A QUALITATIVE STUDY OF PEER TUTORING
DEVELOPMENTAL MATHEMATICS AT THE UNIVERSITY LEVEL

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By

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The purpose of this study was to find the elements found in successful peer tutoring programs at the university level. Particularly, this study focused on the experiences of tutors and tutees by observing tutoring sessions and using questionnaires and interviews to gain a deeper understanding of what is important and necessary in a successful peer tutoring program. Their perceptions and interpretations were organized according to key points, respective to each interview question and from the recorded tutoring sessions and following a basic, interpretive qualitative methodology.

Three tutors and four tutees were observed for one semester in scheduled, weekly tutoring sessions. Each session was audio recorded. The tutors and tutees were also given questionnaires and were interviewed. Four members of the faculty and staff at the university where the study was conducted were also interviewed. These participants were connected to the mathematics program at the university.

This study suggests that there are numerous factors related to the experiences and perceptions of mathematics tutors, tutees and faculty and staff. An interpretive qualitative methodology was used in order to gain a deeper understanding of these perceptions. This may promote a more thorough understanding of the tutoring process in mathematics at the university level and the challenges that can be faced in organizing and maintaining a successful peer tutoring program for mathematics.
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CHAPTER I

INTRODUCTION

“A national crisis of poor learning outcomes is evident in reading, math, and other core subject areas” (Maheady & Gard, 2010, p. 71) is not new information for most educators in the United States. One intervention that may improve this unfortunate situation is the use of peer tutors. The focus of this study is based on peer tutoring in mathematics at the university level.

Peer tutoring can be defined as “people from similar social groupings who are not professional teachers helping each other to learn and learning themselves by teaching” (Topping, 1996, p. 322). Or in other words, peer tutors are students who tutor other students in the same discipline either in small groups or individually (Colvin, 2007). Peer tutoring in the U.S. started in the 17th century at Harvard College to help underprepared students with Latin and Greek (Merisotis & Phipps, 2000). Currently, a large number of underprepared students are often placed into remedial courses including mathematics, writing, and reading (Hollingsworth, 2012). A college course is considered to be remedial when that course is not at college level (Merisotis & Phipps, 2000). For example, at the institution where I did my research, Pre-Algebra is considered remedial because it includes operations and properties of real numbers, an introduction to variables, first degree equations and problem-solving with formulas, equations and inequalities in one variable, linear equations, rate of change and slope, graphing in the Cartesian plane.
A study of various aspects of peer tutoring programs is needed; as Topping indicated: “Research on teaching and learning in further and higher education schools is much less voluminous than that on teaching and learning in (elementary and secondary) schools . . . both the quantity and the quality of research in this area is surprisingly limited” (Topping, 1996, p. 321).

Rationale for the Study

Need for Tutoring Programs

College students who must take remedial mathematics classes compose a large number of incoming freshman classes. *Success in College Mathematics* (1999) reported that:

- A shocking 46% of U.S. college students who have earned more than 10 credits have been enrolled in at least one remedial course;
- Remedial courses are offered in 64% of all four-year colleges, 90% of community colleges, and 91% of public colleges;
- A snapshot of the present situation of remedial mathematics college students leads us to believe that remediation in its present form is not successful (Hagedorn, Siadat, Fogel, Nora, & Pascarella, 1999, p. 263).

A study done by McClenney (2004) showed that of students who were first-time students in community colleges, at least half of them were in need of developmental mathematics classes and almost 20% of students entering four-year college institutions are placed into at least one remedial course (Hollingsworth, 2012). Developmental education differs from remedial education in that it is defined as: “A comprehensive
process that focuses on the intellectual, social and educational growth and development of all students and includes but is not limited to tutoring” (Gallard, Albritton, & Morgan, 2010, p. 10). In Hollingsworth’s aforementioned study of remedial college classes, it was also stated that when institutions use remediation approaches such as tutors, the underprepared students in remedial courses have the same level of success as the students who are not considered underprepared (Hollingsworth, 2012).

The National Conference of State Legislatures (NCSL) reported that:

- More than 42 million Americans aged 18 to 64 do not hold a college degree and would probably need remediation if they chose to attend college;
- The cost of remedial instruction to states and students are about $2.3 billion each year;
- Of students who are considered remedial, less than one-fourth of them earn their degree within eight years;
- Of students who require remedial math classes, only 27 percent earn a bachelor’s degree (NCSL, 2013).

Research by Bautsch demonstrated that students who are less prepared for college-level classes can be successful if support, such as peer tutoring is provided (Bautsch, 2011). These studies demonstrated the need for remedial programs and the high cost to universities and state governments.

**Cost of Remediation**

In other studies, it has been reported that developmental education can cost as much as one to four billion dollars a year (Fain, 2012; Gallard et al., 2010;
Hollingsworth, 2012). The University System of Georgia alone earmarks approximately $22 million per year on remediation (Diamond, 2010). Due to the high cost of remedial education, some states are either eliminating it all together or relegating it completely to community colleges (Fain, 2012). Both institutions of higher education and students benefit from students who persist and earn their degrees—the tuition income raises university coffers while incentives from the state and federal government accompany higher completion rates (Gallard et al., 2010).

Further economic advantages include the possibility of reaching more students more effectively and freeing staff to perform other academic functions (Topping, 1996). In a study by Lee (1988), he discussed interesting and sometimes surprising results, such as the most expensive programs were not found to be more effective than streamlined ones, such as peer tutoring, and the size of an institution was not a factor in retention and dropout rates (Lee, 1988). Peer tutoring is cost effective since it delivers high positive returns at a low cost (Topping, 1996).

Political advantages are another consideration. Topping contends that peer tutoring is a more democratic and empowering pedagogical tool to students rather than de-skill them by reliance on replication of a master culture, and the possibility of reducing student frustration (Topping, 1996). And above all, more students are retained, including those who are at risk (Hughes, 2007).

**Academic Benefits of Tutoring Programs**

In a review conducted by Cohen, Kulik, and Kulik (1982), tutors made better improvements in math than in reading (Robinson, Schofield, & Steers-Wentzell, 2005).
According to a study by Britz (1989), tutees made similar improvements. The study showed that tutoring improved the math performance of tutees in more than 90% of the students reviewed. Kersaint and colleagues highlighted the importance of accessibility of tutors (Kersaint, Dogbey, Barber & Kephart, 2011). The same team posited that:

Consistent with other research we found that the gains in content knowledge of students who used the tutoring services were greater than those who did not, and that students with access to tutoring services persisted in the course when compared with those who do not. (p. 38).

Another group of researchers (Bude, van de Wiel, Imbos, & Berger, 2011) performed a study focused on conceptual understanding of statistics and the effectiveness of a peer tutoring intervention. Directive guidance and directive tutor guidance occurs when the tutor or instructor actively guides discussions of the learning objective or topic using guided questions that are intended to cause the students to reflect on the questions and arrive at their own answers; the information is not spoon fed to the students (Bude et al., 2011). Their findings gleaned that in the experimental group (peer-tutored students), affording directive guidance seems to be an effective supplement and directive tutor guidance has a beneficial effect on students’ conceptual understanding (Bude et al., 2011).

Although there is extensive research on the needs and benefits of programs such as peer tutoring, there is a surprising lack of awareness of the social dynamics involved (Colvin, 2007). Colvin demonstrated that the relationships that are formed as tutors, students, and instructors interact are essential elements to college tutoring programs.
Thus, my study explored the interaction between tutor and tutee and what makes the process successful. The meaning of successful is discussed in Chapter 2 under Measuring Proficiency in Mathematics, further in Chapter 5, and summarized in Table 7.

**Research Questions**

Specifically, my study explored three areas associated with the peer tutoring process:

1. What characteristics and behaviors as displayed by tutors and tutees are most desirable in higher education tutoring programs?
2. What common characteristics are observable between different math tutors and between different math tutees (as separate groups)?
3. How do various university stakeholders (university administrators, math department faculty) define success in university-level peer tutoring programs?

By examining the relational dimensions of peer tutoring it was the goal of this research to find those characteristics of tutoring programs, the processes within tutoring sessions, and the tutor/tutee dynamics that will support students to become successful. The means and tools are available; “The enemy is not material commodities, but the lack of the will to use them as instruments for achieving preferred possibilities” (Dewey, 1999, p. 76).

**Background**

Because there are many approaches to peer tutoring (behaviorist, cognitivism, constructivism [social and radical], design-based and humanism), it was necessary to focus on a learning theory that most aligned to the study of peer tutoring dynamics, which
is social constructivism. In a study by Aguilar and Kaijiri (2007), an Adaptive Tutorial System based in constructivism was formed: “The personalization factors that we propose have their basis on the Constructivist Paradigm which fosters the learners to construct their own knowledge” (p. 30). Palmer (1987) recommended that the system of mutual learning in peer tutoring supports a communal way of knowing and a capacity for critical thought and relatedness to people can be developed by interacting in a circular structure rather than a hierarchical one, where there is an atmosphere of collaboration and support.

This environment for peer tutoring is needed because:

- Tutoring has been used to offset the shortcomings of the lecture system in which a professor is the gatekeeper of knowledge passed from the top down (Claxton, 1991).
- The dominant use of lecturing is still prevailing today even though we currently work with a large, diverse population of students who don’t learn well in the lecture system (Dvorak, 2004).
- Universities need to provide students and staff with a good and supportive environment to allow them to focus effectively on their primary tasks (Luck, 2010).

If these recommendations can be met, the following positive outcomes can occur:

- It is of important significance to establish a tutorial system for undergraduate students. The system can help the students to establish a correct outlook on life, values and world view, formulate scientific and professional learning
program, make clearly the direction of professional development. (Xing, Hongguo, & Guohua, 2012, p. 40)

• Understanding in higher education is a highly demanding process . . . where they can tolerate and foster such an atmosphere of not knowing, tutors can potentially contribute to students’ developmental as well as their learning environments. (Karagiannopoulou, 2011, p. 15)

Summary

In sum, despite the large amount of research available on tutoring, there is still a need for more research on what can be defined as a successful tutoring program (Robinson et al., 2005). In addition, there is a very limited amount of research available on the personal dynamics involved in peer-tutoring: relationships and communication among tutors, tutees, and instructors are at the very heart of what can make college tutoring programs most effective (Colvin, 2007).

Definitions of Terms

Andragogy: “The characteristics of adult learners that are different from the assumptions about child learners, on which pedagogy is premised” (Gom, 2009, p. 19).

At-Risk: “Exposure to particular conditions, or risk factors, increas(ing) the likelihood that an individual will experience certain adverse consequences . . . associated with academic difficulty or dropping out of school” (Finn & Rock, 1997, p. 221).

Constructivism: “Human development occurs within the context of the interaction between individuals and the cultural dynamics and forces in their environment” (Henderson & Kesson, 2004, p. 68).

Developmental Education: “A comprehensive process that focuses on the intellectual, social and educational growth and development of all students and includes but is not limited to tutoring” (Gallard et al., 2010, p. 10).

Peer Tutoring: “People from similar social groupings who are not professional teachers helping each other to learn and learning themselves by teaching” (Topping, 1996, p. 322).

Procedural Knowledge: Knowledge made up of two distinct parts. One part is composed of the formal language, or symbol representation of mathematics. The other part consists of using such constructs as algorithms, procedures, and rules to solve mathematical problems (Hiebert, 2013).

Radical Constructivism: A learning philosophy that holds that a student must make his own meaning from the material at hand (von Glasersfeld, 1992).

Remedial Classes: “Coursework below college level (academic work at a level beyond what is expected in high school) in higher education institutions” (Fowler & Boylan, 2010, p. 67).

CHAPTER II
THEORETICAL FRAMEWORK FOR PEER TUTORING

This chapter examines research in the area of peer tutoring. Because learning theory is foundational to the tutoring process, this review investigates various theorists and how their theories impact tutoring. Because behaviorism and constructivism are well-documented learning theories and are prevalent in today’s learning environments in various forms, I have investigated the influential theorists within each field. First, constructivism is defined with the contributions of von Glasersfeld and Vygotsky while behaviorism is described through the lens of Gagne. An in-depth discussion of tutoring follows with peer tutoring in particular. Using the definition of mathematical proficiency as the criteria of success in the tutoring process, the final section describes how proficiency in mathematics (a goal of tutoring) can be measured.

Learning Theories

Constructivism

Henderson and Kesson, who situated their book *Curriculum Wisdom Educational Decisions in Democratic Societies* (2004) in constructivism, stated that: “More recent theories of human development posit that development occurs within the context of the interaction between individuals and the cultural dynamics and forces in their environment” (Henderson & Kesson, 2004, p. 68). Constructivism is a theory of learning and intellectual advancement, which is derived from the Latin *construere*, which means “to interpret” or “to analyze” (Henderson & Kesson, 2004). The stress is on dynamic construction of a specific meaning or importance (Henderson & Kesson, 2004).
Constructivism is not limited to children; it is progressing not only in the traditional idea of relating to children but also to the development of an individual during the course of his or her lifespan (Kegan, 1980). Constructivism was the lens for this study.

In this chapter, the theories of von Glasersfeld and Vygotsky were reviewed. These theorists were chosen because of their foundational work in the field of constructivism.

Through years of careful research on the nature of student understanding, which drew on the foundational work of Ernst von Glasersfeld . . . and Lev Vygotsky . . . (based on their theories) educators came to appreciate the “constructivist” nature of student understanding. (Henderson & Gornik, 2007, p. 230)

First, I chose von Glasersfeld because his work with radical constructivism aligns perspectives shared by some mathematics educators, researchers, and mathematicians. In his book, Questions and Answers about Radical Constructivism (1992), von Glasersfeld spoke of how a student must make his or her own meaning from the material at hand. Since students who seek out tutors are struggling with mathematics and only see mathematics from a procedural perspective, peer tutors may help students to find their own meaning by guiding their learning. Von Glasersfeld’s tenets in radical constructivism have been applied in such studies by CIRADE (the interdisciplinary learning and development research center at the University of Quebec at Montreal) and by many other theorists such as Confrey (2011) and Yackel and Cobb (1990; these applications are further discussed in the von Glasersfeld section). Steffe (2010) summarized this best by stating: “we construct second order-models which are models...
and observer constructs of an observed persons’ knowledge in order to explain their observations” (p. 46).

Second, I chose Vygotsky because he also used a form of constructivism to form his theory of social constructivism. Social constructivism emphasizes the use of collaboration in learning (Yackel & Cobb, 1990). He is believed to have laid the foundations for constructivism (Jaramillo, 1996). His theory of the Zone of Proximal Development (ZPD) which discusses the importance of interaction with others in learning, using what he termed leading learning development (Holzman, 1995) is certainly central to peer tutoring. ZPD has been applied by researchers in mathematics in order to learn how students construct their own meaning from mathematical signs and how they are used in society, how environment influences learning, and the benefits of learning in a guided setting. These applications are discussed further in the Vygotsky section of this paper.

Third, I chose Gagne because he was founded in behaviorism and he also focused on information processing in learning and memory. Gagne was an important contributor in learning how to learn paradigm, which analyzes the ability to learn effectively in any learning experience (C. Smith & Bath, 2006). He developed a model of teaching that was based on how to keep students engaged, the importance of giving relevant feedback, the value of practicing what is taught, and how to apply this knowledge (Gagne & Rohwer, 1969). Gagne stated that learning guidance can be the difference between effective and ineffective learning (Gagne, 2001).
**Ernst von Glasersfeld.** Ernst von Glasersfeld was born in Munich in 1917. His parents were of Austrian descent and raised him in Switzerland and Italy. He studied mathematics in Zurich and Vienna and worked in the United States as the director of a research project in computational linguistics funded by the United States government. He taught cognitive psychology at the University of Georgia in the U.S. from 1970–1987 and began to develop his radical constructivist theory in the 1970s. Although he never pursued his PhD, several PhDs were conferred on him. He passed away in 2010 (Riegler, 2013).

Von Glasersfeld based his radical constructivist theory from the works of Piaget and Vico. Radical Constructivism (RC) is based on “the practice of psycholinguistics, cognitive psychology, and . . . the works of Jean Piaget” (Matthews, 1994, p. 148). However, von Glasersfeld believed the first true constructivist was Giambattista Vico and that his work was later continued by Piaget and Silvio Ceccato (Cardellini, 2006, pp. 130–131). Von Glasersfeld was chosen for this study since he has had a significant impact on the development of constructivist theory in mathematics and science education in the last two decades; this inspiration is apparent by the unanimity by which he is recognized and by other important scholars (Cardellini, 2006). In addition, Cardellini has stated that von Glasersfeld was and remains a leader in the constructivist movement, especially in his leadership in the field of Radical Constructivism (Cardellini, 2006).

Radical Constructivism was distinguished from cognitive constructivism by von Glasersfeld in that radical constructivism broke away from the tradition of cognitive representationism (von Glasersfeld, 1992). He also said that it is *radical* because it splits
with convention and develops a theory of knowledge where knowledge is not seen as an objective ontological reality, but is organized by one’s own experience (von Glasersfeld, 1984). The term radical here is not meant to be drastic, but instead “thoroughly consistent” (Riegler, 2001, p. 27). The two basic principles of Radical Constructivism are:

1) Knowledge is not passively received either through the senses or by way of communication, but it is actually built up by the cognizing subject;
2) The function of cognition is adaptive and serves the subject’s organization of the experiential world, not the discovery of an objective ontological reality. (von Glasersfeld, 1996, p. 24)

The relevance of radical constructivism to peer tutoring in mathematics was outlined by von Glasersfeld in his book, *Questions and Answers about Radical Constructivism* (1992), where he outlined his constructivist theory for instruction by stating that: (a) The knowledge they (students) have is their only basis; (b) A student’s answer to an inquiry (or “problem”) is what makes sense to the student at that moment, whatever a student says, and must be seriously considered by the instructor; (c) If a teacher desires to modify a student's conceptions and thought processes, the teacher must build upon the student’s existing mode of thought; (d) Inquire to the student how he or she derived his or her answer; this may give the instructor some insight on how that student processes the information at hand and may aid the teacher in how to explain that topic and future topics; (e) Create situations where the students have a chance to experience the pleasure inherent in solving a problem; (f) Getting the correct answer is
not as important as using successful thinking techniques; (g) Instructors must use accommodating thinking as the students may be coming from somewhere the teacher would not otherwise comprehend; (h) Constructivist teachers must not teach their lessons as the “truth;” students must build their own “truth” by struggling with the material and making it their own (von Glasersfeld, 1992).

One significant study based in von Glasersfeld’s theories was conducted by a group of mathematics research colleagues in Quebec, Canada, and demonstrated von Glasersfeld’s direct influence on how one may think differently than was traditionally and previously done in mathematics education. This influence produced ways by which mathematics could better be taught and learned, based in radical constructivism. This cohort was known as CIRADE (the interdisciplinary learning and development research center); von Glasersfeld often visited this group (Bednarz & Proulx, 2011, p. 239). Bednarz and Proulx compared the effects of the research of CIRADE as it applied to mathematics both in 1980 when the group emerged and again in 2010 in order to revisit von Glasersfeld’s influences and legacy to the CIRADE group and its new scholars (Bednarz & Proulx, 2011).

Von Glasersfeld’s influence on CIRADE was substantial in that he influenced new ways of comprehending and implementing educational actions, and showed how to approach research in various areas such as mathematics and science education (Bednarz & Proulx, 2011). His radical constructivist ideas were revolutionary at the time and provided a new lens for the study and teaching of mathematics in that he challenged some of mathematics education’s firmly held tenets such as the belief that graphs, figures,
tables, and symbols are self-explanatory and mathematical symbolism tangibly refers to an external universal reality (Bednarz & Proulx, 2011). He also gave a new perspective on how students’ ideas and views are crucial in research and development of mathematics education (Bednarz & Proulx, 2011).

In the 25 years that CIRADE existed, three main areas showed the most growth and are briefly summarized in the mathematical learning process of children: Their ways of thinking are meaningful and errors must be thought of as opportunities for learning and not mistakes, students will form their own meaning and conceptions and need interventions to help develop these. Each teacher’s expertise and experience must be considered in teaching and implementation of interventions and collaboration of teachers is important (Bednarz & Proulx, 2011).

This group, along with von Glasersfeld, created a springboard for new ideas and theories even after the dissolution of CIRADE:

The perpetuation and continuity of von Glasersfeld’s constructivism can be seen in these terms: radical constructivism’s offspring resides within the concepts and epistemology put forth and that continue to be put forth through a large number of new and different generations of theories. (Bednarz & Proulx, 2011, p. 246)

Jere Confrey discussed how von Glasersfeld’s theory applies directly to learning and teaching mathematics. She met von Glasersfeld at Mount Holyoke College where she was studying in a summer mathematics program (Confrey, 2011). Confrey was struggling to see how children think in mathematics and to appreciate their views as legitimate and not just incomplete, undeveloped mathematics (Confrey, 2011). Although
she had already studied Piaget thoroughly, she felt von Glasersfeld took his ideas a step further by showing her a more robust elucidation of Piaget in such writings as *Genetic Epistemology* (Confrey, 2011). Her viewpoint differed from traditional ways of teaching mathematics, guided by radical constructivism, in that she believed that it is not enough for a student to be able to regurgitate mathematical concepts and be able to solve problems by rote learning. She defined her approach as trying to see how students see and process mathematical ideas that are new to them by not connecting their interpretations to an external truth and by not controlling how they progress in their learning and in making their own meaning (Confrey, 2011).

Radical Constructivism is a valuable theory for teaching and learning mathematics at all levels. Confrey suggested that “we need to examine the implications of our results for how mathematics can viably evolve into more sophisticated thinking, even if this challenges assumptions made by common agreement among mathematicians” (Confrey, 2011, p. 108). From this, she listed how radical constructivism can improve teaching mathematics by leading to important changes in content presentation; it can generate conversations about how language should be used to describe the progression of students; with the use of new tools and technologies, it can produce new speculations about mathematics; and the very fundamentals of mathematics can be tested (Confrey, 2011).

Von Glasersfeld’s theories have been put into practice. One example is a study done by Yackel and Cobb (1990). The main goal of their research was to test if their
method of teaching mathematics was consistent with the National Council of Teachers of Mathematics’ (NCTM) standards:

- Knowledge must be constructed by each individual knower
- Knowledge is not simply transferred to the student
- Ways of thinking have to be developed by the student
- Students must be allowed to and encouraged to find their own way of constructing knowledge (Yackel & Cobb, 1990).

In agreement with van Glasersfeld’s recommendations, the researchers set their goal by having students cultivate mathematical ideas and connections in ways that are personally meaningful (Yackel & Cobb, 1990). They also emphasized students working in collaboration to find understanding since they believed that even though each student will construct his or her own understanding, they should not do so in isolation. Collaborations both with other students and their instructors provide for vital learning opportunities (Yackel & Cobb, 1990). They further said that collaborative learning between students creates emerging explanations that are meaningful to others and trying to understand another’s ideas and solutions aid the students as they progress (Yackel & Cobb, 1990).

In this same study, the instructor’s role was defined as a facilitator who subtly emphasized selected facets of the students’ mathematical contributions (Yackel & Cobb, 1990). At the conclusion of their research, Yackel and Cobb found that their teaching method was consistent with the NCTM standards in alignment with van Glasersfeld and
that the students and instructors alike enjoyed the experience and found it to be a positive experience (Yackel & Cobb, 1990).

Radical Constructivism is not embraced by all. Some think of it as “denying reality,” having no usefulness in actual teaching and therefore irrelevant to the classroom, and is only useful for philosophical concerns (Steffe, 2010). These opinions are likely based on a misunderstanding of radical constructivism. Steffe explained the importance of radical constructivism in that neither radical constructivism nor social constructivism gives us a set theory for science or mathematics education; the purpose of these theories are decidedly useful in making explanatory second-order models of teaching and learning that are foundations of the experience of teaching students while concurrently being directed and constricted by the general models (Steffe, 2010). A second-order model is the teacher’s attempt to understand a learner’s experience (Steffe & Gale, 1995).

Steffe also suggested that those who reject or criticize radical constructivism do so “as an attempt to further entrench materialism and commonsense realism as the mainline philosophical system in science and mathematics education” (Steffe, 2010, p. 118). Whatever the reason, as educators we all need to deeply consider and study all viable theories in order to improve our teaching and everyone’s learning; or as Dewey stated: “If dogmas and institutions tremble when a new idea appears, this shiver is nothing to what would happen if the idea were armed with the means for the continuous discovery of new truth and the criticism of old belief” (Dewey, 1999, p. 76).

**Lev Semyonovich Vygotsky.** L. S. Vygotsky was born in 1896 in Orsha, Russia, and died in 1934 in Moscow, Russia. He was a psychologist specializing in linguistics
and philosophy at the University of Moscow before turning his focus to psychological research. He was a leader in Soviet psychology where he studied human consciousness as it relates to the development of cultural factors. He developed theories in mathematical signs and their role in the development of speech. His work does not, however, apply only to language. Vygotskian perceptions have influenced many different areas of education, including evaluation, computers and technology, multicultural education, math and science education, and peer collaboration (Winsler, 2003). Vygotsky has been credited as the father of social constructivism from his beliefs in the use of social interaction as an important part of learning (Powell & Kalina, 2009). Social constructivism is defined as a variation of cognitive constructivism that stresses the collaborative nature of learning (McLeod & Adams, 1989). Vygotsky believed that collaboration is not only defined as interaction between teachers and students, but also between peers (Tzuriel & Shamir, 2004, p. 144). He differentiated himself from cognitive constructivists such as Piaget and Perry in that he believed that it was impossible to separate learning from its social environment because all rational functions begin and occur in social settings (Vygotsky & Cole, 1978).

Despite the fact that he died almost 80 years ago, his work is still prevalent and relevant in education; Vygotsky spoke to us from the future and although his writings were authored over 70 years ago, they couldn’t have more modern-day relevance (Winsler, 2003). Additionally, about 70% of all accessible research throughout history on Vygotsky and education has transpired during the last 10 years (Winsler, 2003). His
theories are also considered constructivist in thought even though they predated the constructivist movement because his theories helped lay the groundwork for constructivism (Jaramillo, 1996). Furthermore, he was also a classroom teacher, which gave him a valuable perspective in connecting theory to practice (Jaramillo, 1996).

One of the main themes in Vygotsky’s social constructivist theories is the Zone of Proximal Development (ZPD). “Teachers of the Vygotsky mold must foster learning among students that combines internal and external experiences . . . The surrounding social nature of learning encompasses the student’s interactions with other peers and the instructor” (Jaramillo, 1996, p. 137). Vygotsky himself said that one’s mind is not contained solely in one’s body, it projects beyond itself and is joined inseparably with others minds (Wertsch, 1991). He also explained ZPD in saying that it is the difference between what one can do with others and what one can do by oneself (Holzman, 1995).

Peer tutoring is especially beneficial for students who generally fail to learn in the classroom (Holzman, 1995). Vygotsky focused mainly on children but all people learn progressively by engaging in activities they don’t already know how to do (Holzman, 1995). A study at the Barbara Taylor School in New York City based its theories in Vygotsky and about developmental learning. Developmental learning was defined in this research as learning that continuously creates development and what Vygotsky denoted as learning leading development (Holzman, 1995). Specifically, in mathematics, learning leading development is valuable because:

One reason that repeated attempts to teach a child who is ‘not good in math’ or is ‘math phobic’ the mechanics of multiplication—in the absence of creating an
environment for the child to perform as a mathematician—typically produce failure. (Holzman, 1995, p. 204)

Holzman provided an example of ZPD from an experience she had with David, a student at her school. She defined the use of ZPD in this case “to highlight the subtlety, complexity and ordinariness of creating an environment for developmental learning, a ZPD, for mathematical meaning-making” (Holzman, 1995, pp. 206-207). In this example, David was asked how he had previously been taught math before he enrolled at her school. He stated that he learned from textbooks and he was routinely bored and didn’t learn much (Holzman, 1995). The learning director, Holzman, and a peer worked together on mathematics exercises with David and in the end, he felt as though he was learning math and understood it. This is an example of creating a successful learning environment via ZPD. Holzman continued by stating that it is important to create these environments, using cooperative learning and peers, to make meaning together, especially in teaching math since beginning early in life children in our society are deprived of opportunities to make their own meaning (Holzman, 1995). Peers are useful in this regard since the use of peers creates an environment of shared discovery rather than the feeling of a teacher imposing the material at hand; this creates a more relaxed atmosphere for tutees (Holzman, 1995).

Berger (2004) did research on how college and university students understand mathematical signs. She derived her hypothesis directly from Vygotsky’s theory of how children learn words. She drew the following parallel:
Using an analogy with Vygotsky’s theory (1986, 1994) of how a child learns a new word, I argue that a learner uses a new mathematical sign both as an object with which to communicate (like a word is used) and as an object on which to focus and to organize her or his mathematical ideas (again as a word is used) even before she or he fully comprehends the meaning of this sign. (Berger, 2004, p. 81)

She defined a sign for her research as mathematical symbols, statements, expressions and names of objects (Berger, 2004).

Berger’s main consideration in this study was to find “how a student constructs personal meanings and develops usages of mathematical signs which are compatible with the culturally established meanings and usages of those signs” (Berger, 2004, p. 81). She posited that university-level students are expected to derive their own meaning of mathematical signs from diagrams and given definitions. Her rationale was based in the Calculus Reform and Back-to-Basics Movements and how skill and understanding are linked. Berger posited that the Back-to-Basics Movement emphasized that if a student could successfully perform mathematical procedures then that is proof that the student has a deep understanding of mathematics, and so a high skill level is equal to a high level of understanding (Berger, 2004). Berger’s purpose was to show that math skills and learning are not separable.

Another direct application she used from Vygotsky was when a student is able to use the function of a mathematical sign in a social setting, it leads to personal meaning making in conjunction with the sign’s cultural meaning (Berger, 2004). She also cited his
belief that understanding is situated in the social world and ZPD and applied that to mathematics such as when a student sees something new in math that he or she has never before experienced, that new symbol has little or no meaning for the student but with the use of ZPD the student can be guided to use that symbol and start to form a meaning for it through communication with others (Berger, 2004).

In sum, Berger believed that a mathematical sign that is new to the student before he or she “fully understands how to use that mathematical sign in a culturally meaningful way” can be understood by the student (Berger, 2004, p. 86). In order to test her thesis, she interviewed several freshman-level university students. The students were given a mathematical sign that was new to them and then gave them a definition and exercises to do. The students were allowed to use a textbook, if needed. She used a ZPD environment in her interviews. The interview was constructed so that it imitated certain facets of a university student’s where he would often use mathematics to function with few mediations by instructors or peers (Berger, 2004). After analyzing her data, Berger believed that she showed how the ZPD is related to functional uses of signs (Berger, 2004). The particular student she used as an example showed that he used mathematical signs before he understood their meaning by using them as a means of communication and also as a tool to order his mathematical ideas (Berger, 2004). A possible example of this may be asking a student to do an exercise involving pi using the symbol, π. A student can easily find pi on his or her calculator and push it to complete the exercise without knowing its meaning.
From the theories of Vygotsky, Feuerstein and others developed a model known as Peer Mediation with Young Children (PMYC). “The PMYC program . . . is based on two theories: the sociocultural theory of Vygotsky, especially the concept of zone of proximal development, and the mediated learning experience theory” (Tzuriel & Shamir, 2004, p. 144). They based their theory of mediated learning experience and cognitive modifiability on Vygotsky’s model of ZPD. They defined cognitive modifiability as a person’s ability to learn from new educational encounters that can alter their ways of thinking and processing by a combination of seeing new information and by learning in a guided environment (Tzuriel & Shamir, 2004). One of the main tenets of Feuerstein, Rand and Hoffman’s theory is that when a mediator has more experience they are more successful in determining the level a student is operating at and how to aid the student at an appropriate rate (Tzuriel & Shamir, 2004).

PMYC was a peer tutoring model based on their prior investigations of tutor and tutee relationships (Tzuriel & Shamir, 2004). They drew on Vygotsky with their own variation: “According to Vygotsky the novice internalizes the shared cognitive processes and uses it later independently in other problem-solving contexts. Our approach is based on Vygotsky with one modification: the importance laid on cognitive development of the expert” (Tzuriel & Shamir, 2004, p. 160).

Tzuriel and Shamir used five of the principles developed by Feuerstein, Rand, and Hoffman’s model for peer tutoring (aka peer mentoring): (a) Intentionality and reciprocity; (b) Transcendence; (c) Meaning; (d) Feelings of competence; and (e)
Regulation of behavior (Tzuriel & Shamir, 2004). I give a brief description of the first four, since the fifth principle does not apply to my own research.

1. Intentionality and reciprocity: Mediators must intend to use the interaction with learners as a means of producing cognitive change in the learners, either verbally or non-verbally;

2. Transcendence: Encourage the search for solutions, characteristics considered essential for learning how to learn and cognitive modifiability;

3. Meaning: Mediation for meaning refers to interactions in which the mediator emphasizes the affective-motivational and value-oriented characteristics of the stimuli by expressing their importance, significance, and worth . . . meaning will actively attach meaning to new information rather than passively waiting for meaning to come;

4. Feelings of competence: Refers to an interaction in which a mediator provides feedback and arranges the environment so that the learner perceives him/herself as capable of functioning successfully and independently (Tzuriel & Shamir, 2004).

Using these principles in their study, the authors found that PMYC benefited both the tutors and the tutees. The research found that the perception level of either the tutors or the tutees were positively associated with their cognitive transformability as gauged by dynamic assessment (Tzuriel & Shamir, 2004). Dynamic assessment is defined as assessment of thinking, perception, learning, and problem solving by an active teaching
process within the test aimed at modifying cognitive functioning (Haywood & Tzuriel, 1992, 2002; Lidz & Elliot, 2000; Sternberg & Grigorenko, 2002, Tzuriel, 2000, 2001).

A benefit for the tutors was found in that tutors who were part of the PMYC model showed more improvement in cognitive transformation than did those who were engaged in a general peer tutoring program and it was found that the peer tutors in the PMYC program became better learners (Tzuriel & Shamir, 2004). Two significant benefits were shown by the tutees.

The findings of the learners’ group are also intriguing as they show that the PMYC program had an effect on learners who themselves did not participate in the intervention but were taught by mediators who participated in the program . . . The learners who were taught by their experimental peers showed a higher pre- to post-teaching improvement on the serration tasks than did their peers who were taught by control mediators. (Tzuriel & Shamir, 2004, p. 160)

Another trend was discovered by Tzuriel and Shamir in analyzing their PMYC program. They found that:

In the low-functioning learners group, giving of mediation for meaning was higher among experimental than among control mediators, whereas requesting of mediation for meaning was higher among learners taught by experimental mediators than among learners taught by control mediators. (Tzuriel & Shamir, 2004, pp. 160-161)
Behaviorism

Behaviorism consists of a combination of several other learning theories of theorists such as Thorndike, Tolman, Guthrie, Hull, and Skinner (Ormrod, 1995). The credit for its development is attributed to Watson in the beginning of the 20th century (Merriam, Caffarella, & Baumgartner, 2007). There are three basic assumptions associated with behaviorism: (a) Learning is an observable behavior and is manifested by a change in behavior, not based on internal thought; (b) One’s environment shapes behavior; and (c) The learning process is defined by the time between events and reinforcement of desired behavior (Grippin & Peters, 1984).

Behaviorist orientation has been foundational to much educational practice including adult learning . . . The teacher’s role is to design an environment that elicits desired behavior toward meeting these goals and to extinguish undesirable behavior . . . behavioral objectives that specify the behavior to be exhibited by learners after some intervention direct much instructional planning even today. (Merriam et al., 2007, p. 280)

For this study, Gagne was chosen for the behaviorist orientation since he has the most applicability to mathematics as is explained next.

**Robert M. Gagne.** Robert Mills Gagne was born in North Andover, Massachusetts, in 1916 and after 50 years of teaching and research, died in 2002 in Signal Mountain, Tennessee. He earned his bachelor’s degree from Yale in 1937 and his PhD from Brown University in experimental psychology in 1940. He was an instructor at Connecticut College for Women, The Pennsylvania State University, Princeton
University, The University of California at Berkeley, and Florida State University. He was also the director of research for the American Institutes for Research as well as working with the U.S. military as a National Research Council Senior Fellow at the Armstrong Laboratories for the United States Air Force (Dempsey, 2002).

Through his writings and teaching, Gagne influenced thousands of instructional designers and educational psychologists, many personally as well as professionally. While Gagne’s earlier efforts were firmly grounded in the behaviorist tradition, his later work was influenced by the information processing view of learning and memory (Dempsey, 2002, p. 365).

Gagne was a major contributor to the “learning how to learn” paradigm (Merriam et al., 2007). Learning how to learn “involves possessing, or acquiring, the knowledge and skill to learn effectively in whatever learning situation one encounters” (C. Smith & Bath, 2006, p. 19). This led to the concept of social cognitive learning theory where it is thought that a great deal of human learning happens within social environment and by interaction with other people, rules, skills, knowledge, and the like are understood (Schunk, 1996).

Gagne’s theories relate directly to what is lacking in current studies of tutoring; he wrote in an article with William Rohwer:

The findings of many studies of human learning presently cannot be applied directly to instructional design for two major reasons: (a) the conditions under which the learning is investigated, such as withholding knowledge of leaning goals from the subject and requiring of responses, are often unrepresentative of
conditions under which most human learning occurs; and (b) the tasks set for the learner appear to cover a range from the merely peculiar to the downright esoteric. (Gagne & Rohwer, 1969, p. 141)

Although this was written more than 44 years ago, it still applies to tutoring in that, as discussed in Chapter 1, the personal communication and relationships involved in peer tutoring are greatly under researched. Gagne suggested a model of instruction based on conditions that are present during teaching a lesson. These events apply to a tutoring environment as well as the classroom. The eight conditions are: (a) Keep the student’s attention; (b) Provide direction verbally and encourage recollection to provide training; (c) Use visual stimuli; (d) Use verbal prompting and guiding; (e) Provide rules for responding by the students; (f) Provide feedback to the students as they progress; (g) To encourage retention, employ repetition and practice; and (h) Show how the knowledge can be used in other environments (Gagne & Rohwer, 1969).

Gagne also posited three elements in the direction and preparation of learners. These are verbal directions, pre-training, and recall of relevant past learning (Gagne & Rohwer, 1969). After he did extensive research in all three of these areas, he concluded that, “Thus far, priming is alone among methods of demonstrable use in stimulating relevant recall. In all cases, much additional research is needed, especially with tasks designed to mirror those commonly involved in instruction” (Gagne & Rohwer, 1969, p. 391). His theory on prompting and learning guidance can be directly applied to tutoring. Gagne stated that learning with assistance is a valuable instructional technique and can be applied to a number of different learning tasks (Gagne & Rohwer, 1969). The one
element in this theory that seems to most directly apply to tutoring mathematics is “in rule learning,” due to the fact that much of mathematics involves understanding rules and properties (i.e., the associative properties, the zero-product principle, etc.). In rule learning, guidance can provide verbal cues which speed the acquisition of rule-governed behavior by limiting symbolic exploration. A number of studies reminds us, though, that too much guidance or over prompting may narrow the limits of what is learned beyond what is most desirable for learning transfer (Gagne & Rohwer, 1969).

Gagne found two elements were among the most important in the transfer of information in learning guidance: (a) Communicating the learned rules by speech and (b) The uses of various examples in the learning of rules and ideas (Gagne & Rohwer, 1969). He reiterated in the conclusion that “additional evidence of their (the aforementioned elements) effectiveness in facilitation breadth of transfer is valuable, particularly when they can be so directly applied in the design of instruction” (Gagne & Rohwer, 1969, p. 41).

In the journal article, Preparing the Learner for New Learning, Gagne (2001) spoke of the necessity of the learner to be prepared in order for learning guidance to be effective. He wrote:

Learning guidance can often make the greatest difference between learning that is facile and learning that is hard; and also between learning that is relatively effective and learning that is ineffective. It is a significant fact, however, that learning guidance cannot usually be adequately planned without taking full account of the preparation of the learner. (Gagne, 2001, p. 6)
Summary. Gagne posited that students who were not able to understand a concept could be identified by having students who did understand raise their hands. He also suggested that an electronic system of response could be installed in classrooms where students would indicate their understanding by pushing a yes or no button. However, not all students would follow these procedures and they would take up valuable class time (Gagne, 2001). If these systems could be instituted, however, he suggested that “the identity of students who were unable to recall the necessary prerequisites would then be immediately apparent, and individual tutoring could be undertaken” (Gagne, 2001, p. 7).

One application of Gagne’s learning theory was reported by Lawson (1974) in regards to technical instruction. This author said that:

Gagne asserts that difficulties in learning, as well as their correlates in instruction, may often be attributed to overlooked prerequisites, i.e., a trainee will not be able to conceptualize examples of “activities” and “events” until he or she initially shows ability for distinguishing between the two terms. (Lawson, 1974, p. 32)

This applies to mathematics as well, since in many instances one concept is built upon a preceding one. For example, in order to solve a division problem, one must first be able to multiply (in real numbers); Gagne thought that critical subtasks must first be mastered in order for a trainee to rise to higher levels of standard performance (Lawson, 1974). In order to achieve this, Lawson interpreted this as necessary for teachers to provide sufficient practice periods (Lawson, 1974).
Tutoring and Peer Tutoring in Higher Education

Based on research in tutoring at the university and college levels for this study, four elements are important to consider: (a) Adult learning styles, (b) Characteristics of tutors and tutees, (c) Tutoring process, and (d) Types of tutoring programs in United States Colleges and Universities.

Adult Learning Styles

First, an adult student can be defined as one who is equally as likely to be either a woman or a man who has successfully completed high school and is less than 40 years old (Merriam et al., 2007). Adult learning styles are based on andragogy which was developed by Malcolm Knowles in 1984 and is thought of as, “the characteristics of adult learners that are different from the assumptions about child learners, on which pedagogy is premised” (Gom, 2009, p. 19). Minter suggested a composite of adult learners. Adults are self-directed, have previous experience, are driven by what they need to know, direct their learning goals, desire instructors who are student-centered. Tenets for adult learners differ from those needed for pre-adult learners (Minter, 2011). One major difference between pre-adult learners and adult learners is that adult learners have experience in the “real world.” They typically have a level of maturity that can be seen by a showing of self-awareness, self-confidence, and better problem-solving skills (Newman & Peile, 2002).

Two models of adult learning emerged over the years, expectancy-valance and force-field-analysis (Gom, 2009, p. 20). “Expectancy relates to different expectations and levels of confidence adults have about what they are capable of doing (and) valence
refers to the emotional orientations people hold with respect to rewards” (Gom, 2009, p. 20). In that, adult learners have a different motivation for learning; they work towards a set goal and are motivated by the value they perceive in achieving that goal (Gom, 2009). Another characteristic that differentiates adult students from pre-adult students is that adults show different patterns of learning: They tend to have unique goals and may pursue them at different times for their own, specific reasons which are different from pre-adults (Gom, 2009). This can be understood best by examining the characteristics of tutors and their students.

**Characteristics of Tutors and Tutees**

Harootunian and Quinn (2008) studied college-level math tutors and identified three types of tutors: the pragmatist, the architect, and the surveyor. They stated that:

The pragmatist views tutoring as a series of organized events . . . The architect views the study of math as finding pieces of information that create the steps necessary to solve a particular problem . . . Like a surveyor, this math tutor examines the mathematical terrain and creates maps, charts, and diagrams to provide his tutees with visual representations of the landscape. (pp. 15-17)

The authors emphasized that it is important to be able to recognize these types and build upon each one’s strengths as they apply to each individual tutor. In addition to this typology, it was the purpose of this study to investigate and potentially broaden the field of the descriptors of tutoring sessions.

In one of the few qualitative studies, V. Smith (2011) looked at the relational skills that are desirable in university tutors. Her study revealed important characteristics
in tutors according to tutees. She listed in her findings the following: Acceptance, affirmation, encouragement, support, openness, genuineness, self-disclosure, empathy, a sense of equality, and demonstrating a positive attitude. In addition, affording a secure, accommodating learning atmosphere was found to be important (V. Smith, 2011). Smith discovered that there was a definite alignment in focus groups of tutors and tutees showing that relationships do have a substantial influence on the learning event (V. Smith, 2011). Another study also stated that critical thinking skills and subject expertise are highly valued by tutees (Jelfs, Richardson, & Price, 2009).

The reasons that tutees seek tutoring services are varied yet the majority seek services because they require academic support (Kersaint et al., 2011). However, not all college students take advantage of available tutoring services. Reasons for this may include a lack of time due to family and/or work-related issues (Kersaint et al., 2011). Other studies found that tutees feel threatened and avoid seeking help. These threat factors include academic low self-efficacy, high instructor expectation, lack of confidence, and threat to self-esteem (Karabenick & Knapp, 1991; Newman & Goldin, 1990; Ryan, Gheen, & Midgley, 1998).

**Components of the Tutoring Process**

This section examines what the literature proposes as “typical” tutoring models. Suggested activities include the following components: students are to be asked what they do not know followed by guiding students to form correct conceptions of mathematics (Xing et al., 2012). Another model that has appeared in the literature is comprised of the following elements: selecting appropriate tutors, emphasizing guidance
continuity, and examining the method of the tutor system, including monitoring the
effectiveness of tutors (Xing et al., 2012).

Kersaint and others suggested two other models of the tutoring process. Their
rationale was intent and the engagement of the tutors in providing learning support
(Kersaint et al., 2011). In one model the tutors are actually instructing the students while
the other model emphasizes assistance. The first model was called instructional tutoring
and was defined by the following activities:

a) Analyze the assignment in terms of learner skills needed to complete the
assignment;

b) Analyze the student’s current level of skill and strategy knowledge;

c) Instruct the student through explanation, modeling, and guided practice in
relevant skills, strategies and content knowledge that the student can use to
complete similar tasks in the future;

d) Provide sustained corrective feedback and;

e) Provide immediate support for current assignment to keep the student
academically “afloat” while the student develops proficiency as an independent
learner. (Kersaint et al., 2011, p. 26)

The second model was known as assignment-assistance tutors and had the following
elements:

a) Provide small-group or one-to-one homework assistance;

b) React to the demands of the general curriculum and review content with the
student;
c) Provide feedback on student performance and;

d) Make little or no systematic attempt to teach skills and learning strategies relevant to the homework assignment at hand and generalizable to similar assignments in the future (Kersaint et al., 2011).

Kersaint et al. formed these two different styles due to the fact that vast differences exist in the methodologies used to provide tutoring in terms of venue, students to be aided, and the location where the tutoring took place.

**Delivery Systems of Peer Tutoring Programs in United States Colleges and Universities**

Three types of peer tutoring are online tutorial services, reciprocal peer tutoring, and one-on-one nonreciprocal tutoring. The following is a brief description of each including an example of each.

**Online tutorial services.** Online tutorial services are a recent development in peer tutoring. In recent years, information technology has permeated peer learning in various ways (Topping, 2007). There are two types of interaction used in online tutoring services, synchronous or real time and asynchronous or delayed time (Kersaint et al., 2011). In a synchronous environment, real-time interaction allows the simulation of a real classroom learning situation and immediate, interactive clarification of meaning while asynchronous allows the tutee to review contents of a session at a later time (Goodyear, Jones, Asenio, Hodgson, & Steeples, 2005).

In one study, a tutoring system called NetTutor was used. NetTutor works by pairing tutees with a trained tutor who has experience as a tutor in addition to a master’s
or doctoral degree in mathematics (Kersaint et al., 2011). The tutees in this example were able to communicate synchronously or asynchronously. It was found that students using this online tutoring service showed greater improvement in college algebra than did the students who did not use the service; however, the researchers observed that despite existing research in this area, more is needed to determine “in what ways do the quality of tutor-tutee interactions and learning experiences differ in online versus face-to-face settings?” (Kersaint et al., 2011, p. 39).

**Reciprocal peer tutoring.** In reciprocal peer tutoring (RPT), “students function equally both as tutor and tutee . . . a well-designed procedure provides students with essential feedback” (Dioso-Henson, 2012, p. 34). The procedure used for RPT in the Dioso-Henson study was:

1) Perform a pre-test to assess the academic competence of the class and as a basis in choosing group members;

2) Orient the class on peer tutoring and discuss the guidelines on the format of the process;

3) Upload of instructional materials;

4) Lecture and solve sample exercises (1st meeting);

5) RPT activity for 30 minutes (2nd meeting) with randomly paired students;

6) Collect feedback. (Dioso-Henson, 2012, p. 39)

Although RPT has shown some positive effect for tutoring, it has its limits. Teachers may not regularly carry out their roles in the peer tutoring process with
satisfactory precision and students were not accurately directed to develop items according to cognitive difficulty (Dioso-Henson, 2012).

One-on-one peer tutoring. One-on-one peer tutoring is characterized by specific role-taking (tutor or tutee) and high focus on curriculum content (Topping, Miller, Murray, & Conlin, 2011). The process in a study by Topping and others used what is known as the Duolog Math technique and followed an eight step process:

1) Read the problem out loud;
2) Listen;
3) Check for the correct response;
4) Praise and encourage;
5) Pause for Think-Aloud—give the tutee time to think;
6) Question—ask helpful and intelligent questions which give clues;
7) Make it real—try to make the problem seem real and related to the tutees life;
8) Summarize and generalize key strategies. (Topping et al., 2011, pp. 578-579)

According to Duch, Gron and Allen (2001), peer tutoring is a very valuable resource when implemented and done well; peers are often considered the most powerful influence in undergraduate education, even more so than advisors and instructors. The need for better mathematics teaching and learning may rely on successful intervention such as peer tutoring provides. It is highly doubtful that the need for college mathematics remediation will vanish. Since it is the responsibility of instructors to guide all students toward success, students enrolled in remedial classes need the best instruction and curriculum that is possible to provide (Hagedorn et al., 1999).
Measuring Proficiency in Mathematics

In order to answer how successful mathematics peer tutoring programs are, it is necessary to examine what it means to be mathematically proficient. The National Academy of Sciences (NAS) published a text describing the five components of what it means to be mathematically proficient in teaching and learning mathematics. Five interconnected elements were identified for students to be proficient in mathematics as well. These elements are:

1. Conceptual understanding of the core knowledge required in the practice of teaching;
2. Fluency in carrying out basic instructional routines;
3. Strategic competence in planning effective instruction and solving problems that arise during instruction;
4. Adaptive reasoning in justifying and explaining one’s instructional practices and in reflection on those practices so as to improve them; and

It is necessary to measure a mathematically proficient student if a peer tutoring intervention is successful. The NAS defined proficiency in mathematics as:

Proficiency in teaching (mathematics) is related to effectiveness: consistently helping students learn worthwhile mathematical content. Proficiency also entails versatility: being able to work effectively with a wide variety of students in
different environments and across a range of mathematical content. (National Academy of Sciences, 2001, p. 369)

Even though this report centered on teachers, it is applicable in a peer tutoring application as peer tutors, in tutoring, are in fact acting as a kind of teacher.

In chapter 10 of the NAS study, *Developing Proficiency in Teaching Mathematics*, the NAS discussed what is necessary for one to teach for proficiency in mathematics, the knowledge base for teaching mathematics, and a framework for looking at proficient teaching of mathematics (National Academy of Sciences, 2001).

Three types of knowledge were said to be necessary for successful teaching of mathematics, according to the NAS. These are: (a) Knowledge of mathematics, (b) Knowledge of students, and (c) Knowledge of instructional practices (National Academy of Sciences, 2001). Following are explanations of each type of knowledge.

1. Knowledge of mathematics: *Mathematical knowledge* includes knowledge of mathematical facts, concepts, procedures, and the relationships among them; knowledge of the ways that mathematical ideas can be represented; and knowledge of mathematics as a discipline—in particular, how mathematical knowledge is produced, the nature of discourse in mathematics, and the norms and standards of evidence that guide argument and proof.

2. Knowledge of students: *Knowledge of students* and how they learn mathematics includes general knowledge of how various mathematical ideas develop in children (students) over time as well as a specific knowledge of
how to determine where in a developmental trajectory a child (student) might be.


Thus the definition of mathematically proficient teacher (tutor) and understanding (tutees) were the standard in which the tutoring was observed and rubrics designed within the present study. The NAS also suggested that communities of practice, including people who are specialists in mathematics, and effective professional development programs that are adept in “helping teachers understand the mathematics they teach, how their students learn that mathematics, and how to facilitate that learning” (National Academy of Sciences, 2001, p. 398) are needed.

These elements in future and present mathematics teachers (tutors) are important because: “If their students are to develop mathematical proficiency, teachers must have a clear vision of the goals of instruction and what proficiency means for the specific mathematical content they are teaching” (National Academy of Sciences, 2001, p. 369).

The Conference Board of Mathematical Sciences (CBMS) published a report in 2012 that also discussed the importance of the knowledge of mathematics teachers in order for them to be effective. This report states that college mathematics courses should
prepare future mathematics teachers at any level to be life-long learners of mathematics, not to simply teach them what they “need to know” (CBMS, 2012).

This same report emphasized the importance of collaboration between mathematics departments, mathematicians, and mathematics education professionals. “Collaboration with others in mathematics education has allowed mathematicians to have a major impact on professional development” (CBMS, 2012, p. 16). Through this, concerned mathematicians have grown in expertise and awareness of the challenges existing in bettering mathematical learning in schools and hopefully this will create better math teachers and students in the future (CBMS, 2012).

The Ball and Hill model of mathematical knowledge (Hill, Ball, & Schilling, 2008) for teaching is essential to tutoring as well. For, if the tutor only has knowledge of mathematics but lacks the ability or knowledge to uncover how students are thinking, they will not be successful. The authors examined not only at teachers’ content knowledge, but also what else teachers may know about teaching mathematics and how that could identify teacher qualities.

In order to analyze an item and arrive at their answer, respondents should use knowledge of students’ thinking around particular mathematics topics, rather than purely their own mathematical knowledge, test-taking skills, or other processes (and) they (teachers) should not solely engage in mathematical reasoning when answering these items—they must also invoke knowledge of students. (Hill, Ball, et al., 2008, p. 378)
Their model was based on one developed in California in 2000 called the Mathematics Professional Development Institutes (MPDIs) which included mathematicians and mathematics educators in the design and execution of content-focused, comprehensive learning prospects for instructors (Hill, Ball, et al., 2008). The MPDIs included not only measuring the subject matter knowledge of math, but also student learning. At the conclusion of the KCS study by Hill, Ball, et al., they found that:

1. Teachers do seem to hold knowledge of content and students;
2. Verifying that such knowledge (of content and students) is distinct from pure content or pedagogical knowledge;
3. The type of multidimensionality that emerged—with items relying in different amounts on mathematical reasoning, knowledge of students, and perhaps even on a special kind of reasoning about students’ mathematical thinking—yields difficulties in the construction of parallel forms and teacher scores;
4. This domain remains under conceptualized and understudied; and
5. The very notion of ‘knowledge of content and students’ as knowledge needs further development. (Hill, Ball, et al., 2008, pp. 395-396)

**Summary**

The literature that was reviewed in this chapter demonstrates the importance of learning theory and mathematics education research that impacts the tutoring process. Many applications of these theorists have been cited in an almost innumerable number of studies; however, very few have used their theories in a qualitative study of peer tutors and tutees. I found very few studies on the interrelational skills of college and university
peer tutoring programs in general, especially in the United States. This review has also shown that there are many components to the tutoring process, and because of this, multifaceted data and analysis is imperative to study the peer tutoring experience.

Further study in the aforementioned area is of critical importance. As was mentioned in Chapter 1 of this writing, despite the wide availability of tutoring services in U.S. colleges and universities, the failure rate in mathematics among adult students is too high such as the fact that only one-fourth of remedial students earn a bachelor’s degree within eight years and of remedial math students, only 27% earn a bachelor’s degree (NCSL, 2013). Tzuriel and Shamir (2004) stated that a significant problem is that teachers are not afforded enough opportunities to interact with their students, and even when they may, the interaction is lacking and so the use of peer mediation may remedy this situation and would benefit both the students and the mediators.
CHAPTER III
METHODOLOGY

This chapter describes the methodology that was employed for this study. First, the purpose of the study and the research questions are reviewed. Next, the rationale for the research paradigm, the methods used to choose participants, and methods used to collect and analyze data are examined. Finally, possible limitations of the study are considered.

Purpose of the Study

The purpose of this study was to find the elements found desirable in peer tutoring programs at the university level as described by the participants. Tutoring in mathematics was chosen not only because there is a significant need for quality remediation programs in higher education, but also because mathematics is my discipline as mathematics faculty and a mathematics tutor for more than 13 years. The research questions of this study were:

1. What characteristics and behaviors as displayed by tutors and tutees are most desirable in higher education tutoring programs?
2. What common characteristics are observable between different math tutors and between different math tutees (as separate groups)?
3. How do various university stakeholders (university administrators, math department faculty) define success in university-level peer tutoring programs?

With this study, I hope to be able to inform tutoring programs so that they may become more successful as tutoring programs are a valuable source of student aid to
promote academic success. Tutoring programs help not only tutees but also tutors to be more successful in their coursework (Kersaint et al., 2011) and are a low-cost option to universities and colleges (Topping, 2007).

**Rationale for the Methodology**

This study utilized a qualitative design using observation, interviews, and questionnaires in order to collect data about the participants’ experiences and perceptions in their tutoring experience. Qualitative research was used to understand the nature of a setting and the experiences others have in this context. Qualitative research does not forecast what is to happen in the future; rather, it is an analysis that provides a depth of understanding for those who are interested in the events of a particular setting and time. Tutors and tutees bring a variety of perspectives to the tutoring process. In addition, various university stakeholders have differing definitions of successful tutoring programs. A qualitative approach to this study presented rich descriptions of the tutoring process to accurately describe the experience (Merriam & Associates, 2002).

The goal of this study was best achieved by using a qualitative methodology. Transcripts of observed tutoring sessions and interviews were read a number of times, then coded and analyzed for commonalities and differences among the participants.

Qualitative research focuses on how individuals construct reality in interactions with their social world (Merriam & Associates, 2002). I was interested in understanding the meaning an experience had for the participants: (a) How the experience was interpreted by the participants, (b) How their worlds were constructed, and (c) What meaning was attributed to this experience (Merriam & Associates, 2002). Overall, my
purpose was to understand how participants make sense of their experiences. Qualitative, interpretive research seeks to present an in depth, holistic interpretation of the topic being investigated (Merriam & Associates, 2002).

Basic, interpretive qualitative studies can be found throughout many disciplines and applied to those fields of practice and may be the most common form of educational research (Merriam & Associates, 2002). Constructivism is an underlying tenet of basic, interpretive qualitative analysis where the researcher is interested in understanding the meaning that one has for the topic he or she is studying (Merriam & Associates, 2002). “A central characteristic of qualitative research is that individuals construct reality in interaction with their social worlds” (Merriam & Associates, 2002, p. 37). This methodology collects data using interviews, observations, and questionnaires; the analysis of this data consists of finding recurring patterns as interpreted by the researcher and mediating this interpretation by the researcher’s understanding of the issue being studied (Merriam & Associates, 2002). The principal goal of basic, interpretive research is to understand how meaning is constructed and how individuals make sense of components of their lives and the world in which they live and to interpret the participants’ meanings (Merriam & Associates, 2002).

Data were collected by interviews, analysis of documents, and observation. Data analysis was done by identifying recurring themes that cut through the data. The themes are a mix of patterns supported by the data from the research. The overarching understanding was my understanding, mediated by my disciplinary perspective and of the
participants’ understanding of the experience being studied (Merriam & Associates, 2002).

For this study, observation was the main source of data with interviews and questionnaires. Three tutors and four tutees were observed and the weekly, scheduled sessions were audio recorded over a 5-week period. This practice was chosen in order to be able to collect the most detailed data possible. Combining this with field notes gave me a deeper understanding of the experience than could be ascertained from just conducting interviews. During observations, I could not only hear the interactions between the tutors and tutees, but could also observe facial expressions and body language.

In interviews of participants, I asked open-ended questions so as not to lead the participants to answers. Every interview was performed on a one-on-one basis to assure that the participants were engaged in the interview process. The emphasis of each interview was to understand the participants’ points of view. A total of seven questionnaires were used for this research: (a) Participants’ demographic backgrounds, (b) An exit questionnaire for both tutors and tutees concerning their experiences in tutoring, (c) Tutees’ high school mathematics course work, (d) Tutees’ family backgrounds in mathematics, (e) If tutees attended a public or private high school, (f) Tutees’ major program of study, and (g) Questions including: What is your major, How long have you been receiving tutoring, What are your plans after college, Do you enjoy math, and What do you think is an ideal tutoring situation? These questionnaires can be found in Appendices A and C.
Description of the Researcher

When I began teaching at the university level, I instructed business courses; this is where I discovered my love for teaching. About five years later, I pursued an opportunity to teach mathematics at a small, private college and found that I definitely preferred math instruction over business. This inspired me to continue along that path. As I was talking to a life-long friend about this, she pointed out that I had “kinda always been a teacher.” She reminded me that when we played school as children, I was always the teacher. Also, I was acting as a tutor in that I frequently helped my friends and fellow students with their homework from elementary school through my undergraduate studies. During my senior year of my first undergraduate degree program, I worked as a paid tutor of the college I attended and have continued to be a professional tutor for several years, tutoring high school through college-level mathematics courses.

Upon first learning about constructivism in my first course in my Ph.D. program, a light went on as I thought, “Yes, that is what I have been doing all these years!” I was so excited to finally have a name for my teaching beliefs that I stayed after class that evening to talk about this to my instructor. My constructivist thinking logically led me to use a basic, interpretive qualitative methodology for my research since it is based in constructivist theory (Merriam & Associates, 2002), and math tutoring is close to my heart. I personally struggled with mathematics in high school and had no one to help me. My high school did not offer tutoring, and when I asked my instructors to aid in my confusion, I did not connect with their thinking. I shed many tears and spent numerous hours in frustration trying to understand. When I entered college, I was nervous about
taking mathematics courses, but soon discovered that I did connect with my professors and understood the material. My sense of relief was almost palpable. From this experience, I found it important to try to help others who were struggling with their mathematics courses and I continue to do so. I understand how upsetting mathematics can be for some people, and having experienced that level of angst drives me to do what I can to help others overcome this anxiety. I believe that if a good tutoring program had been available at my high school, I would have been able to comprehend my mathematics classes better and would have had a greater level of success in understanding.

At the start of my research, I had to identify my presuppositions and assumptions about mathematics informed by my own experiences from what I had learned through the literature I had read in my Ph.D. coursework. These were: (a) Everyone can learn math; (b) Almost everyone hates math; (c) Most people have had a bad classroom experience in math in Kindergarten through 12th grade; and (d) Taking math classes makes most people unhappy.

**Research Site**

The research site was a large public Midwestern state university. This site was chosen because it reflected the demographics of most state universities. The percentage of students taking remedial math classes was similar to the national statistics as found in the university’s website as compared to the statistics reported by the National Conference of State Legislatures (NCSL, 2013).

The university in my study provided the resources and facilities of a large, diverse, research institution. The student body was comprised of more than 22,000
undergraduate students and 5,500 graduate students enrolled from all 50 states and 100 countries including males, females, where more than 10% are minorities in both undergraduate and graduate studies. The ethnicities at this institution included African Americans, American Indians, Asians, Hispanics, International, Multiracial, Native Hawaiian or Pacific Islander, Caucasian, Unknown, and Other.

More than 1,500 faculty members taught in 11 colleges. The colleges included applied arts, communication and information, architecture, education, arts, sciences, nursing, honors, and ROTC. Nearly 45% of the university classes had fewer than 20 students.

**Human Subjects Review**

Before collecting any data or doing a participant search, I submitted an application for approval to use human subjects in research to the Institutional Review Board of Kent State University, which was approved (Appendix D). Each participant then signed a consent form, which fully described the study and the participants’ rights and guaranteed their anonymity (Appendix D). A consent form for permission to record the participants’ tutoring sessions and all interviews was also provided and signed by all who participated (Appendix D). These forms provided informed consent by the participants. The tutors were compensated for participating in the study.

**Participants**

Intensity sampling was utilized and is a form of purposive sampling used in order to gather a pool of rich information. Intensity sampling is employed when the participants are sharing the same experience in an intense but not an unusual manner
(Raffanti, 2008). In this case, I mean intense in the sense of “earnest as activity, exertion, diligence or thought” (Dictionary.com, 2016). This method is appropriate for research based in qualitative analysis since all of the participants have experienced the events under study in such a way that aided me in developing a necessary understanding of the data to formulate an accurate composite description (Raffanti, 2008). Purposeful sampling is defined as a sample from which the most can be learned and must begin with what criteria are essential for the study (Patton, 1990). The essential criteria for my sample were that the tutees were engaging in tutoring by their own choice in undergraduate mathematics at the institution, and tutors who worked in the existing math tutoring program and were pursuing a mathematics or mathematics education degree. Also, the tutoring sessions had to be scheduled, individual tutoring. These participants were chosen by recommendation of the administrator of the math tutoring program.

Since the choice of participants was done in this fashion, it may have limited the characteristics and behavior variety I would have preferred to see in my study including a mix of traditional and non-traditional students as all of the participants in my study were traditional students. I observed undergraduate math tutoring sessions with the permission of the tutors, tutees, and persons working in the math labs where tutoring took place. In the non-computer lab tutoring setting, three tutors and four tutees were observed. At the beginning of my study, there were four tutors and five tutees, but the tutee never came to his appointed tutoring times and was removed from the tutoring program. The ALEKS (Assessment and Learning in Knowledge Spaces is a Web-based, artificially intelligent assessment and learning system; McGraw-Hill Education, 2013) computer lab offered
walk-in tutoring, but after talking to tutors who worked in the lab where I would have observed, I was told that few students used this lab at the site of my research and those who did rarely, if ever, asked the tutors for assistance. Therefore, I did not include the ALEKS lab in my research. All of the tutees that I observed in one-on-one tutoring were enrolled in mathematics classes and consisted of traditional students. The tutors were mathematics or mathematics education majors.

In addition, the department chair of mathematics, director of tutoring programs, math faculty, and the dean of Arts and Sciences were interviewed. These participants were chosen because they were all connected to the mathematics program at the university. They were asked questions regarding their beliefs and expectations for a university tutoring program. These interviews were audio recorded and transcribed and took approximately one half hour in length. A summary of demographic information (education and experience) for all of the participants can be found in the following subsection (see Tables 1, 2, and 3).

**Faculty and Staff**

F/S1 had a BA, MA, and PhD in mathematics. He taught and tutored mathematics for 41 years at the university level and has been a mathematics professor for 17 years. He was a department chair at the university where this research was conducted.

F/S2 had a BS and PhD in biology. He taught and tutored biology undergraduates for 38 years, beginning as a graduate student. He was a dean of Arts and Sciences at this university.
F/S3 had a BA and MA in mathematics and a PhD in curriculum and instruction. She taught mathematics for 40 years, 11 years at a high school and 29 years at the university level. She also coordinated and taught college algebra-level courses.

F/S4 had a BS and an MS in mathematics. He tutored levels of mathematics from basic algebra, calculus III, linear algebra, and others for 8 years and taught for one semester. He was the coordinator for academic program tutor management at the university and was the supervisor for the tutors in my study.

Table 1

Demographic Information for Faculty and Staff

<table>
<thead>
<tr>
<th>Participant</th>
<th>Education</th>
<th>Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>F/S1</td>
<td>BA, MA, PhD in Math</td>
<td>Taught and/or tutored math 41 years at the university level, mathematics professor 17 years</td>
</tr>
<tr>
<td>F/S2</td>
<td>BS and PhD in Biology</td>
<td>Taught or tutored biology at the freshman-senior level for 38 years, beginning as a graduate student</td>
</tr>
<tr>
<td>F/S3</td>
<td>BA and MA in Math, PhD in Curriculum and Instruction</td>
<td>40 years teaching math: 11 years at a high school, 29 years at the university level, coordinates and teaches college algebra level courses</td>
</tr>
<tr>
<td>F/S4</td>
<td>BS and MS in Math</td>
<td>Tutored math from Basic Algebra, Calculus III, Linear Algebra and beyond for the past 8 years, taught for approximately 1 semester, Coordinator for Academic Program Tutor Management (supervisor for T1-T3)</td>
</tr>
</tbody>
</table>
Tutors

T1 was majoring in aeronautical engineering and was a math tutor for 3 years. After completing her bachelor’s degree, she planned to take a short break from her studies and then pursue her master’s degree.

T2 majored in early childhood education. She had tutored mathematics for 1 semester. She planned to become an elementary school teacher after she finished her bachelor’s degree.

T3 was a math tutor for 3 years and was in his last semester as an applied mathematics major, with a focus in probability and statistics. He began his college career as a mathematics education major, but changed to applied math because he believed he could make more money with an applied math degree. After college, he planned to find full-time employment.

Table 2

Demographic Information for Tutors

<table>
<thead>
<tr>
<th>Tutor</th>
<th>Education</th>
<th>Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>Major: Aeronautical Engineering</td>
<td>Math tutor for 3 years; After college: Take a break then pursue a master’s degree</td>
</tr>
<tr>
<td>T2</td>
<td>Major: Early Childhood Education</td>
<td>Math tutor for 1 semester; After college: Elementary school teacher</td>
</tr>
<tr>
<td>T3</td>
<td>Major: Applied Mathematics, Probability and Statistics</td>
<td>Math tutor for 3 years; After college: Full-time employment</td>
</tr>
</tbody>
</table>
Tutees

S1 majored in psychology and received math tutoring for one semester. After college she wished to open a women’s shelter and help foster children find adoptive parents.

S2 majored in early childhood education and received math tutoring for one semester. After graduation, she aspired to finding a permanent teaching position and get married and have children.

S3 majored in early childhood education and received math tutoring for one semester. After graduation, she wanted to teach Kindergarten.

S4 majored in pre-nursing and received math tutoring for three months. After college she wanted to become a registered nurse.

Table 3

Demographic Information for Tutees

<table>
<thead>
<tr>
<th>Tutee</th>
<th>Major</th>
<th>Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Psychology</td>
<td>Received math tutoring for 1 semester; After college: Wants to open a women’s shelter and help foster and adoptive children</td>
</tr>
<tr>
<td>S2</td>
<td>Early Childhood Education</td>
<td>Received math tutoring for 1 semester; After college: Permanent teaching position, get married and have children</td>
</tr>
<tr>
<td>S3</td>
<td>Early Childhood Education</td>
<td>Received math tutoring for 1 semester; After college: Kindergarten teacher</td>
</tr>
<tr>
<td>S4</td>
<td>Pre-Nursing</td>
<td>Received math tutoring for 3 months; After college: Registered nurse</td>
</tr>
</tbody>
</table>
Setting

Drop-in tutoring was available throughout the day in the designated area on the first floor of the university library, and in the evenings at select residence hall locations and was free to the students. It was also offered by scheduling appointments with a tutor or online. For scheduled tutoring, there was guaranteed availability; most sessions were one-on-one, regular weekly assistance. Drop-in tutoring was available throughout the day in the designated area on the first floor of the university library, and in the evenings at select residence hall locations. Some advantages were convenient access from 9 a.m. to 10 p.m., tutees could ask one question or study for hours, and the tutees could check subject availability in advance. Students who preferred to receive assistance online from the comfort of their home or residence hall had the option of logging on to eTutoring. All university students automatically had free access to eTutoring services by visiting the Academic Success Center. This may have been useful because the students may log in from anywhere at any time, the assistance was in real-time, it provided asynchronous assistance, and tutors from across the state were available to help.

Data Gathering

Data were gathered through interviews, observations, and questionnaires of the tutors and the tutees. In this way, I was able to gather deep descriptions of phenomena and their locations (Kensit, 2000). The questions are found in Appendix A and have been validated by Houston and Lazenbatt (1996) in their research in peer tutoring. The questionnaire was comprised of 31 questions and was structured for both tutors and tutees. The amount of time the questionnaire took each participant to complete was less
than 30 minutes. Houston and Lazenbatt used this questionnaire in their study of undergraduate peer tutoring as it relates to independent learning and working in groups in mathematics and student attitudes towards peer tutoring (Appendix A).

Based on the responses from the participants, I probed for more detail about their experiences as mathematics students, peer tutors, and students who have used tutoring services (Raffanti, 2008). I asked the tutors these same questions, in order to try to determine which various learning and teaching theories they espoused. Each interview took between one and two hours, depending on the respondent (Englander, 2012). The interviews were scheduled at times convenient to the interviewees.

In addition to the aforementioned interview questions, the tutors and tutees were also asked to provide some demographic information in order to get further insight from each participant. Since many studies in mathematics that use demographics tend to focus on gender alone, my questions differed since other factors are also important (Cheema & Galluzzo, 2013). When gender is the only demographic used, it can be assumed that the only difference in students’ achievement in mathematics is based on gender (Cheema & Galluzzo, 2013). Therefore, in my study, the participants were asked several other questions (gender was indicated in the explication of the data): when they graduated from high school, how much mathematics they had in high school (what was their highest-level mathematics class), what mathematics classes they took at the university level, what were their career goals, were they undergraduates, and for only the tutors, how many semesters have they been a mathematics tutor? The faculty and staff
participants were also asked to briefly describe what they consider to be a successful tutoring program.

Before the interviews, I took care to set aside any prejudices or preconceptions of my own so as not to cloud the interviews (Raffanti, 2008) and then I bracketed my preconceptions (Miller & Crabtree, 1992) and attempted to abstain from any presuppositions. I bracketed my assumptions which were: (a) Everyone can learn math; (b) Almost everyone hates math; (c) Most people have had a bad classroom experience in math in Kindergarten through 12th grade; and (d) Taking math classes makes most people unhappy. I had to be sure to set those beliefs and assumptions aside as I did my research.

The interviews were recorded with consent of the participants. The use of interviews, questionnaires, and observation provided triangulation (Arksey & Knight, 1999; Holloway, 1997). During observations, I used audiotaping and memoing which were my field notes describing what I saw, heard, thought, and experienced during observations as well as my reflections of the experience (Groenewald, 2004). Memoing was guided by an observation protocol which consisted of 11 questions. This protocol was used by Bieda (2010) in her research where she observed middle-school mathematics students in their learning of proof-related exercises. This protocol can be found in Appendix B. Bieda’s study was based on her interest in students developing deductive thinking in mathematics, specifically in proofs, and how they justify and prove their answers and not just simply find a solution by imitating the teacher (Bieda, 2010). She observed students who were participating the Connected Mathematics Project (CMP) in
seven mathematics classrooms during exercises developed for students to show how they reach conclusions in proof-related tasks; these classes were led by teachers who were experienced in using the materials developed for CMP (Bieda, 2010). Although Bieda’s study was centered on middle school students, the questions she used for observation were useful for my study.

Field notes consisted of: (a) Observational notes, which annals what I observed and deemed important to record; (b) Theoretical notes which were my reflections on her observations; and (c) Methodological notes which are notes to oneself as reminders, instructions, or criticisms while observing (Groenewald, 2004). Field notes are valuable since humans tend to forget, so in using field notes, important data will not be lost but the researcher must be careful not to use judgment (Groenewald, 2004). In addition, field notes also helped me to recall my feelings at a later date (Groenewald, 2004).

Triangulation was first cited in 1948 by Foreman to establish validity; in the case of this research, multiple sources of data were used to confirm evolving findings (Merriam & Associates, 2002). Triangulation establishes validity by checking what is heard by the researcher and comparing that to other sources of information to find agreement; it increases the quality of collected data and checks the correctness of the researcher’s interpretations (Frankel & Wallen, 2007). Triangulation also provides for reliability in that by its use in qualitative research: “a qualitative researcher can use (triangulation) to ensure for consistency and dependability” (Merriam & Associates, 2002, p. 27). Concurrence of comments from interviews with tutors, tutees, and math
department staff served as sources of triangulation along with questionnaires and observation.

**Interviews**

For all interviews conducted, initially two questions were asked. This number of questions was chosen due to the fact that too many questions may result in the interviewer unconsciously leading the person being interviewed instead of directing the person through the process (Englander, 2012). Any questions after the first two were asked in order to glean more information from the interviewee based on his or her responses.

**Faculty/Staff (F/S)**

The first interviews were done with F/S. Each participant was interviewed separately and privately; each interview took about 30 minutes and were audio recorded and later transcribed. The goal of these interviews was to learn what the F/S thought defined a successful tutoring program and to get their personal perspectives and experiences with tutoring. The following questions were used as a guide for these interviews: (a) What characteristics and behaviors of tutors and tutees do you feel are most desirable and successful in higher education math tutoring programs? (b) How do you define success in a higher education math tutoring program? By engaging these participants in their interviews, I hoped to get specific information as well as personal anecdotes in order to provide deep insights from the participants.
**Tutors**

At the end of my observation period, I asked the tutors each two questions. Each tutor was interviewed separately and privately and were audio recorded and later transcribed. The questions were: (a) What is your philosophy for tutoring? (b) Why did you choose to become a tutor? The questions were constructed in order to learn how the tutors personally defined tutoring and what drove them to become tutors.

**Tutees**

There was one interview conducted with the tutees which was performed at the end of the semester in which they were being tutored. The question was, do you feel better about mathematics now than you did at the beginning of the semester? The reasoning for this question was to learn if they felt as though their tutoring experience was worthwhile and helpful.

**Questionnaires**

Questionnaires were given to the tutors and tutees. See Appendix A and Appendix C.

**Tutors**

The tutors were given a questionnaire at the end of the observation period that consisted of 31 questions. This survey was completed and collected on site. The purpose of this questionnaire was to find out how the tutoring sessions made them feel about their experiences while peer tutoring in mathematics at the university. This questionnaire may be found in Appendix A and was adapted from a similar study by Houston and Lazenbatt (1996).
Tutees

The tutees were given seven questionnaires. The first questionnaire was the same as the one that was given to the tutors and their replies were combined with the tutors’ replies in Table C4 in Appendix C. It was also completed and collected on site. The purpose for this questionnaire mimicked the reason for administering this questionnaire to the tutors. The second questionnaire was done using Survey Monkey and asked: (a) What is your major? (b) How long have you been receiving tutoring? (c) What are your plans for after college? (d) Do you enjoy math? (e) What do you think is an ideal tutoring situation? The remaining questionnaires asked what math classes they took in high school and also what type of high school (private, public, city, rural) they attended. They were also asked if their parents were strong in mathematics; the responses to this question were based on the tutees’ opinions. These questions were asked to try to get a feel for their backgrounds and past experiences with math before they attended college and also to perhaps gain insight as to why they may need tutoring. I also wanted to learn about their attitudes towards the study of mathematics, and to gain insight into their perspectives on one-on-one math tutoring at the university level.

Field Notes

Field notes were taken at every observation of tutoring sessions. This was done by following an observational protocol adapted from Bieda (2010). This protocol can be found in Appendix B. Answering each question in this format as many times as they applied to my observations was done for each tutee and tutor. As mentioned in the
previous data collection of this chapter, these notes and observations were taken as a means of memoing so as to not forget any important interactions during tutoring sessions.

Transcriptions of Interviews

As previously mentioned, all of the interviews and observed tutoring sessions were audio recorded and transcribed. A copy of all transcriptions was kept by me on paper as well electronically. A copy of all the paper transcriptions was also kept by my adviser. The transcription was done to preserve information since the observations took place over several weeks and the interviews were done at different times. That way important facts would not be lost. Transcriptions are an important tool to remind us of all important facts and observations. They are also valuable in developing theme analysis as they provide concrete records of data collection that can be reviewed any number of times and also useful for understanding the participants’ experiences and perceptions in their tutoring journeys.

Data Analysis

Since this was a qualitative study, it required recursive data collection and analysis. The practice of recursive data collection and analysis was described as beginning with a large amount of data and funneling it down to specifics at the end of the study (Bogdan & Biklen, 1992). I used the following methods to analyze the data: (a) Reviewed interview and observation transcripts (paper and audio recordings) several times, (b) Reviewed questionnaires several times, and (c) Reviewed field notes several times.
The first step in data analysis was to engage in bracketing. Bracketing can be described as a researcher taking no position, pro or con (Lauer, 1978). In their studies, “researchers usually explore their own experiences, in part to examine dimensions of the experience and in part to become aware of their own prejudices, viewpoints, and assumptions” (Merriam & Associates, 2002, p. 94). After considering these dimensions, the researcher must bracket or put aside all assumptions and prejudices so they do not attribute their own bias to the process (Merriam & Associates, 2002). This must be done so that the experience being studied can be described from its own intrinsic meaning without an outside meaning being imposed upon it (Merriam & Associates, 2002). Next, data had to be analyzed as to its significance to the study (Groenewald, 2004). The third step was to form categories and themes from the data (Groenewald, 2004). Then, summarizing each interview was undertaken to provide further themes and then the participants member checked the information as I interpreted it (Groenewald, 2004). Member checking was done by emailing participants the document and asking them if they were in agreement. All of the participants agreed that my report was consistent with their meanings or beliefs. Finally, a common theme was found from the preceding steps (Groenewald, 2004).

**Trustworthiness**

“One of the major challenges in qualitative research is establishing confidence and trust in the theoretical insights that the researcher proposes to explain or understand” (Whiting & Stines, 2012, p. 22). In order to establish the trustworthiness required to produce a valid and replicable study, I had my data verified by the participants by having
them read and verify my interpretation of their responses and observations; in other words, the meaning-making of the reported data must be checked by the participants (Whiting & Stines, 2012). This is also known as member checking, which is the practice of providing the partakers in the study with transcripts of their interviews after they have been summarized so they may make corrections (Simon & Goes, 2011). Although this practice has been rejected by some scholars, Guba and Lincoln (1981) have confirmed the validity of its use in establishing both trustworthiness and credibility.

Guba and Lincoln (1981) used the term “host verification” and described it as a system of member checks where the participants compared their experience and understanding of the experience against the researcher’s interpretations as well as whether or not the interpretation was a fair representation of the “shared experience” (Whiting & Stines, 2012). If after examination a participant finds something that he believes to be inaccurate, the item is removed or revised from the data set (Whiting & Stines, 2012).

Coding was also used for verifying trustworthiness; the coding process used in this research involved three steps. Coding is a heuristic, or exploratory technique used to solve a problem without using specific formulas or systems (Saldaña, 2013). Coding is used to link data to ideas and vice-versa (Morse & Richards, 2007). I began coding as I collected data with field notes and transcriptions of interviews and tutoring sessions where I would jot notes for future reference (Saldaña, 2013). I chose to use manual coding which is recommended for small-scale or first-time studies and also because I am
not familiar with coding done by computer programs and did not want to absorb a significant amount of time to learn such programs (Saldaña, 2013).

The first step in the three step process is known as open or initial coding where the data are broken into distinct parts to look for similarities and differences as well as an opportunity for deep reflection on the contents of the data (Saldaña, 2013). Using interviews and transcripts of tutoring sessions, I engaged initially in process coding which “uses gerunds to connote observable and conceptual action in the data” (Saldaña, 2013, p. 266) and is suitable for essentially all qualitative studies, especially those that are observing and analyzing ongoing interaction with an end goal (Saldaña, 2013). I was looking for words and phrases that were related to my research questions. For example, from F/S I looked for understanding, approaching (material), studying, tutoring, knowing, and teaching. With tutors I looked for words such as helping, interacting, understanding, feeling, and connecting. For the tutees, I sought out words such as learning, tutoring, getting, understanding, and showing.

Then I began open coding which is appropriate for virtually any qualitative study, but especially for researchers who are just learning how to code, as was my case (Saldaña, 2013). This step was intended as a starting point to provide me with a direction in which to take my study, as well as to postulate analytic leads for further exploration (Saldaña, 2013). I used highlighting in this step. Different colors of highlighters were used to identify and distinguish each broad concept and category. Here I looked for repeating words and phrases based on what I found during process coding. They indicated patterns in order to develop themes. I then constructed a table of key words and
phrases that were then transferred into a brief outline, with concepts being main headings and categories being subheadings (Whiting & Stines, 2012). Examples from F/S were deep understanding of material, help student understand, willingness to listen to student thinking, continuing relationships, and tutors were approachable. From the tutors, interacting with students, helping people, understanding a process, connect on a personal level, and what worked for the student(s). Phrases from the tutees included, “I wouldn’t have learned anything if I didn’t go to tutoring” (S1), easier to understand, making progress, feeling less confused, and tutoring helped.

The second step was axial coding that extends from open coding and is more focused (Saldaña, 2013). In axial coding I used my concepts and categories while re-reading the interviews and transcripts to first confirm that my concepts and categories accurately represented interview responses and also to explore how my concepts and categories were related. Axial coding is merely a more directed approach at looking at the data, to help make sure that you have identified all important aspects (Whiting & Stines, 2012). The purpose of axial coding is “to determine which (codes) in the research are the dominant ones and which are crossed out, redundant codes are removed and the best representative codes are selected” (Boeije, 2010, p. 109). This process was important for me to be able to find the “if, when, how and why” of my research (Charmaz, 2006, p. 62). I achieved this by re-reading and reflecting on my data numerous times while keeping in mind my research questions.

The third step was selective or theoretical coding where overarching categories were discovered and meaningful relationships between linked data sets were established
(Saldaña, 2013). This level of coding served “like an umbrella that covers and accounts for all other codes and categories formulated thus far” (Saldaña, 2013). In this step, analysis of the study was condensed into a few words to explain the meaning of the research (Strauss & Corbin, 1998). Again, this was done by reflecting about and re-reading the transcripts of the interviews, tutoring sessions, questionnaires, and previous coding and notes several times. Selective coding involved the integration of the categories that have been developed to form the initial theoretical framework and aided in pinpointing the central issue or issues from the research (Saldaña, 2013). This sort of analysis also helps to establish trustworthiness (Whiting & Stines, 2012).

**Limitations**

There are limitations inherent to this type of on-site visitation (Borg & Gall, 1983). Those limitations are:

1. Social desirability of responses could be a factor. Respondents may wish to portray their institutions in a more favorable light or be reluctant to share problematic experiences.

2. There may be limitations with the researcher collecting and analyzing the data. Although a participant observer as a valid qualitative researcher, as a participant observer, the researcher may bring biases to the study (Van Maanen, 1983).

3. The volume of data makes analysis and interpretation time consuming (Anderson, 2010).
Qualitative studies want to describe the particular data in great detail, thereby illuminating issues of interest or concern. According to Merriam (2009) subjectivity does not need to affect reliability and emergent themes are examined rather than preconceived ideas.

**Summary**

This chapter described the methodology used in my study, the purpose of the study, the rationale for the methodology, the research site, the human subjects review, the setting for the study, a brief description of the participants, the method for gathering and analyzing data and finally the possible limitations and trustworthiness of the study. Despite the possible limitations that I have discussed in this chapter, this study was undertaken in an ethical and transparent manner and I hope that it will support other researchers to continue to learn more about the tutoring process at all educational levels. I also believe that the design of this study was appropriate for the type of study that was conducted.

In the next chapter, the results of this study that resulted from the use of systematic data collection and analysis are discussed. It includes more detailed information about the participants and the common categories and themes that were identified through data analysis. These themes and categories answer the research questions that were the guide for this study.
CHAPTER IV
FINDINGS

This chapter includes a detailed analysis of the findings of this study as a result of systematic data collection and analysis. First is a review of the study, then a short biography of each participant. Pseudonyms were used to protect the anonymity of the participants (S1–S4 for tutees, T1–T3 for tutors and F/S1–F/S4 for faculty and staff). Next, I discuss the major categories derived from the data collection and analysis. From these categories, themes evolved and provided evidence for the following research questions:

1. What characteristics and behaviors as displayed by tutors and tutees are most desirable in higher education tutoring programs?
2. What common characteristics are observable between different math tutors and between different math tutees (as separate groups)?
3. How do various university stakeholders (university administrators, math department faculty) define success in university-level peer tutoring programs?

Review of the Study

Through the use of interviews and observations, the experiences of four tutees, three tutors, two university administrators, one professor, and one tutoring administrator were studied over a period of one semester. For this study, all of the tutors were majoring in a mathematics related field, the tutees were enrolled in mathematics courses, and the faculty and staff were in the mathematics or science discipline.
During the semester I observed, the tutees were given seven questionnaires. The first questionnaire consisted of five questions. Question topics included their major field of study, length of time participating in tutoring, post college plans, attitudes towards studying mathematics, and what they felt were characteristics of successful tutoring programs. This information was collected using Survey Monkey. Four additional questionnaires asked tutee what type of high school they attended (rural, urban, city, private or public), what was their family’s background in mathematics, their major course of study at the university, and which math classes they took in high school. These questionnaires were conducted through email to determine the impact background experiences in mathematics may have had on their tutoring experiences. The final questionnaire was conducted at the end of the semester and can be found in Appendix A. The tutees were also interviewed at the end of the study where they were asked if they felt better about mathematics at the end of their tutoring experience than they did before the tutoring sessions that I observed.

The tutors were given one questionnaire during this study. This questionnaire was identical to the first one given to the tutees and was conducted in the same manner (Appendix A). The one interview of the tutors was done at the end of the semester and asked two questions. First, I asked what were their philosophies of tutoring, and second, I asked why they chose to be mathematics tutors. These interviews were done in person and were digitally recorded and transcribed by the university’s transcription service.

The university stakeholders (F/S) were each interviewed once. Two of the interviews were done in person in their offices at scheduled times. The other two chose
to be interviewed by email as it was more convenient for them. The questions asked were: (a) What characteristics and behaviors of tutors and tutees do you feel are most desirable and successful in higher education math tutoring programs; and (b) How do you define success in a higher education math tutoring program? The in-person interviews were digitally recorded then transcribed by the university’s transcription service.

**Demographics of the Participants**

S1 was majoring in psychology and had received one semester of tutoring in mathematics. She took algebra, geometry, and statistics in high school. She went to a private high school. After she graduates, she would like to open a women’s shelter and help foster and adoptive children. Her major required three to five credit hours of any of the following university mathematics core classes: Basic Algebra, Modeling Algebra, College Algebra, Basic Statistics, Exploration in Modern Math, Algebra for Calculus, Intuitive Calculus, Trigonometry and Algebra, Trigonometry, Calculus I. She was being tutored for Modeling Algebra.

S2 was majoring in early childhood education. She received mathematics tutoring for a semester. She went to a public, city high school and took geometry, algebra II, pre-calculus, and AP calculus while there. She hoped to teach full-time, get married and start a family after graduation. Her major had the mathematical course requirements of Basic Mathematical Concepts I & II. She was being tutored for Basic Mathematical Concepts I.

S3 was also majoring in early childhood education and aspired to be a kindergarten teacher. She had one semester of tutoring in mathematics. She took algebra
and pre-calculus at a public, urban high school. Her major had the mathematical course requirements of Basic Mathematical Concepts I & II. She was being tutored for Basic Mathematical Concepts I.

S4 had been participating in math tutoring for three months and was majoring in pre-nursing to become a registered nurse. She attended a public, suburban high school where she took algebra II and statistics. Her major required three to five credit hours of any of the following university mathematics core classes: Basic Algebra, Modeling Algebra, College Algebra, Basic Statistics, Exploration in Modern Math, Algebra for Calculus, Intuitive Calculus, Trigonometry and Algebra, Trigonometry, Calculus I. She was being tutored for Modeling Algebra.

T1 was pursuing a bachelor’s degree in aeronautical science. She had been tutoring mathematics for three years and intended to take a short break before starting her master’s degree in the same field. Her degree had the mathematics course requirements of: Analytic Geometry, Calculus I, Calculus II, and Calculus III.

T2 was majoring in early childhood education and just completed her first semester as a math tutor. After finishing her bachelor’s degree, she wished to find employment as an elementary school teacher. Her degree had the mathematics course requirements of Basic Mathematical Concepts I and II.

T3 was studying applied mathematics with a focus on probability and statistics. He was originally an education major, but due to personal reasons, he decided to use his mathematics education to enter the workplace. He had been tutoring mathematics for three years. His major had the mathematics course requirements of: Geometry, Calculus

F/S1 had been a mathematics professor for 41 years and also had experience as a mathematics tutor. He had been at his current position for 17 years and has a BA, MA, and PhD in mathematics. His interests included functional and harmonic analysis.

F/S2 held both a BS and a PhD in Biology and had been the interim Dean of the College of Arts and Sciences for about one and a half years. His experience was with students from freshman to senior level and he had been a university instructor for 38 years, beginning as a graduate student. He stated that he had informal experience in tutoring.

F/S3 had nearly 40 years of teaching experience in mathematics. This included 11 years as a high-school instructor and almost 29 years at the university level. She was also the coordinator of college algebra level courses and is an associate professor at her current institution. She has taught Calculus I, Fundamental Concepts of Algebra (for pre-service high school math teachers), History of Mathematics, Trigonometry, Algebra-Trigonometry, Intuitive Calculus, and Statistics. She had a BA and an MA in
mathematics and also a PhD in curriculum and instruction. She was a mathematics tutor at her undergraduate institution.

F/S4 was an Academic Program Coordinator, which essentially means tutor administrator, and had held that position for less than one year. He also had been a tutor of courses including Basic Algebra through Calculus III and Linear Algebra for more than eight years and taught mathematics for approximately a year at the university level. He had a master’s degree in mathematics.

These demographics are summarized in Tables 1 through 3 in Chapter 3. The analysis of this data provided by the participants of this study led to the following two major categories:

1. Tutors were well trained. This was evidenced by their professional behavior and their deep understanding of mathematics. Also, they were excellent at reading their tutees and providing thorough and accurate information.

2. Tutees were dedicated. This could be seen by how they participated voluntarily in tutoring, did their homework assignments, were ready with questions at the beginning of each session, and openly discussed their frustrations with their instructors.

Following is a detailed description of the data that support these categories.

Tutees’ (S) Feelings About Tutoring

The students I observed, S1–S4, who were receiving tutoring services shared the same reasons for seeking tutoring for academic support which were the basis for four major themes: for the tutees: (a) they experienced frustration from an inability to
understand in the classroom, (b) they did not retain what mathematics skills they learned in high school or in time gaps between mathematics courses, (c) they came to their tutoring sessions prepared, and (d) they were consistent in attending their tutoring sessions.

Frustration and Lack of Retention

The tutees felt unsure about their abilities and wanted to ensure they did well in their respective mathematics courses. After observing the tutees and interviewing them, one characteristic was outstanding. They all sought tutoring services because of past struggles in mathematics classes and understanding mathematics. They also talked about the struggles they were experiencing in their respective mathematics classes. In addition, all of the tutees were engaging in majors for their future careers that required mathematics classes.

S1 stated: “I don’t know what she (her instructor) said; I don’t know what she’s asking me to do; I don’t know what she did.” S2 remarked during her tutoring sessions:

I got kind of confused on this . . . She (her instructor) did it (counting triangles within a large triangle) like, right in front of us so I don’t really know, and We went through everything really, really fast yesterday. We had to go over the exams, do notes, and do this activity.

S3 shared: “I was just confused. She put so much like on us at the last minute,” and “Yeah, because if we weren’t in tutoring, I don’t know what we’d (S2 and S3) be doing.” S2 added to that: “(It was like) trying to tutor ourselves.” S4 told her tutor in one session: “We did stuff like that (logarithms) today, but I was confused because I
didn’t know what it was, and I didn’t want to be annoying because I emailed him (her instructor) and he didn’t email me back.”

To gain a better understanding of why the students felt so confused in mathematics classes and why they felt they needed and wanted additional help, it was important to examine the factors that led to their difficulties in mathematics. The following questions helped to give some idea of their mathematical experiences. I asked the tutees the following demographic questions: (a) What math classes did you take in high school? (b) Do you come from a family with strong mathematical backgrounds? (c) Did you go to high school in a city, urban area, or small town? Tables 4, 5, and 6 summarize the responses I received. These are important because their backgrounds in mathematics may be a determining factor of how well they do at the collegiate level.

Table 4

*Tutees’ High School Math Coursework*

<table>
<thead>
<tr>
<th>Tutee</th>
<th>Mathematics classes completed in high school</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Algebra, Geometry, and Statistics</td>
</tr>
<tr>
<td>S2</td>
<td>Geometry, Algebra II, Pre-Calculus, AP Calculus</td>
</tr>
<tr>
<td>S3</td>
<td>Algebra, Pre-Calculus</td>
</tr>
<tr>
<td>S4</td>
<td>Algebra II, Statistics</td>
</tr>
</tbody>
</table>
Table 5

*Tutees’ Family Background in Mathematics*

<table>
<thead>
<tr>
<th>Tuttee</th>
<th>Family background in mathematics</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Strong mathematical background</td>
</tr>
<tr>
<td>S2</td>
<td>Weak mathematical background</td>
</tr>
<tr>
<td>S3</td>
<td>Weak mathematical background</td>
</tr>
<tr>
<td>S4</td>
<td>Strong mathematical background</td>
</tr>
</tbody>
</table>

Table 6

*Private High School Versus Public School*

<table>
<thead>
<tr>
<th>Tuttee</th>
<th>Private or public high school</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Private</td>
</tr>
<tr>
<td>S2</td>
<td>Public (city)</td>
</tr>
<tr>
<td>S3</td>
<td>Public (urban)</td>
</tr>
<tr>
<td>S4</td>
<td>Public (suburban)</td>
</tr>
</tbody>
</table>

At the end of the observation period, I asked each of the tutees if they felt better about mathematics than they did at the beginning of the semester. All four of the tutees stated that they did in fact feel better about their understanding of mathematics. As evidenced in the remarks that were cited above, the tutees expressed how much tutoring helped them to understand the material in their classes as well as feeling more comfortable about their abilities in mathematics. They were all clearly appreciative of the tutors’ help and were happy about their decision to participate in the tutoring process. The following remarks from the interviews at the end of the semester with the tutees illustrated this point.
When I asked, “Do you feel better now about mathematics than you did at the beginning of the semester?” S1 replied: “Yesssss. Because I didn’t have—it was an online class so I didn’t have a teacher. So, I mean I wouldn’t have learned anything if I didn’t go to tutoring, honestly.” S2 stated:

I feel like I did better after and during tutoring than the beginning of the semester. It was nice to get one on one time with a tutor and answer personal questions that I was nervous to ask in class. She explained things in ways that were easier for me to understand. I could see progress in things such as quizzes and exams that proved I was getting better.

S3 remarked:

Yes, I do feel better about mathematics now as opposed to the beginning of the semester because I feel more comfortable in my abilities. Tutoring has given me the ability to have an understanding about math and feel comfortable showing what I know.

She added at the end of the semester that “I feel less confused about a lot of things. The tutoring helped me a lot.”

These personal feelings and previous struggles in math of the interviewees suggest reasons why tutees seek tutoring services and their motivation for participating in tutoring for mathematics. From these responses, tutees defined “feeling better” in terms of personal feelings about math as well as improving in their content knowledge and grades.
Questions from the questionnaire in Table C4, Appendix C, also demonstrated how these tutees felt more comfortable and confident about math after their tutoring experience, in particular, questions 7, 16, 19, 22, 23, 24, 25, 26, and 27. The tutees answered unanimously to each of these queries. These questions and the tutees’ answers were as follows:

- Question 7: Did you feel like the tutoring made you feel uncomfortable? S1–S4 replied no.
- Question 16: Did you feel that your level of performance and achievement increased? S1–S4 replied yes.
- Question 19: Did you feel that the tutoring sessions were helpful? S1–S4 replied yes.
- Question 22: Did you feel that the tutoring sessions were a valuable experience? S1–S4 replied yes.
- Question 23: Did you feel that the tutoring sessions reinforced your learning? S1–S4 replied yes.
- Question 24: Did you feel that the tutoring sessions clarified your own personal learning? S1–S4 replied yes.
- Question 25: Did you feel that the tutoring sessions increased your level of performance? S1–S4 replied yes.
- Question 26: Did you feel that the tutoring sessions met your personal learning needs? S1–S4 replied yes.
• Question 27: Did you feel that you will be a more capable student having gone through the tutoring experience? S1–S4 replied yes. All of the questionnaire results can be found in Appendix C, Table C4.

**Preparedness and Consistent Attendance**

I observed at every session that the tutors were prepared to ask questions from their homework assignments, lectures, and tests and did not hesitate to ask their tutors for help. They also attended regularly and on time for their sessions. They brought their books, class notes, calculators, and homework assignments and had specific questions to ask about their assignments and exams in their mathematics classes.

From this research, it was evident that the tutees overall felt they had a very positive experience with their math tutors. The results from their tutoring experience were beneficial and the tutees were very comfortable with their tutors and gained confidence in their math abilities because of their experience with their tutors. There was often some brief social interaction between the tutees and tutors, which helped the tutees feel more comfortable, but the majority of the time in the tutoring sessions was dedicated to tutoring. They also stated that they learned more than they would have without tutoring. Overall, students felt that their tutoring experience was helpful not only because they were more proficient at math, but also because they felt comfortable with their tutors, could trust them, and could freely communicate with them. All of the tutees felt as though their tutoring experience was very helpful and was an important factor in understanding the mathematics classes in which they were enrolled. This perception of
understanding is an important factor in how valuable tutoring mathematics at the university level is for student success.

**Tutor (T) Training**

Tutors in the peer tutoring program at the institution where I conducted my research were required to undergo a very thorough training program. All three of the tutors who participated in this study showed very professional behavior. This behavior evidenced how well they were trained. All of the tutors were held to rigorous standards as outlined by the academic program coordinator of mathematics tutoring at the university. The following section details the training requirements for tutors.

In order to qualify for a tutoring position within the University program, candidates must currently be enrolled as a graduate or undergraduate student; have at least a 3.0 cumulative GPA; have successfully completed 24 hours of coursework; received an A or A- in the courses they will tutor; submit an application; be recommended by a faculty member; be interviewed by the Academic Program Coordinator; complete a math or chemistry subject exam (if applying as a math or chemistry tutor); and complete tutor training. Following their training, tutors must adhere to certain key responsibilities such as only tutoring registered students, reviewing subject content regularly, enforcing Center policies, and communicating schedule changes.

Twice per academic year, University Tutoring Services initiated a hiring process to identify potential tutors. Tutors were recruited via traditional means (suggestions from faculty/staff, website listings, etc.), as well as through targeted emails to encourage students who quantitatively met University Tutoring hiring prerequisites (at least a 3.0 GPA).
GPA and A/A- course grade requirements) to participate in the application process. This information was aggregated and compiled using Cognos (an online training class). All applicants must submit an application that includes their academic history with respect to the courses in their areas of proficiency, and a faculty/staff recommendation for consideration.

Once application materials were collected, potential tutors were selected to begin training and given detailed job description information upon formal acceptance of employment. Math tutors were required to complete Basic Math I-IV and trigonometry on ALEKS over the break between semesters (winter or summer) for the purposes of a review. Before the semester began, training was conducted within the scope of two 5-hour meetings. These sessions involved lecture and workshop-style activities. Once the semester began, the Program Coordinator met with new tutors twice for one hour each in a classroom setting.

During the first training session, tutors engaged in a 5-hour orientation that included lecture-based materials and workshop-style exercises (Spring 2014 Friday Training Day Presentation). Topics included describing basic tutoring protocols, interactive discussions, how to structure a session, tutoring scenarios, and a tour of each tutoring location.

During the second 5-hour meeting, tutors participated in training activities that included a case study, the “board work” model, time management, as well as a subject review for math and science tutors. After a short break, the new tutors met with returning tutors for a general orientation meeting, which outlined protocols and changes within the
program for the upcoming semester. At this time, new tutors had the opportunity to ask returning tutors questions. In the same vein, veteran tutors shared their tutoring experiences to help prepare new tutors for the upcoming semester.

Training continued throughout the semester with at least two workshops (a Student Accessibility Services [SAS] presentation, and a tutor focus group) conducted by a representative from SAS and the Academic Program Coordinator, respectively. The SAS presentation consisted of a one-hour lecture that informed tutors on guidelines for tutoring students with disabilities (SAS Presentation 2014). The tutor focus group consisted of a one-hour guided discussion where tutors shared experiences: what they have learned, challenges they have faced, how they can improve, and tutoring techniques they have implemented from the training (Sample Spring 2014 Tutor Focus Group).

Within the first two weeks of the semester, new tutors were required to observe a veteran tutor during a scheduled session and submit an observation sheet (Sample Spring 2014 New Tutor Observation 1). Moreover, the Academic Program Coordinator observed all new tutors at least once per semester using the same criteria, which typically occurred within the first five weeks of the semester (Sample Spring 2014 Observation of New Tutor 1).

By the midterm of the semester, new tutors had to submit a three-page essay detailing what they have learned from training. In the first part of the essay, new tutors summarized what techniques they have implemented into their sessions and then give feedback and suggestions on how to improve the training process. In the second part of
the essay, new tutors provided feedback on their students’ progress, as well as a self-reflection on their own progress as a tutor (New Tutor Essay Assignment Form).

Given this rigorous training schedule and list of qualifications of the tutors, the three tutors within this study demonstrated the following professional characteristics: Preparation, promptness, content knowledge, task and time consciousness, consistently responded to tutees needs, always had needed materials on hand (paper, pencils, calculators, and laptops), and if needed, they would reference the textbook being used in the course in which the tutee was enrolled. Each of the tutors I observed were there well ahead of their scheduled tutoring times and never missed a session. When the tutors were working with their tutees, they were always prepared to answer any questions the tutees had and answered them correctly. They didn’t “clock watch,” but they were always aware of how much time was left in a session and kept the students on-task and made sure to move at a pace that would let them cover as many questions as possible, without rushing the tutees.

Within the category of tutor training, the two major themes were derived: (a) the tutors showed a blend of procedural knowledge and conceptual understanding of the mathematics for the classes they were tutoring, and (b) the tutors displayed an ethic of caring and had excellent interpersonal and pedagogical skills.

**Blend of Procedural Knowledge and Conceptual Understanding**

Procedural knowledge “is made up of two distinct parts. One part is composed of the formal language, or symbol representation of mathematics” (Hiebert, 2013, p. 6). The
other part consists of using such constructs as algorithms, procedures, and rules to solve mathematical problems (Hiebert, 2013).

Conceptual understanding “refers to an integrated and functional grasp of mathematical ideas” (Kilpatrick et al., 2001, p. 118). The tutors in my research used a blend of both procedural knowledge and conceptual understanding which appeared to help the tutees not only to understand the math they were studying, but to also help them perform better on their tests.

T1, for example, was explaining exponential functions to her tutee and gave the following example:

Suppose over Christmas break you have two job offers. Team A offers you a million dollars for thirty days, to be their sports consultant for their cross-country ski team. For the same work, Team B offers you $0.01 for the first day of work, but will double that amount the second day, double it, etc. They will give you a final doubled amount on day 30. Which job would you take and why?

T3 also made his own problems to explain concepts. For example, when his tutee asked him this about graphs of functions: “Do they have to be the same numbers? Is it still a reflection over the x?” T3 then replied: “So if we had f(x) equals negative four x squared,” and then drew her a graph of that function to show her what that would look like. Later, he explained what symmetry of graphs of functions were by saying: “So you’d have to be able to fold it one way and then fold it the other way and on top of each other.”
T3 was explaining repeating decimals from fractions, and gave this example: “So if there was like one-third, as a decimal, that’s point three repeating.” She also used the text for the class to show her tutees how to do a problem. In one instance, S1 asked her how to set up ratios, and she found the page in the text for the student to reference before explaining the concept.

In addition to the tutors’ subject expertise, they employed other means to be sure their tutees understood the content for their respective math classes. At the beginning of each tutoring session, the tutors would find out what their tutees needed to work on, either by listening to their questions or by directly asking them what they needed to work on that day. For example, the tutors would ask such questions as, “Any specific questions?” “So what are we doing now?” “So what are we reviewing?” “You were kind of confused on Wednesday too. So A and B, so let’s go ahead and do it.” Tutees would make statements such as, “I don’t understand (question) number four.” This would lead smoothly into the tutoring sessions.

In week one, S1 asked a question about adding numbers. T1 told her to use rounding to make the problem easier. They then moved on to graphs, and T1 asked S1 what the graph of x-squared would look like. S1 asked, “Is that a V or a parabola?” After explaining the graph was a parabola, T1 explained how the graph would change as the value of x was changed. T1 would walk S1 through problems step-by-step with concrete examples (Procedural Knowledge). When discussing graphs of equations, she stated, “So the first thing you wanna do is figure out what equation we’re changing.” When explaining solving equations by the square root property, T1 said, “So to solve for
y, we’d just take the square root of both sides and it’s gonna be y equals the square root of x.” For another problem, T1 was helping S1 solve how to find income of a country given an equation. She again walked S1 through by explaining each step. First, T1 read the problem out loud, then asked S1 what the value of x would be using the given parameters. Next, T1 listened as S1 explained how she would solve the problem by steps. T1 would interject if S1 was incorrect, or had a question. T1 would also frequently ask leading questions such as, “And then the outside (of the graph) is up or down?” “And is it the opposite?” “Okay, where is that going to be?” and “Okay, and which one are you going to plug into?”

This strategy seemed to be effective for this tutee. T1 would always check for understanding by asking S1 if she understood, or more often, would have S1 go through problems on her own to be sure she understood the process and procedure from a more relational perspective. T1 frequently asked S1, “Does that make sense?” She would also ask S1 questions such as, “Do you understand why that would be right?” (Conceptual Understanding). One example of having S1 do a problem to check understanding was a problem involving logarithms. T1 began by saying, “Let’s just kinda start from scratch here. Um, if I had log base 2 of 8 equals x, do you know what that one would be?” S1 answered correctly, but to be sure she understood, T1 asked her a similar question. When S1 got that problem right, T1 moved on, seeing that S1 did understand.

T2 would ask her tutees, S2 and S3, questions such as, “Do you remember how many factors that something has?” and “So 1, 2, fit into one of these?” After drawing a picture (they were using triangles), she stated, “Okay, so we can visualize it better.” T2
would either give or ask her tutees to find the pieces of information they needed to solve problems. For instance, they were working on fractions, and T2 led them by saying, “You’ve seen fractions before in your math classes” to get them to find the piece of information they would need to solve the problems they were working on that day. S2 was working on number lines, and T2 let her begin to explain her process and told her, “That’s a good place to start.” In another problem, S3 was trying to figure out a total number of shapes that would fit into a figure. T2 started by asking her, “So how many shapes are there?” While working on factorization, S3 was confused, so T2 said, “What are those (terms) both divisible by?” T2 would continue in this manner until S2 and S3 understood the concept. In addition, she would ask her tutees, “Does that make sense?”

T3 would often draw graphs and pictures to help his tutee. In addition, he would, as did T2, try to get S4 to find the pieces she needed to solve problems. When going over inverse functions, T3 had S4 go through a problem until she hit a bump. He then asked her, “And that would be what? f(g(x)) or g(f(x))? You don’t have any g, so it would be?” While working through that problem, T3 was showing S4 the graphs of these functions on her graphing calculator. While reviewing graphs of cubic functions, S4 was confused, so T3 led her by asking her, “Is the minus one under the cube root?” S4 continued to work on the problem until she got the correct answer, and to be sure she did understand, T3 asked her if it made sense. When they were working on exponential functions, T3 would draw her graphs as he explained the topic. S4 wanted to review completing the square for her final because she was struggling with simplification. T3 then asked her, “So these are all reducible by two, right?” He asked her leading questions
such as these until he was satisfied that she understood. He also often asked S4 if what they were studying made sense to her.

No matter what means these tutors used to help their tutees find understanding, they all checked often during tutoring sessions to be sure they understood. In addition to asking them questions, they would also watch their tutees’ facial expressions as a kind of double check to see it they understood. On several occasions with all three tutors, if they saw a glimmer of doubt in the tutees’ faces, they would continue to explain the topic at hand. It was clearly important to these tutors that their tutees understood everything they were studying.

The pace was also important. Tutors did not have a set agenda; they took the lead from the students. The type of scaffolding used by the tutors was the system known as I do, We do, You do. The tutees would ask a question, the tutors would explain the topic while asking the tutees leading questions to gauge their understanding and work through the problem together, then the tutors would ask the tutees to work a similar problem on their own. Frequent questions and scaffolding ensured that the tutors and tutees were on the same page. In doing so, the tutors helped the tutees to gain better conceptual understanding. Conceptual understanding was developed not only from the scaffolding style the tutors used, but also because the tutors and tutees met at regular, scheduled times throughout the semester in the same pairs or groups and tutors were able to build on tutees’ previous knowledge.

These examples demonstrated the professional characteristics of preparation, promptness, and content knowledge (what were the courses that each of the tutors had).
In addition, tutors showed how they responded to tutees’ needs; the tutors always had needed materials on hand (paper, pencils, calculators, and laptops), and if necessary, they would reference the textbook. These consistent behaviors clearly showed the tutors’ adherence to professionalism.

**An Ethic of Caring and Excellent Interpersonal and Pedagogical Skills**

Nel Noddings (1984) defined teachers who work as caring individuals as those who strive to help students confirm their best selves by means of caring, sensitive and supportive interactions. She stated:

> When we attribute the best possible motive consonant with reality to the cared-for, we confirm him; that is, we reveal to him an attainable image of himself that is lovelier than manifested in his present acts... Confirmation, the loveliest of human functions, depends upon and interacts with dialogue and practice. I cannot confirm a child unless I talk with him and engage in cooperative practice with him. (Noddings, 1984, pp. 193,196)

The tutors in my research consistently displayed this sense of caring while interacting with their tutees. The tutors helped their tutees to be more comfortable in the tutoring experience by showing interest in their lives. It was my observation that the tutors were always pleasant and friendly with their tutees and if the tutors sensed their tutees were frustrated they would ask them how they were feeling. The sessions often started and concluded with pleasant conversation where the tutors expressed interest in their tutees. The following are examples of this kind of interaction. In one tutoring session, S1 was telling T1 how she’d been having a bad week. T1 told her, “That’s
totally okay, I understand, I’ve had those days. This whole week I thought that each day was the day after.” S1 shared how she was going to have to take care of her roommate in the upcoming weekend. At the beginning of one meeting between T2 and S3, T2 remarked, “Hello. Oh my goodness I love your hair.” At the end of T1 and S1’s session in week two, the following conversation ensued:

S1: Okay, can we be done today?
T1: Yeah. Are you just gonna go back to bed?
S1: Um, I’m gonna get food and then go back to bed.
T1: I envy you. I work, and then I work, and then I work. And then I sleep.

T2 and S3 once had a discussion about skipping classes:

S3: I never missed a class but I was like something is going to happen. She’s going to change the quiz day or something.
T2: I was always afraid like I mean what am I going to do skip it? Stay in my room and sleep.
S3: I was afraid my dad—he was going to text me like I know you didn’t go to class.

These exchanges helped the tutees to feel more comfortable with their tutors and established a good repertoire between the tutors and tutees.

T1, who was majoring in aeronautical engineering and had been a math tutor at the university for three years, said her favorite elements in tutoring were that (a) she loved math, (b) she enjoyed one-on-one interaction with tutees, (c) she liked helping people, (d) she liked seeing someone understand math, and (e) she felt very comfortable
tutoring students. She said, “I love helping people . . . that moment when you teach them something and they’re like, oh! So knowing that you can help somebody understand is a really good feeling.”

All three tutors stated that they enjoyed helping people and connecting with others one-on-one. This was important since having compassion for tutees was one of the recurring statements made by faculty and staff when asked what characteristics are important for a successful tutoring program.

**Faculty and Staff (F/S)**

The following statements are from faculty and staff in interviews about their opinions on qualities that tutors and tutees should possess. The choice of faculty and staff was significant because it provided multiple perspectives where faculty and staff stated multiple levels of consensus about why successful tutoring programs were important. There was agreement from the faculty and staff that tutors need to demonstrate understanding of the mathematics they are tutoring, be compassionate and friendly, and that tutees need to retain the material they learned in their tutoring sessions so that they may advance to their mathematics classes that are required for them to take in their majors. These interviews were the basis for the major theme: Tutors should be student-centered and want their tutees to succeed. The tutors in my research clearly demonstrated this theme, as enumerated in the previous section of this chapter. What the F/S did not speak of was the importance of tutoring for the purpose of retention of students that I found, as stated in Chapter I, was considered to be a main reason for tutoring at the college level.
F/S 1 stated,

They (tutors) need to have a deep understanding of the material that they are tutoring. They need to understand that they should be eliciting responses from the students rather than giving them answers . . . help the students understand.

He further said that “they need adequate skills for relating to the students.” F/S 1 was stating the importance of interpersonal skills and mathematical skills.

F/S 2 had similar thoughts. He said, “Well for tutors, being good in the discipline whatever is being taught.” And that the tutor should lead the tutees “to do more than just get that material down so they get a good grade on the next test, but to retain it and learn.” As to the tutor being relatable and making the tutees feel comfortable he said, “Approachability is important . . . somebody’s got to want to really be there to help somebody learn rather than to make seven-fifty an hour.” He shared a personal story about a tutoring experience of his own. As an undergraduate student, he sought tutoring for analytical geometry/calculus. He told me:

I had phobia and all that kind of stuff that I shouldn’t have to but I did. I didn’t like it so much, so then I took stats-I liked that. I took some other math, but the second calc course I took was my senior year, and I took a pass-fail and the person (tutor) was really good. It was a real old guy that was really good at teaching integral-calculus, and I found that once I started liking it you know that it became fun. I was taking it pass fail and I was getting hundreds.

He shared that experience with me to emphasize the importance of the personal relationship between tutors and tutees. He also added that the tutor was doing it for free
and that it was obvious to him that the tutor simply loved the subject, that it was his passion.

F/S 3 said that,

A tutor needs to have a deep knowledge of the material . . . the tutor needs to have a willingness to listen to student thinking and guide students’ thinking rather than a propensity to spout off answers and procedures.

She continued with, “The tutor needs to be able to analyze a student’s unconventional approach to determine if it is mathematically sound.”

Here F/S 3 was stating, as did F/S 1 and F/S 2, that it is important for tutors to demonstrate and tutees to understand that mathematics is not simply an exercise in memorization and rote learning. He was also conveying that deep understanding of the material is of great importance and tutors must be able to see from the perspectives of the tutees.

F/S 4 concurred with the other three persons interviewed. He related to me that it is important that the tutor have “the academic skills to understand the material in tandem with the personable social skills to relate to the student to explain the material;” that those characteristics are “crucial for a successful tutor” in conjunction with: “A tutor must demonstrate knowledge of the material.” He said that in his tutoring program, “We seek tutors who possess excellent communication skills and personable attitudes so that they may relate to their students, make them feel comfortable and clearly foster a dialogue to grasp at mutual understanding.” F/S 4, with these statements, was reiterating that tutors
must have not only thorough content knowledge, but also about the kind of knowledge that results in good teaching.

From all of the staff, faculty, and administrative statements, it was clear that a tutoring program must possess the following qualities: (a) the tutor has a deep understanding of the subject that goes beyond memorization to deep conceptual understanding so that tutees can see how the material “makes sense,” (b) the tutor guides the students’ learning, (c) they easily relate to students, and (d) students being tutored are made to feel comfortable. All four of the faculty and staff I interviewed shared these common qualities in their interviews with me. The interviews were done independently of one another, and in that, it became clear to me that these became important themes in tutoring mathematics at the university level from the viewpoint of faculty and staff and were the impetus for the essential themes relating to the faculty and staff. The fact that there was a consensus of these four points as shown from the statements cited in this section led me to essential themes.

As shown in the following quotes from the one-on-one interviews that were done with the F/S in regard to the tutees, the consensus of the F/S was that the tutees should view their tutoring experience as positive and that they show a desire to learn. F/S 1 stated that tutees “should have thought about the problem beforehand. They should be willing to engage with the tutor, so they can develop thought processes as they’re undergoing the intervention, “and that the “students have a positive experience and communicate that.”
F/S 2, as stated above with his anecdote, shared how important it is to have a positive experience. If his math tutor didn’t have a positive attitude and deep knowledge of the material, his experience as a tutee would not have been so memorable to him. He also told me that it is important for students to seek out tutoring because the tutees should be “somebody who is there who really wants to learn how to learn, and just not there to figure out the tricks to do well on the next exam,” and “once I started liking it (intro to calculus) you know that it became fun.”

F/S 3 related that “the tutee needs to have a willingness to work hard and a desire to think independently and LEARN the material” and also that the tutee gains “confidence in her ability.” This, F/S 3 said, could be achieved in part by “the tutor having a willingness to listen to student thinking.”

F/S 4 stated that in order for tutees to have a positive tutoring experience the tutors must “possess excellent communication skills and personable attitudes so that they may relate to their students (and) make them feel comfortable.” He also said that tutors must “foster a dialogue to grasp a mutual understanding between student and tutor.”

One final theme that developed from the interviews is students’ improved performance is a measure of a tutoring program’s success. This mirrors the statements above where F/S shared that a successful tutoring program must employ tutors that can impart both conceptual and procedural knowledge to tutees. That is to say, that the tutors try to be certain the tutees have a strong understanding of the material.

F/S 1 stated that one measure of success is that “ideally they (tutees) would consider it (tutoring) a good experience if they felt they came away with a better
understanding of the material.” As to the effect on the tutees’ grades, he thought that if “students maintain grades that could be an indication of improvement.”

F/S 2 suggested that “the assessment would be an independent test, but are they doing well in some standardized type of examination.”

That would be nice at the end of the class to have (some) sort of an exam or something that would evaluate whether or not the key things you want to have keep in their head for the rest of their life—it’s still there.

F/S 3 thought that “the student would achieve success (i.e., pass with A, B, or C) in the current course. A better answer would be that the student gains skills and attitudes to make him or her an independent learner.”

F/S 4 relayed to me that:

Grade impacts per course should demonstrate a greater impact on student course GPA with students who use tutoring regularly . . . student attitudes and goals should be measured before and after a semester of tutoring to assess their personal goals and if they were able to achieve them (better study habits, the ability to pass a class, etc.).

The faculty, staff, and administrators all mentioned the importance of the personal qualities and grades that make a successful tutoring program. They did not speak of student retention rates or criterion-referenced assessments as indicators of successful tutoring programs but did mention grades as a quantitative measure.

According to the Executive Paper commissioned by the National Research Council (2001), criterion-referenced assessments rely on national and international
standards and best practices in addition to the criteria mentioned by the faculty and staff above. At the research institution where the study took place, faculty and staff did not talk about the use of criterion-referenced assessment that may be used to generate numerical scores indicative of quality level and assurance that tutoring services are meeting the needs of the university and students.

**Summary**

Based on this study, various qualities of long-term success in tutoring programs were found as outlined in Table 7.

Table 7

*Qualities in a Successful Tutoring Program*

- Clear Purpose and Mission
- Staff Development
- Quality Program Management
- Strategic Plan for Participant (Tutors and Tutees) Recruitment
- Effective Management of Tutee Enrollment
- Consistent Attendance and Retention of Tutees
- Quality Tutor Supervision
- Required Ongoing Tutor Training and Orientation
- Effective Student Intervention
- Frequent and Consistent Tutoring
- Well-Structured and Well-Planned Tutoring Sessions
- Positive Tutor-Tutee Relationships
- Strong Partnership Between Schools and Tutoring Programs

This chapter outlined the major themes that emerged from this research as a result of systematic, qualitative analysis. In addition, it provided evidence from the data collected during the study from the participants to support the themes that were derived from the interviews, observations, and questionnaires. Chapter 5 is a discussion of the
relationship between the findings that emerged from this research and the related literature on peer tutoring mathematics. Implications for university peer tutoring programs and future suggestions for educational research in this field are also presented.
CHAPTER V
DISCUSSION

Overview of the Study

This chapter provides an overview of the study as well as a discussion of its findings and the related literature on peer tutoring at the university level. Future implications and suggestions for further educational research are also presented. A descriptive qualitative research design was chosen for this study because I wanted to understand the perceptions of mathematics tutoring at the university level from the perspectives of tutors, tutees, faculty, and administrative personnel. Qualitative research provided specific detail necessary for this level of understanding. I researched and reported on the importance of peer tutoring at the college level as a resource for success in college-level mathematics courses. The rationale behind this study was presented by discussing: (a) the need for tutoring programs, (b) the cost of remediation, and (c) the academic benefits of tutoring programs. The relationship of themes to related research is discussed, and finally, a description of the ideal tutoring environment was defined from a variety of findings.

A review of the literature was conducted in Chapter 2 where the focus was on the learning theories of constructivism and behaviorism. Variations of these two learning theories are prevalent in modern learning environments and their influence in tutoring and the theories of several influential theorists were examined. Through my review of the literature as well as my personal experience as a professional tutor and college mathematics instructor, I found that the majority of the research on tutoring concentrated
on results such as the grades earned by the students being tutored both before and after participating in tutoring and benefits to tutors and tutees gained from the tutoring experience, and student retention statistics. Very little literature examined the importance of the personal, interactive nature of the tutor/tutee relationship. This gap in the literature was my motivation to ask the research questions that were the basis for this study. They were:

1. What characteristics and behaviors as displayed by tutors and tutees are most desirable in higher education tutoring programs?
2. What common characteristics are observable between different math tutors and between different math tutees (as separate groups)?
3. How do various university stakeholders (university administrators, math department faculty) define success in university-level peer tutoring programs?

I began the study by searching for participants by recommendations from faculty and staff at the university where my research was conducted. The requirements for the participants were that they were currently involved in a mathematics-related field, as a tutor, faculty, or staff member and the students had to be enrolled in a mathematics course and were voluntarily engaging in tutoring services. Four faculty and staff members were selected and participated and three tutors and four tutees were selected and participated. In the beginning of the study there were four tutors and five tutees, but due to the fact that one of the tutees failed to attend any of his first three scheduled meetings with his tutor, he and his tutor were both dropped from the study and the tutee was dismissed from the tutoring program.
Data were collected through observations of peer tutoring of mathematics, interviews with students, tutors, staff, faculty and administrators, my personal research journals, and questionnaires. Tutoring was observed over a 5-week period and was digitally recorded and transcribed. Interviews were also digitally recorded and transcribed following the observation period.

Throughout the study, recursive data analysis and collection was ongoing. Transcription of every recording of tutoring sessions and interviews was performed soon after they occurred. I read and reread the transcriptions several times and then coded the data according to categories. Then member checking was done and all recorded data were found to be accurate by the participants. These categories were developed from the data: (a) tutors were well-trained and (b) tutees were dedicated. Seven themes emerged under those categories: (a) the tutors showed a blend of procedural knowledge and conceptual understanding of the mathematics for the classes they were tutoring; (b) the tutors displayed an ethic of caring toward their tutees and had excellent interpersonal and pedagogical skills; (c) tutees experienced frustration from an inability to understand in the classroom; (d) tutees did not retain what mathematics skills they learned in high school or in time gaps between mathematics courses; (e) tutees came to their tutoring sessions prepared; (f) tutees were consistent in attending their tutoring sessions; and (g) tutors were student-centered and wanted their tutees to succeed. Quotations from interviews, questionnaire responses, and recordings all supported these themes.


**Relationship of Themes to Related Research**

The following sections of this chapter discuss the findings of this study and the related literature.

**Tutor Training**

The data in this study coincides with the literature review that high-quality tutor training is vital for a successful tutoring program (Falchikov, 2001). Facets of good tutors and their training include content knowledge, good interaction skills, professional behavior, and personal attributes (Falchikov, 2001). The mathematics peer-tutoring program where this study was conducted required all of these characteristics. The faculty and staff who were interviewed for this research agreed that tutors must be student-centered and want their tutees to succeed and the tutors must demonstrate an understanding of the subject matter they are tutoring. This section cites relevant literature that is not only consistent with the tutors in this study but also concurs with the description of successful tutors by the faculty and staff that were interviewed for this study and discussed in Chapter 4.

**Mathematical Knowledge for Teaching**

Ball, Hill, and Bass (2005) have written extensively that sound mathematical skill and understanding are central to a teacher’s ability to assess student progress and make accurate judgments in their practice. Thames and Ball (2010) stated that although content knowledge is important, the ability to better understand math questions and the situations that math teachers will experience are also essential. In addition, they reported that: “We realized that the capacity to see mathematical ideas from another’s perspective and to
understand what another person is doing involves mathematical reasoning and skill not
needed for research mathematics or for bench science” (Thames & Ball, 2010, p. 222).
Deborah Ball in particular has named this type of knowledge, mathematical knowledge
for teaching, and it is often depicted in the diagram (see Figure 1) as a blend of various
parts (Thames & Ball, 2010, p. 223).

![Diagram of Mathematical Knowledge for Teaching (MKT)](image)

*Figure 1. Mathematical knowledge for teaching (MKT; Thames & Ball, 2010)*

It is my contention that this type of knowledge is not only necessary for teaching
but also for tutoring. Hill, Blank, et al. (2008) defined Mathematical Knowledge for
Teaching (MKT) as not only the mathematical knowledge necessary for teaching math
but also as understanding the why and how of mathematical procedures, how to define
terms, and the ability to recognize types of errors students are likely to make. They also
used the term Mathematical Quality of Instruction (MQI) to describe the rigor and
richness of mathematics lessons which includes presence or absence of errors, explanation and justification, and related observables (Hill, Blunk, et al., 2008).

Ball and colleagues defined the various components of MKT as Common Content Knowledge (CCK), Specialized Content Knowledge (SCK), Knowledge of Content and Students (KCS), and Knowledge of Content and Teaching (KCT; from Figure 1). CCK was described as knowledge used in the work of teaching in ways in common with other mathematics-based professions (Hill, Ball, et al., 2008). SCK means how teachers represent mathematical ideas, procedures, rules, and can understand and examine unusual methods for solving problems (Ball et al., 2005). KCS was defined as content knowledge interwoven with knowledge about how students learn, think about, or know the mathematical content they are studying (Hill, Ball, et al., 2008), and KCT is a combination of knowing mathematics and knowing teaching (Ball, Thames, & Phelps, 2008).

In a study done by Ball and six of her colleagues, “Mathematical Knowledge for Teaching and the Mathematical Quality of Instruction: An Exploratory Study” (Hill, Blunk, et al., 2008), they focused on five teachers’ MKT as compared to MQI (mathematical quality of instruction). This relationship was used to illustrate that teachers’ knowledge of mathematics has a role that is as important as their teaching of mathematical subject matter and to understand how MKT is conveyed during classroom teaching (Hill, Blunk, et al., 2008). MQI included the categories: mathematics errors, responding to students inappropriately, connecting mathematics to classroom practice, the richness of mathematics, appropriate responses to students, and the use of accurate
mathematical language (Hill, Blunk, et al., 2008). They scored teachers’ lessons and compared them to a pencil-and-paper mathematics test taken by the teachers. The participants taught either from an elementary or middle school.

Of the elements in MKT, the tutors in my study most often used SCK, KCS, and KCT. The following are excerpts from tutoring sessions I observed and how the tutors employed these elements. For example, T1 was working with S1 with quadratic functions. The following was their conversation on this topic as categorized by the type of knowledge displayed by the tutor.

SCK:

S1: Um, this is a quadratic function?
T1: Yeah. And which one (graph) seems to fit better?
S1: Fit what?
T1: Fit the points that we plotted.
S1: Of like the dot? Okay, this one then.
T1: Yeah, and that one is the exponential one.

KCS:

S1: I don’t even understand what it’s saying.
T1: Do you have any idea where to start here? What do you think the basic equation that they’re trending from is here?

T2 was explaining factorization to S2 and S3. Their session began with the question: “I don’t understand number four” and continued as follows:
SCK:

T2: If “A” has 15 factors, what is a possible prime factorization of “A”?  
S2: Um, I had the idea, but I did it wrong.  
T2: But fifteen factors would be like, if you had two to the second...  

KCS:

T2: So x squared, so we’re gonna do what with this? You can do it one step at a time, too.  
S2: Can you do x, x plus something? Two, four, three?  
T2: Yes, x +3.  
S2: Is that what it is?  
T2: Yes. ‘Cause I’m pretty sure that goes down to three.  
S2: It’s supposed to be minus four. Squared minus four.  

KCT:

T2: Mhmm. So the first thing you wanna do is figure out what equation we’re changing. Is it gonna be x cubed? Is it gonna be the square root of x?  
S2: X squared plus two.  
T2: Do you remember how to figure out how many factors that something has?  
S2: Um, I had the idea, but I did it wrong.  

In one session, T3 was helping S4 with graphing functions and their inverses. He began the session by asking her about a previous session where seemed confused about that subject.
SCK:

S4: Is there a better way?

T3: Yes.

S4: I don’t know what’s happening.

T3: We’re stat plotting though. And so that turns off the stat plot and now we’ll just got standard (showing S4 how to plot using her calculator).

S4: So it’s one to one?

S4: Is that just f of x minus one?

T3: Yep. Cool, now that’s B. So part C, verify that it’s the inverse; that’s when you plug one of them into the other.

S4: Okay.

KCS:

T3: And you were kind of confused on Wednesday too. So A and B, let’s go ahead and do it.

S4: Mhmm.

T3: Cool, so for part A we show that it’s one to one.

S4: Okay.

T3: And you remember how, right?

S4: Um, he said just to put it in your calculator and then draw the graph.

KCT:

T3: Yes. So now we need to find the inverse.

S4: Okay, so we’re solving for y, right?
T3: Okay, so that’s our inverse, we should call it f inverse.

T3: And if it’s an inverse, what will get you back?

S4: x.

T3: Right. So?

S4: I don’t know.

T3: Take this function and plug it into that x. Or take this function and plug it into that x.

S4: So it’s x into x?

T3: The whole function into the x.

S4: Okay.

Successful tutors must possess the types of knowledge described by MKT to be effective tutors. The tutors in my study showed the ability to represent mathematical ideas and procedures and methods for solving problems (SCK), content knowledge interwoven with how their tutees learned (KCS), and a knowing of mathematics and knowing how to teach it (KCT). The tutors who were observed in my study intermingled MKT skills as outlined in Thames and Ball’s map. This was observed during tutoring sessions in the way the tutors asked and answered questions with their tutees, exhibiting the tutors’ procedural skills and content knowledge. The following section will describe the major themes to relevant research.

**Procedural Skills and Content Knowledge**

Hiebert (2013) has been credited with first using the terms procedural skills and content knowledge in the instruction of mathematics in the United States. He highlighted
the importance of these elements by citing the 1999 TIMSS (Third International Mathematics and Science Study) and his study has been used to inform current policy for teaching mathematics is the U.S. As stated in Chapter 4, procedural knowledge is “knowing how” or the knowledge of the algorithms required to attain various goals (Hiebert, 2013) and conceptual understanding is “the ability to transfer our knowledge and skill effectively . . . (and) to take what we know and use it creatively, flexibility, fluently, in different settings or problems, on our own” (Wiggins & McTighe, 2005, p. 40). “The more we examine teaching, the more we find that teaching well requires an abundance of mathematical skill and of usable mathematical knowledge—mathematical knowledge in and for teaching” (Thames & Ball, 2010, p. 223). The tutors in this study showed a blend of procedural knowledge and conceptual understanding. When a tutee asked a question, the tutor would clearly explain the concept and then help the tutee to solve the problem. T3 was especially good at this, as he would not only thoroughly explain the concept in clear, easy to understand terms but would frequently draw pictures and graphs. In one session, T3 was explaining why functions shift, and when S4 seemed confused, he drew a graph for her. She asked, “And when it’s like less h, you’re shifting to the left and when it’s like minus h, you’re shifting to the right?” He told her that was correct and drew the example they were discussing. He, as well as the other tutors I observed, would always ask the tutees if they then understood after a topic was explained to them. They would then ask them another question about the same concept, often using a question they thought of themselves without the use of a book. They would consistently show how to solve problems while simultaneously explaining the why of the
problems. Two of the four tutors who were observed were education majors (another one began as a math education major then changed his major to mathematics) and for them it was even more important to show they had this level of skill and understanding as it is necessary for teachers of mathematics, as defined by the National Research Council in “Adding it Up” (2001).

**Interpersonal Skills**

Tutors must “strive to construct consultations in such a way that students find them non-threatening and collaborative, making the conversation more egalitarian and personal” (Bell & Youmans, 2006, p. 31). In instructing mathematics, peer tutors must attend to and respect different points of view from tutees, especially when they become frustrated (Chazan & Ball, 1999). This can be done by having respect for viewpoints that may differ from what is considered the norm so that the tutees are free to explore their ideas in order to learn mathematics (Chazan & Ball, 1999). Since some students tend to retreat instead of engage when they are confused in mathematics, the tutor’s role is to be patient and understanding so that learning may occur (Chazan & Ball, 1999). Tutors must be able to hear what the tutees are trying to convey to them about their misconceptions and difficulties in mathematics; this can sometimes be difficult and deciding how to manage this can be even more challenging, but is necessary for a successful teaching experience (Ball, 1993). Ball and Cohen (1996) stated that instructing mathematics must embrace both knowing and caring and find ways to connect both of these components. An ability to successfully communicate with students is necessary for this to happen. This belief was demonstrated by the tutors in my research
and was echoed by all of the faculty and staff that were interviewed in this study. As F/S3 stated, “The tutor needs to have willingness to listen to student thinking and guide students’ thinking rather than a propensity to spout off answers and procedures.” F/S1 also said, “I feel having . . . personable social skills to relate to the student to explain the material is crucial for a successful tutor.”

It was not unusual for the tutees to come to their sessions frustrated because they did not understand a concept from their classes or from a test or quiz. The tutors were prepared for this and were very patient as they listened to their tutees and then answered them in a calm manner. This would in turn relax the tutees and help them to get a deeper understanding of the concept. S4 was often in this state of mind during her tutoring sessions. She was very concerned about her grade in the class that she was taking and was worried about getting an A in the class. T3 was always attentive and reassuring to her. As T3 and S4 were discussing S4’s final exam, T3 reminded her that she had got A’s on all of her exams to date. S4 was upset because she heard from another student that the final was very difficult. T3 had taken the same class previously and explained to her that the exam would be no more difficult for her then any of the others she had taken in that class. He told her not to worry, and assured her that she would do fine. This kind of caring and compassion was typical of the tutors I observed, possibly because of the semester-long relationships they had formed. S2 and S3, who shared T2 as a tutor, were both upset in one of their sessions because they felt as though their instructor moved too quickly through the material and didn’t explain it very well. T2 also had taken the course they were enrolled in that semester and, without saying anything negative about the
instructor, said she understood how they felt and continued by then explaining the topics that confused them. S2 and S3 told T2 they understood after she explained the concept to them; I could clearly see that “aha!” look on both of their faces when they did “get it.”

**Professional Practice**

Professional practice is key for effective tutoring and teaching. “To improve the quality of teaching, educators must establish a common core of professional knowledge and skill” (Ball & Foranzi, 2011, p. 19). Professional practice is not just the content knowledge that is most important for teaching a subject and how to communicate it, but also includes explicit learning goals that include the range of skills, orientations, understanding, knowledge and commitments necessary for responsible teaching (Ball & Foranzi, 2011, p. 38). Ball and Foranzi found that the purpose of instruction is to build bridges between the students and the subject being taught. The future of the students’ success relies on the care with which instructors present the subject matter. They continued by saying that in a high-level practice of teaching is an ability by instructors to recognize ideas, key thinking patterns and misconceptions that students at every level experience. In addition to professional practice, ways to convey the practice of teaching through explicit learning goals that incorporate skills, knowledge, commitments, and understandings that generate responsible instruction are necessary (Ball & Foranzi, 2011). This may be achieved in mathematics by articulating the work of teaching mathematics, developing practices that identify and choose high-level practices, and have mathematical knowledge for teaching (Ball, Sleep, Boerst, & Bass, 2009). These standards must be functional for people at all levels of experience (Ball et al., 2009).
The tutors in my research applied Ball and her colleagues’ definitions of good teaching to their tutoring practices, as was detailed in Chapter 4. They used an effective blend of procedural knowledge and conceptual understanding, used multiple representations, conducted themselves professionally, and showed empathy as well as excellent communication skills with their tutees. The tutors did build bridges between the tutees and the subject matter repeatedly. There was an ease and feeling of acceptance; if a tutee said they understood something but the tutor could sense they did not, they tutor would explain the subject again in a different way.

For example, T2 was going over fractions with S2 and S3 who were struggling with mixed numbers. T2 first explained by using subtraction, but S2 and S3 still seemed confused so she told them how to do the same operation by using division. To that S2 said, “That’s probably the easier thing.” Tutors made sure that the tutees knew any topic where the tutees had questions. The tutors were always in the tutoring center well before their scheduled tutoring times and kept the tutees on task. They did not clock watch, but made sure the sessions ended on time. The tutors always had paper and pens on hand as well as calculators and laptop computers. All of the tutors I observed showed how well trained they were and complied with the requirements for the tutoring program at the university, as outlined in Chapter 4.

**Tutees Were Dedicated**

Tutees came to their tutoring sessions prepared and tutees were consistent in attending their tutoring sessions. Within academic success literature in higher education,
Carey, Brigman, Webb, Villares, and Harrington (2013) identified three critical skill sets that are necessary for academic success in students; these are:

- Cognitive and metacognitive skills such as goal setting, progress monitoring, and memory skills
- Social skills such as interpersonal skills, social problem solving, listening, and teamwork skills
- Self-management skills such as managing attention, motivation, and anger.

(Carey et al., 2013, p. 171)

These skills are considered to be the standards that separate successful students from at-risk students and align with the American School Counselor Association national model (ASCA, 2012) with its three programmatic pillars of academic, personal/social, and career success. The first critical skill set was demonstrated by the tutees because they volunteered for tutoring with the goal of passing their respective classes and wanting to understand math. Since mathematics is progressive, they showed their memory skills by being able to progress forward in their courses by building on what they learned previously. The tutees showed the second critical skill set by being able to communicate with their tutors in a way that the tutors could understand. They also listened carefully when their tutors were explaining concepts to them and worked together with their tutors. Critical skill set three was evidenced by the tutees by coming to their scheduled tutoring times every week and being able to pay attention to their tutor despite the fact that there were several tables where other students were being tutored in the same area as they were being tutored, which could sometimes be noisy. Participating in tutoring voluntarily
attested to their motivation. When the tutees told their tutors they were angry from being frustrated because they didn’t understand something, they quickly calmed when the tutor explained what they did not understand.

Knowles (1980, 1984) identified six assumptions for learning that are foundational for designing learning programs such as tutoring:

1. As a person matures, his or her self-concept moves from that of a dependent personality toward one of a self-directing human being;

2. An adult accumulates a growing reservoir of experience, which is a rich resource for learning;

3. The readiness of an adult to learn is closely related to the developmental tasks of his or her social role;

4. There is a change in time perspective as people mature—from future application of knowledge to immediacy of application;

5. The most potent motivations are internal rather than external;

6. Adults need to know why they need to learn something. (Knowles, 1980, p. 44–45)

Under these assumptions, Knowles (1980) suggested that the learning climate should be a comfortable one between the students and instructors and one of “joint inquirers” (Merriam et al., 2007, p. 85).

These theories are indicative of the typical behavior of the tutees that were observed in my research. As described in Chapter 4, the tutees were prepared, on time, self-motivated, and openly inquisitive with their tutors. In the sessions I observed, the
tutees displayed the three critical skills (Carey et al., 2013) necessary for academic success. They each came to their sessions prepared with specific questions and asked until they understood. The fact that the tutees sought tutoring services on their own and regularly attended scheduled sessions showed their self-motivation to succeed and set their own goals. The tutees were all very attentive to their tutors, demonstrating interpersonal listening skills and social skills and the ability to engage in a team-working atmosphere. The tutees would sometimes arrive at their tutoring sessions frustrated with their course material, including the online environment, but after describing why they were frustrated would carefully listen to their tutors, showing their listening, self-management, attention, and anger management skills. As previously mentioned, S2 and S3 shared T2 and often worked together outside of their tutoring sessions and would go to their sessions with a list of questions they had tried to work on by themselves, which exhibited their ability to use teamwork. S1 was taking an online class and therefore had to self-manage her time and goals for her class. Of all the tutees that were observed, S4 exhibited the most frustration, but keeping in mind her goal of getting an A in her course, along with having good interpersonal listening skills with her tutor, she stated at the end of the observation period that her tutor helped her calm down and do better.

Knowles’ (1980, 1984) six assumptions discussed above applied to the tutees in my study because they are adult learners of at least 18 years of age, enrolled in a university. Points five (The most potent motivations are internal rather than external) and six (Adults need to know why they need to learn something) are most closely related to
my research. The tutees were self-motivated to do well in their classes not only because they were classes required for their majors, but also because they wanted to do well for their own personal satisfaction. This could be seen by the fact that they chose to participate in tutoring services on their own and regularly attended and were prepared for the sessions.

A Lack of Preparation

The need for tutoring was first recognized post World War II when students were attending college via the GI Bill. “The nature of four year institutions changed as they attempted to deal with their new underprepared and at-risk students, and give them the support they needed to finish their degrees” (Halcrow & Liams, 2011, p. 324). The lack of college readiness in high school students in the United States has resulted in recommendations for more rigor in elementary and high schools. With this increased rigor, it is reasonable to assume more support services, such as peer tutoring in mathematics, are needed (Fetsco, Tang, & Totura, n.d.). One of the reasons students may be unprepared for learning in college is a reliance on traditional classroom teaching that does not lend itself to a deep understanding of mathematics (Topping, 1996). Without a positive learning environment, students often become confused and may not learn anything at all or not learn what is intended to be taught and can lead to negative feelings toward an instructor, other students, or the school itself (Illeris, 2002). This can be applied to the failure for some to learn in the traditional classroom. Many Americans are concerned about the lack of preparation of students in mathematics because they are not acquiring the necessary knowledge and skills to use the mathematics they have learned
As stated in Chapter 4 and in the discussion above about the three critical skill sets for academic success (Carey et al., 2013), all of the tutees I observed demonstrated frustration from the traditional classroom learning environment. S1 had taken algebra, geometry, and statistics in high school, but was struggling with the basic algebra concepts in the course she was taking. S2 took geometry, algebra II, pre-calculus, and AP calculus in high school but was having problems with her basic algebra class. S3 was enrolled in the same class as S2, and although she took algebra and pre-calculus in high school, she was also having a difficult time understanding basic algebra. Considering the level of classes they took, one may think the tutees would be doing well in their respective math classes in college. Even though all of the tutees in this study were freshmen, they were all struggling to grasp the concepts in their classes. This suggests that they either did not learn from those classes in high school or their coursework in high school did not adequately prepare them and necessitated tutoring in college. S4 took algebra II and statistics in high school, and unlike S1, S2, and S3, did not really seem to have trouble understanding, but needed her tutor’s reassurance that she was doing the math correctly so she could achieve a high grade in the course.

**Implications and Suggestions for Further Educational Research**

The findings of this research show the need for further research on the personal relationships between tutors and tutees. This study focused on a small group of
participants at a single university, and its approach to peer tutoring in mathematics. In that, this study looked specifically at a single incidence of one-on-one peer mathematics tutoring at the university level. A study including several higher education institutions and a larger sample of participants over a longer time period may reveal more findings. It would also be of great interest and provide deeper insight to research a peer tutoring program in mathematics at a higher education institution where the program has less rigorous qualifications as the program studied in this research.

As discussed previously, tutoring is a useful tool in building bridges between students and subject matter (Ball & Foranzi, 2011). However, it can be difficult for a student to transition from high school mathematics to university-level mathematics. Kajander and Lovric (2005) collected information from 2001–2003 at Macmaster University in Canada using a survey and used that information to re-design their first-year mathematics course. They recommended closer alliances between university and high school teachers to better design first year university mathematics courses based on preparation in high school mathematics courses. They found, however that “it was difficult to make up for inadequate high school experiences” (Kajander & Lovric, 2005, p. 157). This indicates that more research needs to be done to help bridge the gap between high school mathematics programs and university-level mathematics programs. This would provide valuable data for designing more effective tutoring programs, as the tutors would better know what knowledge their tutees have coming into their university mathematics courses.
Another factor that may be considered for future study is one that includes a wider range of demographics in the tutors and tutees, meaning one that looks at non-traditional students and the relationships that exist between perhaps a non-traditional student and a traditional student in a peer tutoring situation in mathematics at the university level.

**Conclusion**

This study focused on the experiences of traditional university students in a peer tutoring environment at a large, Midwestern university that lasted throughout their semester. This was done in order to explore the importance of the tutoring relationships between tutors and tutees in a mathematical, peer tutoring environment, and the characteristics that enable successful programs. Based on the findings of this study, it was found that not one quality or characteristic exists to create a successful tutoring program; instead, it demands a cluster of pedagogical, content, and social skills that tutors and tutees must possess. The university has responsibility as well. It is imperative that the administration find funding for quality tutor programs and provide a variety of experiences (drop-in tutoring versus scheduled tutoring). After thorough research, he observed that many studies have been done about peer tutoring; however, most of these studies are quantitative, which leaves out the important facet of the personal connection between the tutors and tutees. There is also a limited amount of research that has been done concerning peer tutoring in mathematics in higher education, as most of the research focused on elementary through high schools. In that same regard, little has been investigated about students who seek out peer tutoring services on their own. Also, achievement gains, such as test scores, are the typical focus of peer tutoring studies.
Since a qualitative methodology was used for this study, I understand that it may not be applicable to all higher education institutions nor all of the students found within. Still, I was motivated as both a teacher of mathematics at the higher education level and a former mathematics student who was sometimes very frustrated in the subject, having worked as a mathematics tutor, I was inspired to shine a new light on the peer tutoring experience to find, at least in part, what may work to help those students who may also be facing some of the maddening frustrations I have felt myself.

Since resources for higher education seem to continuously become fewer and fewer, I believe it is of extreme significance for universities and the faculty, staff, and even more importantly, the administrators of colleges and universities to see that peer tutoring is an invaluable and highly cost-effective and low-cost tool for student success on a number of levels given highly rigorous training and long-term tutoring sessions. It is my hope that peer tutoring will be more readily recognized and implemented at every level so that students may realize not only their potential as a life-long student, but also as a person in society.

A higher education institution that provides and promotes peer tutoring not only encourages students to use the services, but gives them the feeling that they are receiving support from the campus and are an important part of the university, and will be more likely to stay at that institution (Stern, 2001).
APPENDICES
APPENDIX A

QUESTIONNAIRE OF TUTORING EXPERIENCE
## Appendix A

### Questionnaire of Tutoring Experience

[Adapted from Houston & Lazenbatt, 1996] *

Overall, did you feel like the tutoring sessions made you feel:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. That you could work easily without pressure?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>2. That peer tutoring is a complete waste of time?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>3. That you were bored?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>4. That your tutor cared?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>5. That you had the chance to learn more by talking?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>6. That you had an inadequate understanding of the subject matter?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>7. Uncomfortable?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>8. That you have developed better communication skills?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>9. That you could learn skills by working with (as) a tutor?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>10. That you became pressured for time?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>11. That you were embarrassed?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>12. That you were confident enough to demonstrate how much of the subject matter you really know?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>13. That you could get help without showing ignorance to a lecturer?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>14. That you have insufficient ability/knowledge to understand the subject?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>15. That you would prefer to be responsible for your own learning?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>16. That your level of performance and achievement have increased?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>17. That academic standards would fall if peer tutoring became an established mode of learning in higher education?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>18. That you understood the subject matter better than you would have during conventional lecturing?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>19. That the tutoring sessions were helpful?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>20. That it was easy to work with (as) a tutor?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>21. That you were reluctant to work with (as) a tutor?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>22. That the tutoring sessions were a valuable experience?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>23. That the tutoring sessions reinforced your learning?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>24. That the tutoring sessions clarified your own personal learning?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>25. That the tutoring sessions increased your level of performance?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>26. That the tutoring sessions met your personal learning needs?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>27. That you will be a more capable student have gone through the tutoring experience?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>28. That you would recommend tutoring to other students?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>29. That you would volunteer to participate in tutoring next year?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>30. That you would have learned more if you had worked alone?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>31. That you would have learned more from the traditional lecture method?</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

**Comments:**

Appendix B

Observation Protocol

[adapted from Bieda (2010)]*

1. What questions did students have about the problem(s), and what were the tutors’ responses?
2. In what ways, if any, did students not follow instructions?
3. How did the tutor assess student progress on the problems in the investigation?
4. How did students respond to the tutor’s guidance during the investigation?
5. What changes did the tutor make to the investigation as it was enacted?
6. What questions/responses from students prompted changes?
7. Did the tutor restate the explanation or ask for other justifications to the problem(s)?
8. When did the tutor ask students to explain their justification further?
9. What kinds of information were assumed/ “taken-as-shared” during the discussion of the problem?
10. Were any explanations given for responses to the problem highlighted and in what way?
11. What aspects of the problem discussion seemed to be difficult for the tutor to facilitate?

APPENDIX C

DATA
## Appendix C

### Data

Table C1

*Demographic Information for Faculty and Staff*

<table>
<thead>
<tr>
<th>Participant</th>
<th>Education</th>
<th>Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>F/S1</td>
<td>BA, MA, PhD in Math</td>
<td>Taught and/or tutored math 41 years at the university level, mathematics professor 17 years</td>
</tr>
<tr>
<td>F/S2</td>
<td>BS and PhD in Biology</td>
<td>Taught or tutored biology at the freshman-senior level for 38 years, beginning as a graduate student</td>
</tr>
<tr>
<td>F/S3</td>
<td>BA and MA in Math, PhD in Curriculum and Instruction</td>
<td>40 years teaching math:  11 years at a high school, 29 years at the university level, coordinates and teaches college algebra level courses</td>
</tr>
<tr>
<td>F/S4</td>
<td>BS and MS in Math</td>
<td>Tutored math from Basic Algebra, Calculus III, Linear Algebra and beyond for the past 8 years, taught for approximately 1 semester, Coordinator for Academic Program Tutor Management (supervisor for T1-T3)</td>
</tr>
</tbody>
</table>
### Table C2

**Demographic Information for Tutors**

<table>
<thead>
<tr>
<th>Tutor</th>
<th>Education</th>
<th>Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>Major: Aeronautical Engineering</td>
<td>Math tutor for 3 years; After college: Take a break then pursue a master’s degree</td>
</tr>
<tr>
<td>T2</td>
<td>Major: Early Childhood Education</td>
<td>Math tutor for 1 semester; After college: Elementary school teacher</td>
</tr>
<tr>
<td>T3</td>
<td>Major: Applied Mathematics, Probability and Statistics</td>
<td>Math tutor for 3 years; After college: Full-time employment</td>
</tr>
</tbody>
</table>

### Table C3

**Demographic Information for Tutees**

<table>
<thead>
<tr>
<th>Tutee</th>
<th>Major</th>
<th>Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Psychology</td>
<td>Received math tutoring for 1 semester; After college: Wants to open a women’s shelter and help foster and adoptive children</td>
</tr>
<tr>
<td>S2</td>
<td>Early Childhood Education</td>
<td>Received math tutoring for 1 semester; After college: Permanent teaching position, get married and have children</td>
</tr>
<tr>
<td>S3</td>
<td>Early Childhood Education</td>
<td>Received math tutoring for 1 semester; After college: Kindergarten teacher</td>
</tr>
<tr>
<td>S4</td>
<td>Pre-Nursing</td>
<td>Received math tutoring for 3 months; After college: Registered nurse</td>
</tr>
</tbody>
</table>
Table C4

*See the questionnaire in Appendix A*
### Table C5

**Tutees’ High School Math Coursework**

<table>
<thead>
<tr>
<th>Tuttee</th>
<th>Mathematics classes completed in high school</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Algebra, Geometry, and Statistics</td>
</tr>
<tr>
<td>S2</td>
<td>Geometry, Algebra II, Pre-Calculus, AP Calculus</td>
</tr>
<tr>
<td>S3</td>
<td>Algebra, Pre-Calculus</td>
</tr>
<tr>
<td>S4</td>
<td>Algebra II, Statistics</td>
</tr>
</tbody>
</table>

### Table C6

**Tutees’ Family Background in Mathematics**

<table>
<thead>
<tr>
<th>Tuttee</th>
<th>Family background in mathematics</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Strong mathematical background</td>
</tr>
<tr>
<td>S2</td>
<td>Weak mathematical background</td>
</tr>
<tr>
<td>S3</td>
<td>Weak mathematical background</td>
</tr>
<tr>
<td>S4</td>
<td>Strong mathematical background</td>
</tr>
</tbody>
</table>

### Table C7

**Private High School Versus Public School**

<table>
<thead>
<tr>
<th>Tuttee</th>
<th>Private or public high school</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Private</td>
</tr>
<tr>
<td>S2</td>
<td>Public (city)</td>
</tr>
<tr>
<td>S3</td>
<td>Public (urban)</td>
</tr>
<tr>
<td>S4</td>
<td>Public (suburban)</td>
</tr>
</tbody>
</table>
Table C8

*Abbreviated List of Tutee Questionnaire Responses*

<table>
<thead>
<tr>
<th>Question</th>
<th>Tutees Answering</th>
</tr>
</thead>
<tbody>
<tr>
<td>13: If you could get help without showing ignorance to a lecturer</td>
<td>S1-S3 S4</td>
</tr>
<tr>
<td>14: You have insufficient ability/knowledge to understand the subject</td>
<td>S1-S4 0</td>
</tr>
<tr>
<td>18: You understood the subject material better than you would have</td>
<td>S1-S4 0</td>
</tr>
<tr>
<td>during conventional learning</td>
<td></td>
</tr>
<tr>
<td>28: You would recommend tutoring to other students</td>
<td>S1-S4 0</td>
</tr>
<tr>
<td>29: If they would participate in tutoring next year</td>
<td>S1-S4 0</td>
</tr>
<tr>
<td>31: If they would have learned more from the traditional lecture method</td>
<td>S2 S1, S3, S4</td>
</tr>
</tbody>
</table>

Table C9

*Tutees’ Majors and Required Mathematics Coursework*

<table>
<thead>
<tr>
<th>Participant</th>
<th>Major</th>
<th>Required coursework</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Psychology</td>
<td>Basic Mathematical Concepts I, II</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Modeling Algebra</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Algebra for Calculus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Trigonometry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Algebra &amp; Trigonometry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Analytic Geometry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Calculus I</td>
</tr>
<tr>
<td>S2 &amp; S3</td>
<td>Elementary</td>
<td>3-5 Credits from the University Math Core*</td>
</tr>
<tr>
<td></td>
<td>Education</td>
<td>Basic Mathematical Concepts I &amp; II</td>
</tr>
<tr>
<td>S4</td>
<td>Pre-Nursing</td>
<td>3-5 Credits from the University Math Core*</td>
</tr>
</tbody>
</table>

*The University Math Core courses are: Basic Algebra, Modeling Algebra, College Algebra, Basic Statistics, Exploration in Modern Math, Algebra for Calculus, Intuitive Calculus, Trigonometry, Algebra & Trigonometry, Calculus I.*
Table C10

*Qualities in a Successful Tutoring Program*

- Clear Purpose and Mission
- Staff Development
- Quality Program Management
- Strategic Plan for Participant (Tutors and Tutees) Recruitment
- Effective Management of Tutee Enrollment
- Consistent Attendance and Retention of Tutees
- Quality Tutor Supervision
- Required Ongoing Tutor Training and Orientation
- Effective Student Intervention
- Frequent and Consistent Tutoring
- Well-Structured and Well-Planned Tutoring Sessions
- Positive Tutor-Tutee Relationships
- Strong Partnership Between Schools and Tutoring Programs
APPENDIX D

INFORMED CONSENT FORMS
Appendix D

Informed Consent Forms

Informed Consent to Participate in a Research Study
A Phenomenological Study of Peer-Tutoring Developmental Mathematics at the University Level

Principal Investigator: Joanne Caniglia

You are being invited to participate in a research study. This consent form will provide you with information on the research project, what you will need to do, and the associated risks and benefits of the research. Your participation is voluntary and in no way will affect your grade in your present or future mathematics classes. Please read this form carefully. It is important that you ask questions and fully understand the research in order to make an informed decision. You will receive a copy of this document to take with you.

Purpose: The purpose of this study is to find what characteristics and behaviors are found in math tutoring environments, what are the common characteristics found in math tutors and determine how the university-level math tutoring program is aligned with institutional learning outcomes as well as departmental outcomes.

Procedures
I will be observing students being tutored in mathematics. I may be video and/or audio taping tutoring sessions. Data being collected will include scores on homework for those students who use the ALEKS system. I will also ask the participants to fill out a survey as well as to be interviewed. The data collection will be for one semester only and all data gathered will be for my research only.

Audio and Video Recording
Any audio and/or video recordings will be used for my research only and may be reviewed by the participants. All audio and/or video recordings will be destroyed at the completion of the study.

Benefits
This research will not benefit you directly. However, your participation in this study will help us to better understand the inner dynamics of peer tutoring to better develop successful peer tutoring programs.

Risks and Discomforts
There are no anticipated risks or discomforts beyond those encountered in everyday life.

Privacy and Confidentiality
No identifying information will be collected. Your signed consent form will be kept separate from your study data, and responses will not be linked to you. Your study related information will be kept confidential within the limits of the law. Any identifying information will be kept in a secure location and only the researcher will have access to the data. Research participants will not be identified in any publication or presentation of research results; only aggregate data will be used.

Compensation
A Phenomenological Study of Peer-Tutoring Developmental Mathematics at the University Level
Participants who complete the interview at the end of the study will be compensated ten dollars each.

Voluntary Participation

Taking part in this research study is entirely up to you. You may choose not to participate or you may discontinue your participation at any time without penalty or loss of benefits to which you are otherwise entitled. You will be informed of any new, relevant information that may affect your health, welfare, or willingness to continue your study participation.

Contact Information

If you have any questions or concerns about this research, you may contact Dr. Joanne Caniglia at 330-672-6615 or joanne@kent.edu. This project has been approved by the Kent State University Institutional Review Board. If you have any questions about your rights as a research participant or complaints about the research, you may call the IRB at 330-672-2794.

Content Statement and Signature

I have read this consent form and have had the opportunity to have my questions answered to my satisfaction. I voluntarily agree to participate in this study. I understand that a copy of this consent will be provided to me for future reference.

Participant Signature

Date

A Phenomenological Study of Peer-Tutoring Developmental Mathematics at the University Level
AUDIO/VISUAL TAPE CONSENT FORM

NAME OF STUDY: A Phenomenological Study of Peer-Tutoring Developmental Mathematics at the University Level

PRINCIPAL INVESTIGATORS: Joanne Caniglia and Jennifer Curry

I agree to participate in an audio/videotaped interview about the tutoring process as part of this project and for the purposes of data analysis. I agree that Joanne Caniglia and Jennifer Curry may audio/video-tape this interview. The date, time and place of the interview will be mutually agreed upon.

Signature Date

I have been told that I have the right to listen to the recording of the interview before it is used. I have decided that I:

_____ want to listen to the recording  ______ do not want to listen to the recording

Sign now below if you do not want to listen to the recording. If you want to listen to the recording, you will be asked to sign after listening to them.

Joanne Caniglia and Jennifer Curry may / may not (circle one) use the audio-tapes made of me. The original tapes or copies may be used for:

_____ this research project  _____ publication  _____ presentation at professional meetings

Signature Date

Address:

[Stamp: Approved - Feb 19, 2014]
REFERENCES
REFERENCES


