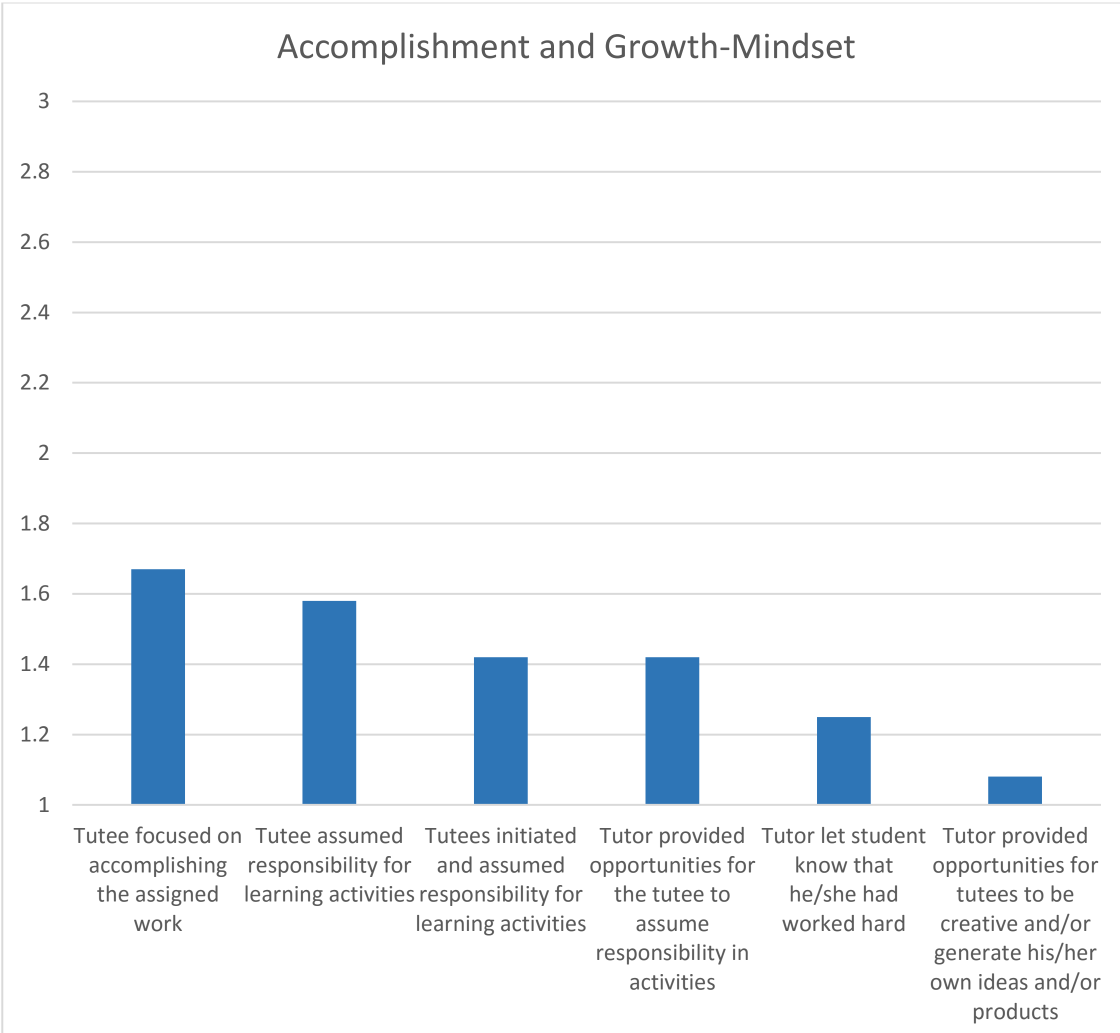

Figure 4.14. Accomplishment and Growth-Mindset Observed During Tutor-Tutee Sessions

Results from Field Notes

Field notes were created by four researchers that observed the tutor training and one-to-one tutoring sessions. They recorded the behaviors, activities, classroom practices, and classroom environment observed during classroom interventions. This section reports the summary of the field notes related to tutor training and the field notes connected to one-to-one tutoring sessions.

How do the activities address the student's academic deficits and improve achievement in math? Observers indicated that the mnemonic-based learning strategy, SOLVE, helped students to understand and solve word problems. This strategy facilitated the process to analyze the information, make a plan, and find the solution, and check the answer. Facilitators modeled how to use this strategy during tutor preparation sessions. Students used this strategy any time they need to solve a word problem.

Some observers also noted that the content of the lessons seemed too simple and there were not opportunities for guided practice. The lessons did not address the student's academic deficits in mathematics as planned. Mathematics activities for students were generally limited to the solution of one or two word problems. Many students completed their assignments early and they did not have anything to do after they finished their assignments. Lack of additional learning activities caused loss of academic learning time.

How do the activities build the social and emotional skills of students? Observers stated that there was not an effort to address the social and emotional skills of students. For example, rules for appropriate behavior were posted, but facilitators never referred to them. Some facilitators kept distant from students while students worked on classroom activities. Facilitators did not provide positive feedback to students.

Facilitators' behaviors. Observers reported that sometimes it took several minutes to start because students did not arrive on time for the tutoring sessions. In addition, some observers noted that facilitators did not monitor individual student's problem-solving process to ensure that they understand what they were doing. One observer stated: *No one checked to see if what the tutors were explaining was correct or provided positive feedback.*

Additionally, facilitators did not demonstrate high expectations for their students. Classroom activities were too simple. Facilitators did not create cognitive challenging activities for students by guiding students to solve more challenging problems. They limited student mathematics activities to the solution of one or two problems during each session.

Tutor's behaviors and attitudes. During the tutor training sessions, some tutors were more willing to participate in classroom activities than others. Also, during the tutor-tutee sessions, some tutors did not encourage tutees to analyze the information, make a plan, and solve the problems by themselves. They told tutees what to write in every step of the SOLVE mnemonic method and provided the answers before the tutee had time to and assimilate the information in the problem and figure out the ways to solve it.

Sometimes, tutors had difficulties remembering the sequence of the lesson. Tutors used the *Tutor Guidebook* to follow the scripted lessons. However, since the different sections of the lesson were not written in consecutive pages, tutors needed to search different parts of the manual; which sometimes could be difficult to remember. Interestingly, some tutors read the scripted lesson in English, but preferred to provide explanations to the tutee in Spanish. This seemed to help ELLs who had a limit academic vocabulary in English.

Tutee's behaviors and attitudes. In general, tutees spoke less than tutors during classroom activities. They listened to tutors most of the time. Some tutees were ELLs and seldom spoke in English. These students seemed to understand better when their tutors explained mathematics concepts of the steps to solve a problem in Spanish.

Physical setting. Facilitators and students did not have an exclusive physical space or classroom during the tutoring sessions. Many times, facilitators had to ask about the room availability when they arrived at the school. Consequently, they had to set the classrooms in few minutes. The space for the session differed from school to school. Sometimes the space provided was the science lab or the school library. At times students were interrupted by other students or school staff that were talking or performing other activities.

Social environment. Sometimes students were loud when they came into the classroom. Peer-tutoring instruction seems to improve communication among students. Student-centered learning environment provide students opportunities to talk, ask questions, and express their point of view.

Low academic expectations. The mnemonic strategy helps students to navigate through the steps of the solution of the problem. However, tutors and tutee completed only one or two word problems during the tutoring sessions. When they were finished there was not anything for them to do. Consequently, low expectations about students' ability to solve more problems during the tutoring sessions lead to a considerable loss of academic learning time.

Use of first and second language. Peer-tutoring environments provided multiples opportunities to English language learners to learn mathematics concepts, ask questions, answer questions, and solve problems in both English and Spanish. During tutor-tutee sessions, students had more flexibility to use their language of choice. Tutors and tutees were observed switching languages from English to Spanish or vice versa in response to immediate needs that emerged during the lesson. For example, sometimes tutors read the scripted lesson in English but they provided explanations to tutee in Spanish when they noted that his/her partner has limited English proficiency and consequently, understood faster and better in his/her first language. Likewise, sometimes tutees listened to tutors in English but since they were less fluent in English, they used their first language to ask questions, answer questions, or explain the procedure that they were using to solve problems.

In contrast, this kind of behaviors was never observed during tutor training where the language of instruction was in English only. Students never asked or answered questions to facilitators in Spanish. It seemed that peer tutoring provided the perfect environments were tutors and tutees felt fee use the language that helped them to enhance comprehension of mathematics ideas or assist them to understand the steps to solve problems.

Results from Facilitator Interviews

Analysis of the open-ended responses revealed facilitators positive perceptions about the tutoring program. In the beginning of the interview, facilitators were asked to describe one or two specific incidents that exemplified tutor success in the Peer-to-Peer Math program. Their responses portrayed several scenarios that evidence tutors and tutees' accomplishments. They stated that they witnessed tutors and tutees improving not only academically, but also enhanced their self-confidence, social skills, and strengthened relationships with their peers. Examples of their statements included:

> *Tutors got really comfortable with their tutees which made it really easy for them to just kind of guide them through the lesson on a personal level. One specific incident was between one of our tutors and her tutee. They got really comfortable with each other. They were always really kind of on the same level and they even interacted a lot during school hours, too.*

> *[Tutee] sometimes struggled with some of the stuff but he really loved working with his tutor and he was always like, oh I get to work with her, like you know, she's really cool. And so you could really tell he enjoyed sort of the interaction with someone who is older.*

> *We had kids that were always there, always on time, always did their stuff. And I remember when I first started working there they were very hesitant to answer. And there was one girl in particular, who she'd answer but then once she got it wrong she'd stop talking because she's wrong. But we opened her up to where if*

she was wrong she'd tell us to hold on, try it again and then continue until she got it right. So that was exciting.

Next, facilitators were asked whether they thought that the peer-to-peer math program improved tutors and tutees academic self-efficacy, enjoyment of learning mathematics, perceptions about the usefulness of math, and leadership skills. All of them believed that this peer-tutoring was effective in improving students' self-efficacy or students' beliefs about their ability to learn and perform well in math. Examples of facilitators' responses included:

> *The tutors were willing to take more risks in math, trying problems that they don't necessarily understand. Even if they got it wrong or not, they would definitely attempt them.*

> *I did see a huge improvement towards the end where they would always be raising their hands to answer questions, like way more than the beginning. They were engaged in the lessons. I had them come up and write stuff a lot more because they were willing to take on that kind of mentality.*

Likewise, all facilitator responded that they believed that the program improved both tutors and tutees enjoyment of leaning mathematics. Tutors and tutees seemed to enjoy personalized attention provided in student-center instruction that characterizes peer-to-peer-tutoring programs.

Then, facilitators were asked whether they thought that the program improved tutors and tutees' perceptions about the usefulness of mathematics. All of them responded that this peer-tutoring program enhanced students' perceptions about the value of mathematics in the present and in the future. Facilitators indicated that there is one specific part of the lesson where students talk about careers. They had the opportunity to see how math is connected to these careers and realized that they needed to know math in order to peruse the career they liked. Examples of these responses included:

> *There's a section of the lesson where it's talking about careers -- the career focus. I think that if they wanted any of those careers that we focused on, then yes they saw that they had to do math.*

Facilitators were asked to describe specific strengths and challenges of the math peer-tutoring program. They said that the program helped students to understand fundamental mathematics concepts and ideas. Another strength of the program was the career focus. This is a specific section of the weekly lesson plan. Students were able to read and talk about several careers and connect them to math. Facilitators also indicated that the program improved tutors and tutees' leadership skills.

Some challenges identified by facilitators included lack of students' commitment to the program, some of them did not attend the sessions. Also, lack of school collaboration prevented the students from leaving their regular class on time for the tutoring sessions. One middle school established tutoring time before school but did not provide transportation for students who participate in this program. Consequently, many students were not able to arrive on time and start their tutoring intervention at 7:00 AM. Regular schools buses were schedule to arrive to school after 7:00 AM. Consequently, students needed to rely in their parents' availability to take them to school.

Next, facilitators were asked how the tutoring program impacted them. Responses indicated that their participation in the program improved their personal and professional life. After this experience, they are more comfortable talking in front of people, have self-confidence as mathematic learners, and have better leadership skills. The following are some responses to this question:

> *I feel like I'm a lot more comfortable, you know maybe, being in front of people. You know, interacting with people in that way. I've never been like a really outspoken person, I guess. I guess I've gotten a lot better at that, you know, I've gotten a lot more comfortable, and I can go into a room and I don't know, make an announcement or do – and be completely comfortable, you know. I didn't know I was good at math until I started this.*

Facilitators indicated that they learned to prepare lessons plans, to build back up plans to adjust instruction to unexpected conditions. They also learned that many students need extra help in mathematics because they are at-risk of academic failure. These students are behind their peer and need effective instruction to reach appropriate achievement levels in mathematics.

I definitely think there's no like norm that ever happens. It's always like – what is it, Angel said something like, the only thing you can expect is the unexpected, or something along those lines. Like nothing is going to really go exactly as you planned it, and so just being able to – that you have to be able to think on your feet. And have back up plans as well because for example if you have kids who are doing something and they finish early, you have to have something ready for them, if they do, you know.

That some kids are really behind the at risk label. Some kids don't know how to multiply zero times any number is zero, so it's kind of hard to get them where you want them to be when they're not even where they should be.

Overall, the interviews with facilitators indicated that they had positive perceptions about this tutoring program. They believed that peer-tutoring was effective to promote tutors and tutees' academic success, leadership skills, self-perceptions as mathematical learners, enjoyment in learning mathematics and perceptions about the usefulness of mathematics. Furthermore, facilitators indicated that participants in the program enjoyed the personalized attention created in one-to-one instruction provided in peer-tutoring interventions.

Some challenges identified by facilitators included the lack of students' commitment to the program resulted in absents or tardiness. In addition, lack of school collaboration prevented that students arrive on time to the tutoring sessions. Facilitators also indicated that their participation in the program increased improved their personal and professional life. They stated that this experience improved their knowledge of mathematics, self-confidence, leadership and teaching skills. They learned how to become better teachers, understand the needs of at risk students, design lesson plans, and deliver instruction that addresses the needs of students who are at risk of academic failure.

Discussion

Mathematical skills are important for students' academic success and to prepare them to be an effective participant in a complex and changing global job market. Consequently, it is necessary to help students who struggle in mathematics by using research-based instructional strategies. A growing body of research supports the use of peer tutoring in mathematics classroom as an effective strategy that can improve students' academic outcomes, attitudes toward school, motivation, self-esteem, and social and behavioral skills.

The current cross-age tutoring program included objectives that ranged from the academic standards to be taught to the socioemotional outcomes that students were supposed to achieve as a result of their participation in the program. Classroom observations were carried out with the purpose of evaluating the effectiveness of the program in achieving the proposed objectives. Trained observers recorded whether teachers and tutors implemented instructional practices as designed, their ability to keep students motivated and engaged in the lessons, and their ability to foster critical thinking skills to solve mathematical problems.

As previously mentioned, the academic objectives of this tutoring training involved the improvement of students' knowledge and skills contained within the following mathematics standards: (a) number and operations, (b) algebra, (c) measurement, (d) geometry, and (e) data analysis and probability. The NCTM (2000) recommended to include a complete set of mathematics standards to ensure high quality education for all students. However, the results indicated that during tutor training, facilitators focused only on instruction related to number and operations. They rarely provided instruction related to algebra, geometry, and measurement. Instruction related to data analysis and probability was never observed.

In addition, field notes indicated that facilitators did not have high expectations for students participating in the program. Also, the math activities were too simple and the application of the mnemonic strategy SOLVE was limited to one or two problem solving applications for lesson. The mnemonic SOLVE seemed to help students to analyze the information and remember the logical steps to solve the problem. Low expectations of the students' ability to solve problems resulted in the loss of instructional time since most of the students solved the one of two problems and they don't have anything more to do the rest of the lesson.

Collier and Thomas (2009) indicated that some teachers tend to simplify the classroom instruction for low-achieving students because they don't believe that students can handle more challenging tasks. In this particular peer-tutoring program low expectations and low cognitive complexity of lessons prevented students from making adequate academic progress. Consequently, students at-risk should be challenged with cognitive challenging age appropriate work (Collier & Thomas, 2009).

Observations during the tutor-tutee sessions revealed that tutors followed similar instructional patterns. For example, tutors focused on number and operations just as they been taught by the facilitators. Since there was little instruction that addressed important areas such as algebra, measurement, geometry, and lack of instruction related to data analysis and probability, the instructional goals of the program were only partially achieved during tutoring sessions.

Instruction balanced across all mathematics standards is necessary to help students connect their ability to do calculations to other areas of mathematics and to other subjects. For example, when students calculate the mean and standard deviation in statistics, they need to connect what they know about basic operations with statistical concepts. In doing that, they need to reason quantitatively, analyze data, and interpret results of numerical computations. This could be extremely difficult for students that were not trained to use their basic computational skills in all mathematical areas.

Furthermore, another important objective of this program was the implementation of instructional strategies that support the mathematics skills that students needed to develop. However, the results from classroom observations revealed that instructional strategies were not implemented as planned. Facilitators seldom used most of the recommended instructional strategies that could have helped students improve their math performance, such us relating math to real-world experiences, connecting mathematical ideas with other content areas, using manipulative materials to make connections between concrete and abstract ideas, using visual materials to explore concepts and construct meaning, and exploring several ways to solve a problem. Tutors followed the same pattern as facilitators, they rarely used the above strategies. Moreover, although one of the purposes of the program was to encourage the use of calculators, students were not observed using calculators to solve problems, even though calculators were part of the instructional package that they received at the beginning of the tutoring program.

Another objective was the enhancement of student's critical thinking skills. However, the achievement of this objective appeared to be undermined by the students' lack of interest in exploring mathematics ideas and searching multiple ways to solve problems. This likely was a logical consequence of the lack of opportunities provided by facilitators for students to be creative and generate their own ideas. Students rarely initiated and assumed responsibility for their own learning activities.

The objectives of the program related to the improvement of students' motivation and self-confidence were not supported by behaviors observed during the tutor training. For example, teachers were seldom observed telling students that they were working hard or encouraging students to persist in learning math ideas, solving problems, or completing classroom activities. During one-to-one peer-tutoring sessions, some facilitators kept distant from students while they were working in pairs and therefore did not monitor their work.

Field notes revealed that one strength of the tutoring program was the use of the mnemonic strategy SOLVE to analyze and process the information contained in word problems. Using this strategy, underperforming tutors and tutees have a great way to remember the logical steps to solve problems. This could improve their mathematical fluency (Nelson, Burns, Kanive, & Ysseldyke, 2013). These researchers found that students who use mnemonic strategies achieve higher mathematical fluency scores than students in control group. Freeman-Green, et al. (2015) found a functional relation between the use of SOLVE strategy and computation scores in mathematics word problems for secondary students with learning problems.

Conclusions

Enhancing academic achievement in mathematics for Hispanic students involves overcoming barriers of instructional classroom practices, motivational, and other nonacademic factors. Research has reported positive effects of peer tutoring on students' outcomes across content areas. Peer-tutoring programs could be a viable strategy to help Hispanic students who struggle in mathematics classrooms, not only for the potential benefits suggested by research findings but also because peer tutoring is a cost-effective strategy, which means that schools can obtain greater academic benefits for each dollar invested in this instructional intervention compared to other available options.

Findings in this study revealed that some strengths of this tutoring program involved the creation of student-centered learning environments that enhanced the communication skills that students need to collaborate with others. In addition, peer tutoring promoted student interactions, and therefore provided opportunities for students to develop their social skills and form positive relationships with peers.

Another strength of this program was the enhancement of second language development during instructional conversations between tutors and tutees. In addition, one-to-one interactions created excellent opportunities to use students' first and second language to enhance comprehension. Although most of the time tutoring instruction was provided in English, tutors and tutees felt free to switch to Spanish to provide explanations that otherwise were difficult to understand in English.

An additional strength of the program was the benefits of using the mnemonic strategy SOLVE. Observers stated that this strategy was helping students to improve their ability to solve problems. Students used this strategy to understand and organize the information in word problems. Empirical research supports heuristic strategies to improve problem-solving skills by facilitating the interpretation, planning, and solution of word problems. Hohn and Frey (2002) found that elementary students who used the heuristic method SOLVED achieved greater improvements in problem-solving skills than students in control groups. They concluded that the use of heuristic approaches leads to superior leaning rates and long-term performance improvement. It is pertinent to note that both SOLVE and SOLVED are mnemonic heuristic strategies; however, SOLVED, created by Hohn and Frey (2002), stands for "State the problem, Options to use, Links to the past, Visual aid, Execute your answer, and Do check back." (Hohn & Frey, p. 374). The heuristic strategy SOLVE used in the present study stands for Study the problem, Organize the facts, Line up plan, Verify, and Examine.

Findings from the classroom observations also revealed some weaknesses of the program associated to the lack of fulfillment of the learning objectives designed in the peer-tutoring program. For example, the design included the five basic mathematics content standards: (a) number and operations, (b) algebra, (c) measurement, (d) geometry, and (e) data analysis and probability; however instruction provided by facilitators focused almost exclusively in one number and operations, neglecting other important standards designed to improve the quality of mathematics instruction for all students. Not surprisingly, tutors focused their instructions with their tutees based on what they have been taught during their training. Therefore, tutors also focused on number and operations.

A more balanced instruction that integrates all mathematics standards is necessary to prepare students to go beyond mechanical calculation to quantitative reasoning, analysis of data, and logical interpretation of results achieved by deep knowledge of all mathematical standards. The results evidence that instructional objectives were not implemented as planned, which could have affected students' academic outcomes.

The results of classroom observations also indicated that facilitators seldom used instructional strategies that could have helped to promote both students' outcomes in mathematics classrooms. Facilitators rarely used visuals materials as a tool to improve understanding of difficult mathematical concepts or manipulative materials to help students understand mathematics by connecting concrete objects with abstract concepts. Furthermore, facilitators almost never encouraged students to connect mathematics with other content areas, even though an important component of the lesson was shared reading. The use of the above research-based strategies could improve the students' outcomes in future tutoring interventions.

Other weakness of the program included the scarce evidence of the development of higher-order thinking skills. Students were rarely interested in exploring mathematics ideas and searching multiple ways to solve problems. They also almost never initiated and assumed responsibility for their own learning. These weaknesses may be explained by the rare opportunities provided by teachers for students to develop their creativity, generate new ideas, or create new products.

Another weakness of the program was the low cognitive complexity of student activities. Underachieving students need more challenging problem-solving tasks that help them to accelerate their learning. Low expectations can affect student mathematics performance and their ability to master the content. Giving students more math-problems to solve is clearly necessary. This will maximize the effective use of academic learning time, which will enhance student achievement in mathematics.

The dearth of positive reinforcement from teachers related to individual student efforts to complete the math activities could have affected students' self-efficacy in mathematics. Teachers rarely encouraged students' persistence on learning activities and were never observed telling students that they select smart ways to analyze data or solve problems. Children need this kind of emotional support to overcome difficult mathematics tasks.

Another weakness of the program was the ineffective use of academic learning time. After completing the reading activity students had to solve only one or two word problems. When they finished there was not anything else that they could do. This wasted valuable instructional time could have been used to improve the mathematical ability of tutors and tutees.

Peer-tutoring programs can be a promising intervention for improving Hispanic student academic and nonacademic outcomes. However, this program may not be working as well as other peer-tutoring programs because most programs select higher-achieving students to be tutors rather than lower-achieving which was the case here. Higher achieving students, with strong mathematics skills could be in better conditions to understand and explain mathematics ideas, concepts, and problem-solving procedures. Many abstract mathematics ideas are difficult to understand and even more difficult to explain to others. Consequently, low-achieving tutors may have difficulties explaining to tutees the mathematical content that they do not master.

Future Research

While the enrollment of Hispanic students in public schools continue increasing, their academic achievement remains low (U.S. Department of Education, NCES, 2016). Future research about instructional interventions that can help this group of students to succeed in mathematics is highly needed. As we mention above, one effective intervention for minority students supported by research is peer tutoring. The present study contributes to the knowledge about peer-tutoring programs by examining the classroom practices, behaviors, and activities during tutor training and tutor-tutee sessions. The findings of the present study identified several aspects of peer-tutoring programs that are particularly effective for Hispanic students. The program examined in this study, nonetheless, found several weakness that need to be considered when developing peer-tutoring programs not only for Hispanic students, but perhaps for all students. Future studies should focus on the factors that contribute to the successful implementation of peer-tutoring programs. Some implementation components that need more research in the future include: (a) training of the teachers in charge of tutoring programs that prepare them to fulfill the unique needs of Hispanic students, (b) appropriate selection of tutors, (c) tutors training that prepare them to deliver effective lessons to tutees, (d) teacher-student interactions during tutoring sessions.

Results from this study indicate that peer tutoring for Hispanic students can have benefits for tutors and tutees. In addition, Hispanic students who are English learners may benefit with one-to-one tutoring interactions that allow the use of their first or second language as tools to enhance comprehension of mathematics content. Future research, however, needs to investigate how to maximize these benefits, how teachers could use more effectively the instructional time, the processes that need to be addressed to enhance student academic outcomes, motivation, and engagement.

CHAPTER V

CONCLUSIONS

Mathematics is essential for students' success. Mathematical knowledge and skills enhance opportunities and options that shape students' future (NCTM, 2000). Mathematical competence is the key that opens the door to higher education and to well-paid jobs in an increasingly complex economy and competitive labor market. Yet, national statistics indicate that one of the biggest problems facing Hispanic students in U.S. public schools is their low achievement in mathematics (U.S. Department of Education, NCES, 2016).Therefore, it is critical to improve the academic outcomes of Hispanic students in mathematics by examining the most effective instructional strategies that might help them overcome their academic difficulties.

One effective instructional strategy supported by research is peer tutoring. Several researchers have suggested that peer tutoring is a cost-effective instructional strategy for improving achievement in mathematics (Levin, et al., 1984; Yeh, 2010). Furthermore, researchers have found that peer tutoring interventions were more effective for vulnerable students, including minority students, low SES students, and students attending schools in urban settings compared to mainstream, higher SES, and students enrolled in suburban-rural schools (Ginsburg-Block, et al., 2006; Rohberck, et al., 2003). According to the National Center for Educational Statistics, high-poverty schools have a great concentration of minority students. In addition, a high percentage of these schools are located in urban settings (US. Department of Education, NCES, 2015a). Based on this information, I hypothesized that peer tutoring could be effective for Hispanic students since their demographic characteristics indicate that they are minorities with low SES status.

One of the factors associated with the critical condition of Hispanic education is the lack of appropriate instruction that fulfills the needs of this group of students. Padrón et al. (2002) found that the most common classroom practice in schools that enroll Hispanic students is direct instruction, where the majority of instructional time is devoted to lecture, seatwork, drill, and memorization (Padrón et al., 2002). Peer tutoring is an effective classroom practice that can help transform teacher teacher-center instruction to student-center instruction, individual seatwork in engaging teamwork, and boring drill and memorization of concepts and formulas in meaningful classroom discussions. Topping et al. (2003), for example, found that peer tutoring improved cooperation among students, tutor-tutee pairs have multiple opportunities to discuss their ideas, ask for help, and formulate questions about math. These unique features of peer tutoring could help Hispanic students who are ELLs to improve their academic language, which is key in promoting academic achievement in mathematics.

Besides the substantial effects of peer tutoring on academic achievement in mathematics, several meta-analytic reviews have reported positive effects of peer tutoring on nonacademic outcomes. For example, the meta-analysis conducted by Cohen, et al. (1982) reported positive tutoring effects on students' self-concept and attitudes toward the subject matter. Ginsburg-Block, et al. (2006) found positive effects of peer tutoring on students' self-concept, behavior, and social skills. The meta-analysis conducted by Bowman-Perrot Burke, et al., 2014 reported that peer tutoring was effective in improving social skills and social interactions, enhancing academic engagement, and reducing disruptive behaviors.

This dissertation embraces three studies that explore the effects of peer tutoring in mathematics classrooms from a general meta-analytic perspective to more specific details in the implementation of a peer tutoring intervention offered in elementary and secondary schools in Texas. These studies focused on the potential benefits of peer tutoring in mathematics classrooms, the academic and nonacademic outcomes of a specific peer tutoring interventions in schools that serve predominantly Hispanic students, and the features of the program that could be improved to obtain greater benefits in the future.

The first study is a meta-analysis that examined the effectiveness of peer-tutoring interventions in promoting student achievement in mathematics classrooms. This meta-analysis offered a panoramic view of the effectiveness of peer tutoring in elementary and secondary schools. Moderator analysis provided the specific effects of peer tutoring for vulnerable student groups including students at risk of academic failure, minorities, and children from low SES families.

The results of the meta-analysis developed in Chapter 2 indicated that peer tutoring had positive effects on academic achievement in mathematics at elementary and secondary school levels. The overall weighted effect size of peer tutoring across the 21 studies included in this meta-analysis ($ES = 0.49$) was greater than Hattie's benchmark of ($d = 0.40$), which suggested that peer-tutoring interventions can make meaningful contributions in improving academic performance in mathematics. Hattie (2009) indicated that educational influences with effect size greater than 0.40 can really enhance achievement in all content areas. Hattie (2011) stated that an effect size of 0.5 corresponds to one grade improvement in students' exam results. Consequently, the results in this meta-analysis review led me to conclude that peer tutoring interventions are worth implementing in schools that want to accelerate the learning curve for students in mathematics.

Demographic moderator analysis indicated that peer tutoring interventions were most effective for at-risk, low socioeconomic status, suburban, African American, and secondary school students. Unfortunately, experimental and non-experimental studies that focused on effects of peer tutoring in mathematics in last three decades did not include more than 50% Hispanic participants. Consequently, it was not possible to have a specific result of the effectiveness of peer-tutoring programs for Hispanic students through moderator analysis performed in the meta-analytic review study. However, stronger benefits of peer tutoring for minorities, low income, and at-risk students, provided the guidelines to hypothesize that peer tutoring could help Hispanic students to achieve higher levels of performance in mathematics classrooms. As explained before, national statistics place Hispanic students among minorities, low SES status, and at-risk of academic failure.

The study presented in Chapter 3, specifically examined the effectiveness of a cross-age peer tutoring program implemented in elementary and secondary public schools that serve predominantly Hispanic students. Results indicated that this peer-tutoring intervention program had a positive impact on students' academic achievement in mathematics. Findings from this study showed that there were significant differences in students achievement measured at the beginning and end of the program. Remarkably, the results of this study revealed large positive effects of peer tutoring on basic mathematics facts (*ES* = 1.39) and problem-solving skills (*ES* = 1.25) among elementary school students and moderate to large effects on academic achievement of middle school students (*ES* = 0.67). These results were higher than the overall effect found in the meta-analysis developed in Chapter 2 (*ES* = 0.49). Furthermore, the moderator analysis in Chapter 2 indicated that peer tutoring interventions were most effective for minorities, at-risk, and low SES students. Results from the study presented in Chapter 3 evidenced that cross-age peer tutoring interventions were effective in increasing mathematics achievement in classrooms that served predominantly at-risk Hispanic students.

In order to determine key factors in implementing peer tutoring programs with low SES Hispanic students, I examined the classrooms practices and behaviors of teachers and students during tutor training and tutor-tutee sessions through classroom observations and teacher surveys. The purpose of this study was to determine the extent to which the objectives of the program were achieved. In addition, the study focused on identifying elements of the program that were key in the implementation of the program.

Overall, the findings of the study indicated that the objectives of the program were not implemented as designed. Results generated from classroom observations and teacher interviews revealed strengths and weaknesses in the implementation of the program. Classroom observations conducted during tutor training sessions indicated that students displayed positive affect toward the teacher, appeared to be happy in the class, enjoyed being in the tutoring training class. In addition, teachers appeared to have a warm and supportive relationships with tutors. Perhaps, this positive learning environment that was contributing to the gains in student achievement in mathematics.

Classroom observations during tutor training sessions, however, also revealed that there was little evidence of students' engagement in meaningful mathematics activities. Tutors, for example, were rarely observed exploring math ideas and/or searching for multiple paths to solve problems, enjoying solving problems, eagerly volunteering to answer questions. In addition, the instructional practices and behaviors observed during tutor training sessions and tutor-tutee sessions were very similar. Tutors seldom provided tutees opportunities to be creative and generate her own ideas and products or opportunities for the tutee to assume responsibility in activities. Tutors were never observed encouraging tutee's to be persistent about learning or to keep trying to answer questions to solve problems. These results are not surprising since the tutors modeled the same type of instruction provided by the teacher during the tutor training session. That is, teachers, during the tutor training sessions focused on passive/low-level activities. This type of instruction did not promote the development of critical thinking, and provided tutors with little opportunities for assuming responsibility for their own learning. Tutors repeated the same pattern when they delivered instruction to their tutees. These findings may help to explain the decline of elementary and middle school tutors' enjoyment of mathematics and self-perceptions as mathematical learners described in

Chapter 3. These findings also highlight the importance of the tutor training when implementing peer tutoring programs.

The fact that the teachers in this study were not professional educators and did not have specific training in mathematics is a limitation of this intervention. It is also one plausible explanation for the lack of appropriate tutor training. In addition to not being professional educators and not having specific training in mathematics content, these teachers may have lacked pedagogical knowledge could affect the quality of mathematics instruction that the tutors received and the subsequently the tutees received.

Future studies examining peer tutoring programs need to ensure that tutors are trained by high-quality teachers that have the required knowledge and skills in pedagogy and mathematics content. In addition, there are some aspects of implementing the program for Hispanic students that need to be considered. The majority of Hispanic students who participated in the cross-age tutoring programs stated that they preferred to speak Spanish at home; consequently, teachers involved in tutoring interventions for Hispanic students need to know the appropriate instructional strategies for students who are learning English as their second language.

In summary, the studies presented in this dissertation examined the effectiveness of cross-age tutoring interventions in improving mathematics achievement for Hispanic students. Findings from the studies provided evidence that tutoring programs can have significant academic benefits for elementary and secondary Hispanic students. Finally, a deeper exploration of the classroom practices and behaviors in tutor training and tutor-tutee sessions found that the effectiveness of tutoring could be enhanced by providing better training in mathematics for the teachers instructing the tutors in the program. Peer and cross-age tutoring program are worth to consider as one of the solutions for improving achievement among Hispanic students. Positive effects of peer tutoring combined with relatively low cost of implementation compared to other programs, make peer tutoring a great resource among other educational interventions available for mathematics classrooms.

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APPENDIX

Peer Tutoring Coding Form

Bibliographic reference

1. Study ID number

2. Publication year

    1. 1980-1989
    2. 1990-1999
    3. 2000-2009
    4. 2010-2015

Sample Descriptors

3. Education Level of Tutor

    1 Kindergarten
    2 Elementary (Grades 1-5)
    3 Secondary (Grades 6-12)
    4 Mixed Elementary and Secondary
    5 Unknown (not reported)

4. Education Level of Tutee

    1 Kindergarten
    2 Elementary (Grades 1-5)
    3 Secondary (Grades 6-12)
    4 Both Elementary and Secondary
    5 Unknown (not reported)

5. Race of participants

    1 > 50% White
    2 > 50% Hispanic
    3 > 50% Black
    4 > 50% Asian
    5 mixed, cannot estimate proportion
    6 Unknown (not reported)

6. Gender of participants

1 >50% male
2 < 50% male
3 50% male and 50% female
4 Unknown (not reported)

7. Socio-economic Status (SES) of Participants

1 < 50% low SES
2 ≥ 50% low SES
3 Unknown (not reported)

8. Location

1 Urban US
2 Suburban US
3 Rural US
4 Outside US
5 Unknown (not reported)

9. At risk students / low performing

1 > 50% students at risk
2 ≤ 50% students at risk
3 Unknown (not reported)

10. Ability level of tutor

1. Low
2. Average
3. High
4. Mixed
5. Unspecified

11. Ability level of tutee

1. Low
2. Average
3. High
4. Mixed
5. Unspecified

Research Design Descriptors

12. Control and Treatment

    1 Random assignment included control group (experimental)
    2 No random assignment included comparison group (quasi-experimental)
    3 Non experimental

13. Nature of control group

    1 Receives nothing
    2 Wait list
    3 Differed treatment
    4 Alternative treatment

14. Treatment group sample size
15. Control/Comparison group sample size
16. Total sample size

Nature of Treatment Descriptors

17. Type of Peer Tutoring

    1 Same-age peer tutoring
    2 Cross-age peer tutoring

18. Time where the tutoring was provided

    1 During school normal hours
    2 Before and during school normal hours
    3 Unknown (not reported)

19. Structured Tutoring

    1 Yes
    2 No

20. Replace math instruction

    1 Yes
    2 No

21. Tutor Training

1 Yes
2 No

22. Fidelity Check

1 Yes
2 No

23. Duration of Tutoring (in weeks)

1. 1 to 6 weeks
2. 7 to 12 weeks
3. 13 to 20 weeks
4. more than 20 weeks

24. Frequency of tutoring sessions (number of sessions per week)

25. Length of each tutoring session (minutes per session)

1. 1 to 2 sessions per week
2. 3 to 5 sessions per week
3. Unknown (not reported)

26. Total amount of tutoring (total number of hours)

1. 0.5 to 12 hours
2. 13 to 24 hours
3. More than 24 hours
4. Unknown (not reported)