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An Application of Vygotsky's Social Learning Theory on Calculator Self-Efficacy and Calculator Achievement by Gender

Debbie M. Kohler
Kennesaw State University

AN APPLICATION OF VYGOTSKY'S SOCIAL LEARNING THEORY ON CALCULATOR SELF-EFFICACY AND CALCULATOR ACHIEVEMENT BY GENDER

by

Debbie M. Kohler

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The dissertation of

Debbie M. Kohler 000055747

CANDIDATE NAME/KSU ID

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Susan Hoskdale — 11/22/2010

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COMMITTEE MEMBER SIGNATURE — DATE

Marla M. Bell — 11/22/10

COMMITTEE MEMBER SIGNATURE — DATE

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DEDICATION

I dedicate this dissertation to my mom, Mavis Aulday, whose tireless love, support and belief in my abilities have stayed with me all these years, and who I lost in the middle of this doctoral program. Though you are gone, you are still with me. And I also dedicate this to my dear niece Amanda - mama also believed in you with her unwavering love. It's your turn now.

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ABSTRACT

AN APPLICATION OF VYGOTSKY'S SOCIAL LEARNING THEORY ON CALCULATOR SELF-EFFICACY AND CALCULATOR ACHIEVEMENT BY GENDER

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The purpose of this study is to determine what relationships or differences exist between males and females in calculator self-efficacy and calculator achievement, and if social learning groups better support females in calculator achievement and efficacy. To accomplish this purpose, this quasi-experimental study examined pre-test and post-tests using a teacher developed Calculator Self-Efficacy Instrument and a Calculator Achievement Test. The study involved three treatment classes that were arranged into social learning groups according to Vygotsky's social learning theory and one control class that was arranged in traditional rows. Four major findings emerged. Males scored significantly higher than females on the post- Calculator Achievement Test (CAT), however there was no significant difference between males and females in the net gain in calculator achievement. Males scored significantly higher than females on two-step calculator tasks and multi-step calculator tasks. There were no apparent gender related themes among calculator efficacy and calculator achievement except when students predicted their ability to program. Students were able to accurately predict their ability to program the calculator. Males' predictions were higher than females', but this positive correlation was statistically significant. Finally, students in the treatment group (Vygotsky's social learning groups) scored higher than the control group on the post-CAT and on net gain in calculator achievement and these differences were statistically significant. Females in the treatment group also scored higher on all measures than students in the control group, though all differences were not statistically significant. Recommendations include a teacher workshop on Vygotsky's learning theories and how to apply them to the mathematics classroom and to graphing technology; release time and funding for teachers who are not comfortable working with calculators to attend workshops so they may become proficient with the calculators; and further education on gender equity and technology for teachers. Recommendations for further research includes a longitudinal study on calculator self-efficacy and calculator achievement, developing an instrument to determine if a teacher is a "Vygotskian" type teacher and creating a study that includes a diverse number of teachers and students, and adding a qualitative component to the research study.

Keywords: social-learning, Vygotsky's learning theory, graphing calculator, self-efficacy, mathematics, calculator achievement; gender equity

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CHAPTER 1

INTRODUCTION

> As I progressed through my advanced mathematics classes in high school, I became the only female in our senior statistics course. Though I was always an excellent student in mathematics, what stands out in my mind is that no teacher took the opportunity to encourage me to study mathematics or science even though I was the only female in the most difficult and highest level mathematics course our school offered, and there were fewer than a dozen students who took the course. Yet the unintended consequence of my high school experience is a desire to study women, encourage women, and find ways to help them succeed in mathematics and technology.

Today, technology's role in mathematics education is critical. A casual review of literature indicates that the practice of teaching mathematics has changed as a result of the availability of technology and calculators. For instance, students can graph many functions quickly on a calculator and determine through discovery how a function is transformed. Previously, the number of problems students could graph or view was limited due to time. Computer algebra systems (CAS) have also allowed students to solve complex problems quickly, where before, the study of algebra and calculus was limited to problems that could be solved analytically with simple calculations. As a result students who regularly use a graphing calculator show increased achievement on problem solving techniques as well as mathematical achievement (Khoju, Jaciw, & Miller, 2005). Students also show increased achievement on the calculator portion of the AP Calculus exam when CAS instruction has been integrated into their mathematics class (Brady, 2006).

However, research suggests that gender inequity exists in calculator usage and calculator efficacy, and while studies have indicated that calculator usage can enhance education and impart knowledge, there are unanswered questions concerning how one actually learns how to use a graphing calculator. Learning how to operate a calculator requires ascertaining the initial competency level of the student with the technology (Bosco, 2004; Forster, 2006; Kaino & Salani, 2004). Calculator concept development can be nurtured and developed much like other mathematical concepts. Functional literacy with graphing technology can lead to improved understanding of many mathematical concepts, so it is critical to help all students achieve this competency (Isiksal & Askar, 2005).

Though teachers typically demonstrate to an entire class the use and features of a graphing calculator, group work and cooperative learning tasks that involve a graphing calculator offer the opportunity for students to work in a social setting or with partners. Research suggests that the social setting offers greater opportunity for students to become more confident in their graphing calculator abilities (Kaino & Salani, 2004) . Teaching by rote and transmission often fails to engage the student. Unfortunately, much of the mathematics curriculum is still taught in a traditional manner. Also, the transmission model is a mode that many females find less engaging and may fail to connect and learn the functionality of the calculator if they get lost in the steps involved. Yet the use of graphing technology lends itself to socio-cultural interaction that is the essence of Vygotsky's theory (Charnitski & Harvey, 1999; Crawford, 1996). The centrality of calculator usage to mathematics education today makes it imperative to ensure that all students have the opportunity to achieve with a graphing calculator. If differences in calculator achievement and efficacy with a graphing calculator do exist between males and females for graphing applications, then possible pedagogical changes based on gender theory may create an opportunity to empower girls to become stronger in their graphing calculator aptitude.

Statement of the Problem

In this age of technology, a gender disparity involving the use of technology exists between males and females and is well documented (Dyer, 2004; Forgasz & Griffith, 2006). The educational system may be inadvertently contributing to the inequity between males and females in regard to calculator achievement and efficacy. Calculator studies thus far have focused primarily on the use of calculators and their effect on achievement tests. This study seeks to fill a gap in the research and provide insight into gender differences specific to the ability to effectively use a graphing calculator as measured by a graphing calculator efficacy survey and achievement test.

Purpose

The purpose of this study is to determine what relationships or differences exist between males and females in calculator self-efficacy and calculator achievement, and if social learning groups better support females in calculator achievement and efficacy. To accomplish this purpose, this study will utilize the results of three pilot studies including two mixed method pilot studies to: (a) examine one-step, two-step and multi-step calculations, (b) examine collaborative partners' and groups' outcomes as compared to students working independently according to Vygotsky's social learning theory,

(c) compare student demographic background information to determine what, if any, effect they have on the outcome.

Research Objectives

There are nine research objectives addressed by this study and the pilot studies. They are as follows:

1. A reliable Calculator Efficacy Survey (CES) will be developed based on Griffin's calculator efficacy instrument (Griffin, 2006). For purposes of this study, this scale will have an internal consistency of at least 0.80, using Cronbach's alpha (Pilot Study 1).
2. The content validation of the Calculator Self-Efficacy Survey will be established using a panel of experts and high inter-rater reliability for face validity, appropriate wording and comprehensibility (Pilot Studies 1 and 3).
3. The content validation of the Calculator Achievement Test will be established using a panel of experts with positive agreement and high inter-rate reliability for face validity, vagueness in questions or instructions (Pilot studies 1 and 3).
4. The views of females about graphing calculators and their own personal attitudes about technology will be captured (Pilot Studies 1 and 2).
5. The calculator achievement scores will be compared by gender to determine if differences exist.
6. Calculator skills will be analyzed by gender to determine if differences exist.
7. Calculator self-efficacy ratings will be compared to calculator achievement scores to determine if efficacy matches performance for all students.

8. Students' length of ownership of calculators will be compared to achievement to determine if ownership contributes to achievement.
9. Scores of students working in collaborative pairs or groups (based on Vygotsky's social learning theory) will be compared to students working independently.

Conceptual Background

This section presents the general conceptual background of this study. This study will be grounded in Vygotsky's social learning theories (Vygotsky, 1978). Gender equity to include subtle forms of bias in education and differences by gender in the social setting will be reviewed (Gilligan, 2005b; Walkerdine, 1994). Self-efficacy and its association with mathematics and calculator efficacy will be reviewed (Pajares, 2005). The final piece of the conceptual background will include calculators and technology in education (Ellington, 2003; Forster, 2006).

Vygotsky's Learning Theories

This study is grounded conceptually in Vygotsky's social learning theory (Vygotsky, 1978; Harvey & Charnitski, 1998). Though much of the mathematics curriculum is still taught in a traditional manner, the use of graphing technology lends itself to socio-cultural interaction that is the essence of Vygotsky's learning theories (Charnitski & Harvey, 1999; Crawford, 1996). Teaching by lecture and requiring students to constantly regurgitate information fails to engage the student, whether one is using a graphing calculator or studying pure mathematical theory. Though not often practiced, the use of the calculator naturally offers the opportunity for students to work in a social setting of groups to collaborate and become more confident in their abilities (Kaino & Salani, 2004). Classroom discussions with partners or within groups are an important resource for knowledge construction because they allow for classroom discourse that becomes part of socially constructed knowledge that becomes internalized and can be used for concept formation (McNair, 2000). Vygotsky's themes of social interaction and discourse, and the zone of proximal development will be reviewed in detail in Chapter 2.

Gender Theory

Gender theory, the study of the cultural and social constructions of male and female, is used to illuminate the educational experience of females. Traditional psychological theory has historically defined the behavior of females in terms of males for years. Females typically define themselves and their experiences in terms of relationships, whereas males define their experiences in terms of self-identification (Gilligan, 2005a). Research indicates that girls have made great progress in education, but subtle forms of gender bias still exist in classrooms (Beaman, Wheldall, & Kemp, 2006). The psychological development of males and females is also different and can contribute to differences in instruction, discussions, and interactions (Gilligan, 2005b). Girls receive less encouragement in the classroom and are often in classrooms filled with an atmosphere of competition, which intimidates many girls (Williams, 2007). Many talented girls undermine their own success in education though they have superb abilities (Walkerdine, 1994).

Self-Efficacy and Calculator-Efficacy

Bandura introduced the concept of self-efficacy within the framework of social-cognitive theory in 1977. Many studies on self-efficacy have continued since Bandura originally introduced the concept, and it has since expanded to include domain specific mathematics self-efficacy, computer self-efficacy and calculator efficacy (Griffin, 2006; Pajares, 2005; Pajares & Graham, 1999). Technology efficacy has been developed and includes the belief that one can successfully complete a task involving computers, software and technology. Within the domain of technology efficacy, calculator efficacy surveys have been developed to evaluate a student's efficacy beliefs regarding calculator abilities. Technology also plays a role in efficacy as well, and scales have been developed to ascertain these ratings (Griffin, 2006).

The Intersection of Gender, Calculators and Technology in Education

In technology careers, a lack of females could threaten gender equality in the workplace. Many theories discuss the lack of women in the field, but one fact is evident - females often distance themselves from technology because they define it as being masculine (Kelan, 2007). Calculators do represent an exposure to technology, and if this experience is not positive, it could contribute to females' views on technology and careers.

Calculators in education have been studied for years, but the main focus has been on specific applications of the technology, and questions regarding gender bias have been absent (Ellington, 2003). Many studies emphasize graphing calculators and their impact on high stakes testing while other studies inspect a specific class level and specific application (Berry, Graham, & Smith, 2006; Forgasz & Griffith, 2006; Forster, 2006; Overall, 2007; Wiegand, 2007).

Significance of the Study

Calculators are a critical component of the learning process in mathematics. Simply being exposed to the calculator does not imply that students will learn or achieve the greatest benefit from the calculator (Forster, 2006). In a previous pilot study, findings indicated that females rated themselves moderately high on the calculator efficacy survey, yet when they actually used the calculator, they had difficulty (Kohler, 2008). Specifically, if a procedure required several screens to accomplish the task, many females were observed giving up on the task or handing the calculator over to someone more fluent. Since Forster's (2006) contention that calculator usage allows for collaborative work and real-life applications embedded in the socio-cultural setting, if the results of the study indicate the social intervention aid females in calculator achievement, different learning opportunities may be explored to allow calculator proficiency for all students.

This research may have an impact on teachers, educators and parents by providing them with pedagogical strategies conducive to teaching females. The findings will be shared with the local district as well as with the mathematics coordinator at the county level. Since previous studies have failed to address issues of equity in calculator use, this study may be able to provide new information regarding how to teach students in context, female and male, in such a way so that both may become calculator proficient with a strong calculator self-efficacy. It may also have an impact on the rationale for calculator technology in instruction, as well as show a need for professional development specific to collaboration among students and graphing technology.

Pilot Study Investigation

The first set of questions was employed in the pilot studies to investigate psychometric scales properties and qualitative data.. They were as follows:

Question 1: Can Griffin's original efficacy survey be adapted to develop a reliable high school Calculator Self-Efficacy Survey (CES) as determined by a measure of internal consistency?

Question 2: Utilizing a panel of knowledgeable high school teachers, can positive agreement be established using inter-rater reliability for wording, face-validity and comprehensibility for the Calculator Self-Efficacy Survey?

Question 3: Utilizing a panel of knowledgeable high school teachers, can positive agreement be established using inter-rater reliability for wording, face-validity and comprehensibility for the Calculator Achievement Test?

Question 4: How do females view their graphing calculator capabilities?

Main Study Research Questions

The present quasi-experimental study was designed to investigate the impact of using Vygotsky's social learning theory while teaching calculator concepts in context with the curriculum. The following questions were investigated.

Question 5: Do calculator assessment scores as measured by a teacher-developed assessment test differ based on gender?

Question 6: Are all calculator skills required on the test items equally performed by males and females including one-step, two-step and multiple-step calculations?

Question 7: Do personal self-efficacy ratings match actual calculator performance for all students?

Question 8: Is there a relationship between the number of years owning a graphing calculator and operational ability as defined by the test score?

Question 9: Does working in collaborative groups based on Vygotsky's social learning theories versus students working independently increase the performance level of students?

Assumptions

It is assumed that students taking part in the survey are representative of all students in the county taking similar classes, specifically Advanced Algebra and Trigonometry or Honors Analysis. Students are also encouraged to respond truthfully and thoughtfully to all parts of the efficacy survey and the calculator achievement test.

Delimitations

This study was delimited by its scope and limited sample size. The additional teacher could have added a confounding variable even though the second teacher was trained on how to teach all calculator concepts in context and how to administer the surveys. Both teachers involved in this study collaborated together throughout the year for planning purposes, but teaching methods differ nonetheless. Each teacher differed on delivery as well as their teaching skills with calculator activities. Though one additional teacher was used in the study, two teachers do not represent a large variety or sample size. The inability to use multiple schools and teachers within the district or within the state further limits the study.

The small sample size from the limited population of one school poses threats to external validity. The extent to which the study can be generalized to other groups was very limited.

Limitations

This study was conducted at a school in which the enrollment did not reflect national ethnic, gender, socioeconomic and cultural demographics. Students at the school had the following population characteristics: Asian – 1%, Black – 5%, Hispanic – 7%, White – 86%, and Multiracial – 1%. Approximately 15% of the students were economically disadvantaged and received free or reduced lunch. Special education students represented 11.7% of the population, gifted – 15.9%, vocational – 37.7% and 7.6% are in remedial programs.

Another limitation of the study is within the control group. Students will sit in rows, but this arrangement does not preclude discourse. Discourse was a form of social learning employed. If students in the control group feared they were not achieving at the same level as students in the other groups, they may have sought advice outside of class, which posed a threat to the internal validity of the study.

Definition of Terms

Graphing technology or graphing calculator. A hand-held calculator that will produce graphs of functions, solve systems of equations, find roots of functions, as well as perform scientific and basic mathematical calculations. It may also have symbolic representations and numeric methods for visualizing two and three dimensional mathematical objects.

Calculator achievement test. A teacher developed assessment test that measures one-step, two-step and multi-step calculator processes.

Calculator self-efficacy. This refers to how one perceives their ability to accomplish a task on the calculator. Self-efficacy is grounded in theory by Bandura (1977, 2007) who defined self-efficacy as the belief about one's capabilities of performance that further influences other events in one's life.

Technology. Electronic hardware, software or other devices that may be used for instructional purposes. Graphing calculators, computer mathematics programs and the TI-Smartview are all forms of technology.

TI-Navigator. A system that wirelessly connects the teacher to the students' calculators and allows for collection of data, dissemination of information, instant feedback, and tracking students' progress in real time (http://education.ti.com).

TI-Nspire CAS. A handheld graphing calculator with a touchpad navigation system and a built in computer algebra system. It performs symbolic and numeric calculations and allows multiple representations to be displayed on a single screen (http://education.ti.com).

TI-Smartview. A computer program that emulates the TI-84 calculator and that can be displayed on a white board with an in-focus projector (http://education.ti.com).

TI-84. A calculator manufactured by Texas Instruments with the model number 84. This calculator has programming, matrix, solving, graphing, statistical and scientific capabilities and was the calculator used for this study (http://education.ti.com).

Summary

This chapter presented an introduction and the background for this study on calculator efficacy and achievement by gender. It also provided the statement of the problem, the purpose of the study and research objectives. The conceptual background for the study was given as well as the significance of the study. Research questions were posed, and assumptions, delimitations and limitations relative to the study were delineated. Definitions of the terms relative to the study were also given.

Chapter 2 will review the relevant literature and research pertinent to this study. A review of the theoretical framework of social-cognitive learning theory as well as gender theory examining sociological differences between males and females and how these differences could influence the educational setting will be examined. Studies of self-efficacy and calculator efficacy will be reviewed. The final section will examine technology and graphing calculator technology in mathematics education.

Chapter 3 provides a description of the research methodology for this study, including the research design, the selection of participants, instrumentation, data collection and data analysis. Chapter 4 presents the results of this study on calculator achievement and efficacy by gender by using social learning group interventions. A discussion of the results, with conclusions, recommendations and implications is given in Chapter 5.

CHAPTER 2

REVIEW OF LITERATURE

This chapter provides a review of pertinent literature related to the question of what relationships exist in calculator self-efficacy and calculator achievement between males and females and the influence social learning may have on female achievement. After an introduction, the first section will explore social-cognitive learning theory while the second section will discuss gender theory and its relationship to the educational setting. Calculator efficacy and technology efficacy will then be discussed, followed by a review of pertinent literature on the roles of graphing calculators and technology in education and their connection to Vygotsky's learning theories.

Introduction

Gender differences in the area of mathematics learning have been studied extensively in the United States and abroad over the last twenty years and these have revealed many changes. Prior to the groundbreaking research captured in the American Association of University Women Educational Foundation's report *How Schools Shortchange Girls* (1992) and Sadker and Sadker's (1994) book *Failing at Fairness: How Schools Cheat Girls*, there was a noticeable lack of concern for girls in the educational arena, especially in science, technology, engineering and mathematics as could be evidenced in standardized test scores. In 1985, the National Assessment of

Educational Progress (NAEP) found that sex-related differences in mathematics achievement increased from ages 9 to 13 and increased again to age 17, favoring boys. However, between 1990 and 2005, females made impressive gains on the NAEP mathematics scores. Fourth grade mean scores increased from 213 to 238 with males remaining one to three points above females, and eighth graders' mean scores increased 16 points with a small sex difference favoring males by one to four points (Lacampagne et al., 2007). According to the 2009 National Center for Educational Statistics, NAEP scores indicated males remain ahead of females with a two point advantage, though it is not a statistically significant difference. The 2009 report from the National Association of Educational Progress indicates that gender differences in mathematics achievement have all but disappeared.

However, replacing the reduction in the gender gap in mathematics scores is a new gender divide in the area of technology. Though females enjoy some facets of technology, the literature indicates that there are distinct differences in proficiency with technology between males and females. Females enjoy many forms of technology, but they possess deficit skills in numerous technology areas (Ash, Coder, Dupont, & Rosenbloom, 2009; Cooper, 2006; Kay, 2006). Having a technology deficit can be an impediment in the educational realm for females. Schools depend on technology as a method for teaching students, yet much of the technology was created using models of what males prefer. A specific form of technology that has been shown to have gender related differences is the graphing calculator (Griffin, 2006; D. M. Kohler, 2008). Technology that involves graphing calculators is a key component of the mathematics classroom. Students must be taught the methods necessary to operate the calculator if they are to be successful when using the calculator. Concern exists regarding calculator usage in the classroom by teachers on several levels. Some teachers refuse to let students use a graphing calculator because they cannot take a high stakes test with the calculator. These teachers fail to see the benefits available of using the calculator for concept formation and multiple representations (Forster, 2006).

A recent study by Forgasz (2009) indicates that males scored higher than females on the 2007 Trends in Mathematics and Science Study. This finding may be problematic since students in year 12 Mathematics Methods in one district in Australia will be required to use a CAS (computer algebra system) graphing calculator in their year of mathematics study, as well as on their grade 12 examination. For many years in Australia, there were no significant gender differences in mathematics. However, in 1997, Victoria allowed graphing calculators on high stakes exams and in 2002 it began offering two parallel courses. One course involved a regular graphing calculator and the other required a CAS graphing calculator, and since 2006, a regressive trend has been noticed in which there are fewer students, both male and female, in the CAS course. The percentage decrease of females is significantly higher than that of males. Forgasz states, "Concern has been expressed about this regressive trend, and it has been postulated that the increased emphasis on technology for the learning of mathematics may be implicated." (p.286)

The key issue is how to help females reach a level of comfort and fluency with the technology so they can reach the maximum level of proficiency. Functional literacy with graphing technology can lead to improved understanding of many mathematical concepts, so it is critical to help all students achieve this competency (Isiksal & Askar, 2005). Though females may have equal capabilities with technology, their self-efficacy ratings are typically lower than those of their male counterparts (Barkatsas, Kasimatis, & Gialamas, 2009; Forgasz & Griffith, 2006; Forgasz, 2009; Kaino & Salani, 2004; Kelly, 2002; D. M. Kohler, 2008). The technology divide in the classroom is a distinct problem as the literature indicates, and females need specific help to increase their competency level with calculators so this technology divide can be remedied.

Social Learning Theories

The main focus of social cognitive learning theory is learning that occurs through observation and modeling (Bandura, 1986). Social cognitive learning theory includes several general principles. For instance, students can learn by observing the behavior of other students; learning can occur without a change in behavior and the consequences of behavior play a role in learning (Bandura, 2001). Cognitive processes are also very important in social cognitive learning theory. The cognitive processes of social learning include learning without imitation or performance, cognitive processing or thinking while learning, outcome expectations and an awareness of the response-reinforcement or response-punishment contingencies (Bandura, 1977). An individual has to recognize why a behavior is being punished before the behavior is likely to decrease. In education, if a student receives a poor grade without sufficient comment regarding why the grade occurred, it is unlikely that the student will improve because of a lack of critical feedback.

Observational learning is one method of social-cognitive learning that children begin shortly after birth. People learn by observing the behaviors of other people. The behavior or attitude learned can be learned through observational learning, and may be intentional or accidental. Learning can also modify one's behavior, but that is not a requirement. If a person is modeling someone with whom they identify or have characteristics in common, they are more likely to learn from the model and mimic the behavior. Self-efficacy also affects the learner's behavior. If the learner has a high degree of self-efficacy, there is a better chance for learning behaviors or attitude. The consequences to the model for his or her behavior can affect the learner's behavior vicariously as well, and can lead to innovative and creative behaviors (Bandura, 1986).

Modeling is a common vehicle for observational learning. Modeling involves attention to behaviors, competence and power, retention for encoding information, production to produce responses and motivation (Bandura, 1986; Graham & Weiner, 1996; Rosenthal & Zimmerman, 1978). Though modeling begins very early after birth, it is used in the academic domain as well. Models may include a live model, a symbolic model (movie character) or verbal instructions. All types of models aid students in learning. Specifically, students master academic skills when they use modeling. Students learn how to do mathematics problems by first seeing how a teacher completes a problem. Yet, in small groups, this modeling process is also advantageous because students adapt and use each other's strategies and solicit opinions to complete tasks. Modeling in small groups can be highly rewarding and also beneficial for students with lower self-esteem, the lesser competent student, or those who are highly dependent (Vygotsky, 1978; Vygotsky, 1986). It is critical, however, to note that students learn more effectively in modeling when they think aloud about the process, and not simply complete a process (Bandura, 1986).

Obviously, social-cognitive learning contains the social component, yet very little emphasis is placed on the cultural aspect of the learning process. Society and culture emerged as an important aspect of learning with Lev Vygotsky and the sociocultural perspective (Vygotsky, 1978). Vygotsky determined that complex mental processes were actually initiated as social activities, and students gradually internalized these activities and could use them independently of the surrounding people. More knowledgeable adults and peers are critical for students to attain their maximum potential because these people foster a student's growth and development (Kravtsova, 2009; Vygotsky, 1997) .

Vygotskian Social Learning Theory

According to Vygotsky (1978) major themes that lead to concept development and learning include: (a) Socio-cultural interaction is fundamental for full cognitive development; and (b) a Zone of Proximal Development (ZPD) exists in which a child's performance is developed with the aid of someone who has higher knowledge. It is within the Zone of Proximal Development that a student's current level of development is raised through communication and mediation with an adult or a more competent peer (Harvey & Charnitski, 1998; Vygotsky, 1987; Zaretskii, 2009). These themes (socio-cultural interaction and the Zone of Proximal Development) illuminate the differences in how females differ from males in the classroom, as well as in how they differ in calculator ability and efficacy (Carter, 2005; Charnitski & Harvey, 1999; Norton & D'Ambrosio, 2008).

Vygotsky's Socio-cultural Environment and Discourse

The first theme, socio-cultural interaction, is critical in the process of cognitive development and growth (Vygotsky, 1986). Social learning actually precedes a student's development of knowledge and true understanding. Vygotsky's theory states that individual mental processes begin initially with social interaction on a psychological plane (Vygotsky, 1986). Two or more students interact about an interpsychological category. It is only after that process takes place that a student may move to an intrapsychological plane and internalize the information, structures and functions. The social functions, speech and discourse are necessary components to prepare the student for the higher mental functions and synthesis to internalize the information (Penuel & Wertsch, 1995; Vygotsky, 1986).

Therefore, language is critical in the learning process for students. Initially as a means of communication between a student and the people in the environment, language is the first stage of development as a vocal means of learning in the social process. Yet a student moves beyond the initial stage of development when the thought processes become internalized (Brodie, 2000; Obukhova & Korepanova, 2009; Vygotsky, 1978; Vygotsky, 1986). When a concept emerges as a result of abstract traits that have been synthesized internally, the result is an abstract synthesis that is the main instrument of thought that has guided the thought process (Carter, 2005; Yildirim, 2008).

Making meaning out of thought processes is a component of Vygotsky's theory as well. According to Vygotsky (1978), meaning could function in terms of mind and behavior within the social context. Meaning exists in two places: between two people and in the thinking process; "the transactional space between the individual and the world of objects and events" (Prawat, 1999). Meaning first occurs between two individuals, but moves to a higher level when it is internalized between the student and an object, event or problem.

Too often in the mathematics classroom, learning and meaning making, even with the use of calculators, takes place by transmission (Harvey & Charnitski, 1998; Kozulin, 2004). In the transmission model, the teacher plays the central role in the classroom through dissemination of information. Students who learn through rote memorization fail to connect mathematics in context to real life situations, and their cognitive development is not maximized. Vygotskian theory holds that social interaction is critical to cognitive development. It personifies cognitive development as first occurring on a social realm and then individualized to the student's realm. Learning takes place on a social level initially and is followed by internalization on an individual level (Vygotsky, 1986). Females have indicated in previous studies that social learning, or learning in groups is particularly effective in helping them understand concepts, which is consistent with social learning theory (El-Haj, 2003; Sadker, Sadker, & Zittleman, 2009). It is also this process that allows the development of learning so that students can move through the zone of proximal development.

Vygotsky's socio-cultural learning theory in the classroom involves a reliance on the processes of growth and development. The first idea is a reliance on the mental phenomena or the process of growth. The second idea, is based on the social origins of higher mental functions—attention, memory, concepts, and reasoning (M. Goos, 2004). They first appear between students on the social plane and then within an individual on a psychological plane. The third dimension involves mental processes mediated by tools such as writing, systems for counting, algebraic systems, Venn diagrams, and others. A student must move from the acquisition of knowledge phase into a participation phase for the next process to occur. The internalization process occurs within a Zone of Proximal Development (ZPD) in such a way that a transformation takes place. The Zone of Proximal Development is the difference between what a student can accomplish independently and what the student can accomplish with the aid of a more knowledgeable peer or teacher. The use of discourse within the ZPD allows students to begin the process of moving beyond what they could learn independently. Discourse is an important phenomena in the process by which a student moves within the Zone of Proximal Development (Lau, Singh, & Hwa, 2009; Obukhova & Korepanova, 2009). A child may have an interaction with the adult or more capable peer that may awaken mental functions that are not yet mature and lie between actual and potential development. Often, a teacher will collaborate with students as they move through the zone of proximal development, and will scaffold their knowledge with previous knowledge as students add to their existing knowledge bank (M. Goos, 2004). The additional aid of the teacher or peer gives students the extra help needed to move to the intrapsychological level in their learning process through the Zone of Proximal Development.

Students who are able to rehearse mentally and verbally are able to retain information. Though many students can learn without performance, some students need the opportunity for discourse with a community of learners. All classrooms are communities of practice, but differences exist in how teachers carry out their practice (Boaler, 1999). Communities of learners in which students are allowed to speak and act mathematically by participating in mathematical discussions with the teacher and other students is considered the creation of a culture of discourse among communities of learners (M. Goos, Galbraith, & Renshaw, 2002; Steele, 2001). Students first learn the information from someone more knowledgeable than themselves, and then become more confident and can do it on their own. Social learning, or learning in groups, appears to be especially effective for students learning how to use calculators and developing confidence in their applications. The sociocultural aspect of this model links teaching practice with learning outcomes and the nature of the mathematics communication is consistent with mathematics education reform.

Vygotsky's Zone of Proximal Development

According to Vygotsky (1997), there exists a Zone of Proximal Development (ZPD) in which a child's performance is developed with the aid of someone who has higher knowledge. It is within the Zone of Proximal Development that a student's current level of development raises through communication and mediation with an adult or a more competent peer (Bozhovich, 2009; Vygotsky, 1978). According to Vygotsky (1978):

> An essential feature of learning is that it creates the ZPD; that is, learning awakens a variety of internal developmental processes that are able to operate only when the child is interacting with people in his environment and in cooperation with his peers. Once these processes are internalized, they become part of the child's independent development achievement. (p. 90)

The consequences of a Zone of Proximal Development are critical to education today. Educators are interested in what students can achieve. In measuring this achievement objectively, teachers attempt to determine what the student can accomplish independently. The ZPD is essentially seeking the same idea – helping students reach a higher level than they could independently. Students can typically perform at a level beyond what they can do independently if the student is working with a teacher or a more knowledgeable student (Carter, 2005; Lau et al., 2009). Vygotsky (1978) proposed that the only good learning is that which is "in advance of development" (p. 89). Teaching and learning that is geared toward levels at a stage in which the student has already attained are ineffective for the students' overall development.

The Zone of Proximal Development allows for students to be pulled forward in their mathematical abilities with the aid of a teacher or a more knowledgeable other. Through scaffolding, a teacher may provide tasks that structure interactions between students and begin conversation that will allow students to participate in activities that might otherwise be too difficult (Albert, 2000; M. Goos, 2004). The concept of the Zone of Proximal Development allows for the withdrawal of the typical demonstration method of teaching and allows students to become involved in the learning process and internalize each others' actions to reach a higher level than they would have previously (Charnitski & Harvey, 1999; M. Goos et al., 2002; Kozulin, 2004; Schmittau, 2004).

Culture and context, according to Vygotsky (1986) are critical for the cognitive development of students. All knowledge is influenced by culture and is gained through learning experiences (Dahms et al., 2008). Social development is critical for intellectual development and understanding and research indicates it is a necessary agent in learning. The human mind rarely works in solo, but in social contexts (Kim & Baylor, 2006; Vygotsky, 1986).

Using the everyday life experiences of students as the context for calculator activities can also be facilitated in social learning groups. The teacher, or possibly another student with more knowledge leads individuals while they are in the Zone of Proximal Development, which is where true learning takes place (Crawford, 1996; Gredler & Shields, 2007). The teacher or mentor works with the student in a social setting, and helps elevate the knowledge of the student, as well as elevate the student's confidence while the student is in the Zone of Proximal Development. It is within the ZPD that the student develops the ability to perform a task, first with guidance of a teacher or peer, and finally on his or her own. Though the teacher initially serves as a more knowledgeable person to guide the process, she then withdraws, which allows the students to then self-lead. Typically a more-knowledgeable student will be left within each group, and students will proceed to a higher level than they would have achieved alone initially (Vygotsky, 1997). Working within collaborative groups affords students the opportunity to own ideas and experience success in creating personal insights as they move into the ZPD (M. Goos, 2004).

Though not often used according to Forster (2006), social learning is the perfect context for learning technology. The Zone of Proximal Development allows students with technology to promote higher level thinking and support concept development. Students learn to articulate with one another, communicate and solve problems as they work through a mediation environment to solve problems with technology (M. Goos, 2004). Scaffolding by first receiving help from a teacher and then from a peer allows students to construct insights they would not have experienced alone (Harvey & Charnitski, 1998; Steele, 2001). The mature knowledge is acquired, not by a transmission of knowledge, but by linking the discourse of the social learning in the Zone of Proximal Development available in partners or small groups (M. Goos, 2004).

Gender Equity

For years in the classroom, the teacher's view of gender equity was treating both males and females exactly the same. Females were not recognized as individuals with the particular set of talents, sociological views, moral views, and constructs that were different from those of the male. To provide equal access, the only requirement was to treat the female like the male. The problem is that teachers are not truly aware of the differences between the voice of the female and the voice of the male.

The voices of the boys and the voices of the girls are not the same. Psychological development is based on "man" and on "male" by which the measurement is the standard of all things human (M. Goos, 2004; Lau et al., 2009; Meijer & Elshout, 2001). Girls do not speak, see and feel in the same manner as boys. Women are not selfish, but selfless, responsible to others' desires and perceptions and taking others' feelings as their own. The personal self is silent because the main concern is for others. Selflessness is extolled in the face of relationships for others. Women's voices have a fluid connectedness in speaking about problems in the world, and in choosing relationships over self. Empathy, the epitome of feminism, becomes problematic, because theories of development have been framed from a male standpoint. What has been considered an objective view of male and female is actually an assessment of culture and a methodological problem (Gilligan, 1994). These views are critical to recognize in the educational setting.

Recognizing and accepting the differences of males and females as they interact as learners is critical in the social learning process in the classroom. Subtle forms of gender bias still occur in classrooms. Many teachers still favor boys in their classroom discussions by calling on boys more often than on girls (Gilligan, 2005a). The feedback given to boys in interactions is also more substantial related to praise and criticism, while the feedback given to girls relates to neatness. Treating males and females equally is not a solution to equity. Males and females are different and recognizing their differences and accepting them will benefit all the students. Even though these differences exist, teachers are aware and are seeking to create a more gender equitable classroom (Beaman, Wheldall, & Kemp, 2006).

In asking males and females to describe themselves, it is yet again evident that there are differences in their identities. In a generic question in which participants are asked to describe themselves, men typically identify characteristics about themselves (Gilligan, 2005). Men may delineate what they enjoy doing or sports they enjoy playing. Most ideals are spoken in a self mode. A male will identify characteristics that set him apart from the world or by characteristics that he places the world in relation to himself. Girls that are asked to describe themselves will locate themselves within a world of relationships. For example, according to Gilligan (2005), Amy, an eleven year old girl, described her actions, beliefs, and connections with others.

> Well, I'd say that I was someone who likes school and studying and that's what I want to do with my life. I want to be some kind of scientist or something, and I want to help people. And I think that's what kind of person I am, or what kind of person I try to be. And that's probably how I'd describe myself. And I want to do something to help other people. Well, because I think this world has a lot of problems, and I think that everybody should try to help somebody else in some way, and the way I'm choosing is through science. (p. 702)

Though she elaborated on what she liked and disliked, she situated herself in relation to the world and how her actions were able to bring help to others. Amy's description of herself is relational because her worth is measured in a world of relationships.

Socially, males and females react differently in the classroom, as the previously cited study of Amy and Jake indicates (Gilligan, 2005). Girls problem solve in relational terms while boys problem solve in terms that are more logical and mathematical, which may explain their affinity for mathematics. When asked about responsibility to oneself and responsibility to others conflict, how should one choose, the answer was decidedly different for the Amy and Jake. Responsibility to self and others is an important moral task for all children to learn. When asking boys and girls about responsibility, the gender differences were evident as well. Though males are concerned with what others think, they use more of a mathematical logic, than relational logic. Given a moral dilemma that involves responsibility, an eleven year old male typically creates a mathematical equation deriving a formula that determines the solution. For example, in response to what is responsibility, Jake, an eleven-year-old, responded that three-fourths of responsibility goes to him and one-fourth goes to others. This indicates that you have to be able to live with other people and live with yourself. Amy, also eleven, replies contextually. She indicates that responsibility depends on the situation, and if you have a responsibility to someone, you should honor it. Amy extends the idea of responsibility into an idea of "others are counting on you" (p. 705). To females, responsibilities indicate care and concern, where with males it means limitations of actions, restraint of aggression and realizing that actions can have effects on others (Gilligan, 2005b).

Sex differences in personality formation appear in early childhood on the playground as children learn to negotiate rules while playing games. Children's playground games are noticeable for sex differences, and boys' social development is evident on the playground. The playground allows for much conflict resolution and boys learn that on the playground. In games, children learn to take on roles of others and see themselves through another's eyes. They also learn respect for rules and come to understand the ways rules can be made and altered (Piaget, 1965). Males and females play quite differently. Males are defined through separation, so males tend to have difficulty with relationships and must work through these problems on the playground. Females are threatened by individualism or separation, so females work to keep relationships intact during their play behavior.

In a study by Lever (1976), boys play more outdoors, more often in large and age-heterogeneous groups, and are more competitive than girls. Their games last longer more often than girls' games and they are better at conflict resolution than girls, which may explain why their games last longer. In contrast, girls' games were often games that were not competitive, or were games that involved taking turns. In games like jump rope or hopscotch, the girls take turns, so there is no competition. Most girls' games display a pattern of relationships. If a conflict did arise in the girls' games, they would often end the game rather than reach a resolution. The boys' games had more quarrels, but during the study, not one of the games was terminated and no game was interrupted for more than seven minutes. The debates and conflict resolution allowed for the boys to learn critical life skills and organizational skills that are necessary to coordinate large and diverse groups of people, so the participation and competition is worthwhile

(Lever, 1976). These differences in game behavior account for different social skills and social development between males and females.

As the socialization process moves into the classroom, there is evidence in research to suggest that the differential teacher attention to boys and girls differ in some distinct categories. The pattern and distribution of classroom discourse favors boys. When evaluating the discourse pattern of students in the classroom of two teachers with different class management styles, boys talked more than girls overall. Overall when the number of words spoken was considered, the number of speaking turns taken and the number of interchanges with the teacher, boys dominated the conversation. It is important to note that some of the interactions of the teacher related to boys involve behavioral discussion. Eye contact was also evaluated in the study and males dominated the eye contact of the teacher by receiving over 60% of the teacher's eye contact. Boys have more interaction quantitatively with the teacher and are in the teacher's frame of reference more than girls. Boys receive more instruction and criticism from the teacher while girls receive less criticism but also less instruction (Beaman et al., 2006). Males in mathematics classrooms are also quick to create competitive environments. Competitive environments are not conducive for all students to learn and in some studies females have indicated competition stifles their learning processes (Irvine, 1986). Creating a positive environment for all students requires recognizing the needs and abilities of all learners and creating an environment in which all students can succeed and receive the appropriate attention of the teacher (Beaman et al, 2006).

Research also suggests that teachers unintentionally undermine females with their actions (Zittleman, 2004). Teachers, counselors and parents believe the stereotypical view that girls are less capable than boys in mathematics and science. When asked about student performance, teachers will typically identify gifted males as having talent, and females as having worked hard to receive a good grade. The marketing industry promulgated this claim when they produced a Barbie that said “Math is hard,” but GI Joe did not make the same claim (Beaman et al., 2006; Dumais, 2009; El-Haj, 2003). Girls begin to receive subtle messages from their peer groups, family and teachers in middle school that result in a loss of interest in math and science as careers (Ackerman, 2006). Girls in mathematics and science classes do not receive the same encouragement to pursue science careers that boys do. Teachers often finish problems for girls or complete calculations on the calculator instead of talking girls through the steps. In science demonstration labs, it is not uncommon for boys to be asked to help set up or participate in the lab while the girls record the data on the board (Zittleman, 2004). Girls especially need to feel connected to mathematics and science through real life applications, and many teachers are not comfortable teaching with varying approaches (McNees, 2003). Peer instruction, cooperative learning groups, cognitive mapping and electronic clickers are methods for teachers that socially involve females more actively in the math and science classroom and promote equity in learning (Zittleman, 2004).

While some girls have found ways to achieve success in the classroom, other girls have not been so successful. Very bright girls sabotage often themselves because it is not considered “cool” to get good grades (Sadker et al., 2009). This is especially true of girls who are talented or creative. Girls who are gifted intellectually are often referred to as “brains” or “nerds” and are afraid to speak up due to the social consequences. As a result, they will fall behind on homework assignments, sit quietly in a corner in class, and purposefully sabotage themselves so they will not be socially isolated (V. Walkerdine, 1994).

Girls' voices in the classroom are socially acceptable or unacceptable depending on who is viewing the issue. In the past, good girls were silent, so in the social setting they kept silent (Sadker et al., 2009; V. Walkerdine, 1994). In recent years, girls have created three strategies for negotiating school, and they are less than positive. The three types of girls who have made their voices known in the classroom are "doing school" girls, "speaking out" girls and "crossing borders" girls. Each of these girls negotiates school, but is not a stellar leader or pillar of the community and school (AAUW, 2002).

"Speaking out" girls are maverick leaders or trouble makers but are very intelligent. These girls are no longer silent in the classroom, but speak out and can be viewed as unfriendly and boisterous. They not only speak out; they habitually speak out at inappropriate times to make themselves highly visible so they become a "maverick leader" to others in the class. These students may also be labeled as "troublemakers" or students who are at risk for failure. The teacher often regards this student as a troublemaker if he/she is not aware of the intelligence of the student or does not create a rapport with the student. In many situations, these girls are highly intelligent, but are hiding their intelligence and insisting on being heard in friendly and unfriendly circumstances (AAUW, 2002).

"Doing school" girls conform to traditional expectations of teachers. This student may or may not speak up in class, but if she does, she can be expected to be respectful to the teacher. The "doing school" girl may be one of two types. The "good girl" enjoys schools and takes comfort in the traditional ideologies of school such as doing her work on time, listening and complying with teacher instructions and adult expectations. She may have some conflict with her home persona and the school culture, but she has created a separation between the two so that she may negotiate school and reach her desired goals. The second "doing school" girl type is one who is "playing school" and is actually covering up hidden ambivalence. This female is outwardly compliant and successful in school. She leaves some clues to her identity outside of school though this identity may not fit easily in the school culture. Nonetheless, she is accepted by her teachers, and the adults and peers may not realize the challenges she is facing. Both types of "doing school" girls are typically identified by teachers as "good girls" and not as leaders, and do receive adult approval, though they also receive less attention in the classroom (AAUW, 2002).

"Crossing borders" speaks of girls that easily move between borders. They are a hybrid composed of "schoolgirl" but also a "cool girl" who may easily achieve success in school and the community and are translators who communicate across groups and serve as leaders. These girls have a tendency to "know everybody" and be accepted by both students and adults. Some, but not all of these girls emerge as leaders because of their ability to communicate across barriers with students, the school and community. In other situations, the talents of these girls may go unrecognized. An important facet of the "crossing border" girl is that she easily moves between different borders and some of these girls take the responsibility of "translating" across cultures. They may be school leaders, achieve success in school and the community (AAUW, 2002).

Within mathematics, the role of gender has been dichotomized as feminine in opposition to masculine. The oppositional structure involves the two major categories of ‘separation’ or ‘connection’ as derived from Gilligan (1994). The idea of separation involves an individual, abstract, rational or objective method of decision making. One may also equate this to deriving an equation to find a solution to whatever the problem may be—mathematical or sociological. Connection is more relational and grounded in emotion and subjectivity, whether speaking of mathematics or a sociological problem. Females are active learners who prefer to learn through discovery-type inquiry and connection to real-life applications (AAUW, 2002). It is important for females to recognize the significance of the mathematics that they are working with. Within the realm of education and mathematics, providing access to girl-centered curriculum is difficult. Power structures that are present make it difficult, if not impossible to intervene. The dichotomous pattern does not indicate that interventions are actually helping solve the problem of girls feeling accepted in mathematics - a subject that has been stereotyped as a male-centered curriculum (Orhun, 2007).

Though girls are taking more high school and college mathematics courses, they still are slightly behind boys in participation in calculus, and they are behind in physics (Halpern, 2007). Teachers may be inadvertently contributing to the problem. Girls receive less attention than males in the classroom, and less actual instruction time in the classroom. When an intelligent comment was made by a female, often the teacher made a remark that it was due to hard work, suggesting that it was not intellectual (Mendick, 2005). At many levels, starting as young as kindergarten, teachers are enabling girls to “not do well” by doing the work for females. According to research conducted by Zittleman, in kindergarten, a male teacher’s aid would allow the boys to put the tape in the VCR player but would do it for the girls. By the end of the year, the boys did it for themselves, but the teacher's aid was still doing it for the girls. Teachers will often take a girl's pencil and finish the problem for the girl instead of talking her through the problem. If she doesn't know how to put a CD in the player, he will do it for her instead of showing her how. Each of these examples short-circuits the education of the female. It is a quick way to expedite time in the classroom, but it does not help the students learn and grow (V. Walkerdine, 1994).

Even in terms of technology, girls and boys position themselves differently. In studies on video games, girls seek "not to die," while boys seek to be competitive and win. The video game industry has grown to a $10 billion industry in the United States with the vast majority of it focuses on men and boys. Studies indicate that the majority of gamers are males, and the main reason is that the games were created to interest males and not created to interest girls (Sadker et al., 2009). Females do show a genuine interest in video games but they do not typically find computer games that model the classic fighting games to be fun, and many of the educational technology games were built using that type model. The boys like video arcade models that typify fighting, sports and space. Action, heroism and competition combine with technological skill to produce a very masculine product. Girls represent a polar opposite. . The girls enjoy playing the video games, but their games have a feminine side that includes chatting with one another and being more sociable. There is no basis to indicate that the girls do not desire to win, but their game and strategy is different than that of the boys. The educational games that were created for students were often created in a manner similar to gaming- something that males have an affinity for. When working on computers for educational purposes, girls preferred colorful arrays that taught them something. Technology and educational games for females is a tool to be used for a purpose (Groendal-Cobb & Patterson, 2002; Walkerdine, 2006).

In other types of technology, boys see technology as toys, where girls see technology as tools. Boys and men gain pleasure from engaging in the technologies and show more interest in working on computers than females do. Women, however, viewed technology as a tool with a specific function. The interest lay in the function of the technology, but did not extend beyond the hours of the work day. They are necessary evils or tools like cell phones. They are practical and useful. Females typically position themselves within the technology tool whereas males are explorers and inventors of technology. Though boys see technology as toys and girls see technology as tools, gender in relation to technology can be fluid. In education, it is imperative to open the door to allow males and females to explore technologies and excel in computer and technological fields (Cooper, 2006; V. Walkerdine, 2006).

Self-Efficacy and Calculator Efficacy

Bandura (2001) introduced the concept of self-efficacy as a construct of social-cognitive theory in 1977. Self-efficacy is the belief that one holds the capacity to complete a specific course of actions successfully in order to attain a goal or task. Students with high self-efficacy approach difficult tasks as challenges that can be mastered rather than obstacles to overcome. High self-efficacy indicates one who sets high goals will achieve them even though failures may come, the student will become resilient due to the strong belief in the capacity to achieve (Bandura, 1986).

Many factors affect self-efficacy including the choice of activities. People tend to avoid activities in which they think they will fail. Yet easy successes do not produce a strong self-efficacy, and one with a strong self-efficacy will seek challenges in their learning and achievement goals. When students realize they are able to succeed in difficult situations, they are able to persevere toward a goal and develop a stronger self-efficacy (Bandura, 1986).

The goals one chooses and effort exerted are also important factors in self-efficacy. Students who set high goals for themselves are motivated to accomplish the goal and master the task. Effort and persistence are also important. When a student has a high self-efficacy, the student is more likely to persist until the goal is accomplished. A student with a low self-efficacy about a task will put forth less effort and will give up more quickly when difficulty arises. A strong correlation exists between a person's beliefs about performing a task and how well they perform the task. Higher achievement is also associated with students with high self-efficacy. When a student senses they can accomplish tasks, they actually achieve more (Bandura, 1986; Pajares, 1997).

Sociological factors also affect self-efficacy. Students typically have fairly accurate predictions of their own self-efficacy regarding specific tasks. Other factors that affect self-efficacy include the environment and social systems. Previous successes and failures are also critical in self-efficacy ratings. If a student is confident that he/she can succeed at a task, they have a greater self-efficacy. When a student has accomplished a task successfully, an occasional setback or failure is unlikely to damage their self-efficacy. Messages or praise from others can also be a critical factor in self-efficacy, if the message is sincere and is met with ultimate success by the student (Bandura, 1986).

Mathematics self-efficacy developed as a type of self-efficacy modeled from Bandura's model. Mathematics self-efficacy has been the topic of many research studies in which respondents are asked to rate their confidence in the ability to correctly answer a specific type of mathematics question(Forgasz, Leder, & Kloosterman, 2004; Krbavac, 2006). This type of self-efficacy is critical because research has indicated that self-efficacy in many cases is more important than knowledge in mathematics performance. Research shows that mathematics self-efficacy can predict outcomes such as mathematics performance outcomes better than other variables such as mathematics self-concept, mathematics anxiety, previous mathematics experience or self-regulation. Mathematical confidence is often associated with the type of mathematics courses students take. Students in higher level courses are more confident than students in lower level courses. Students also tend to overestimate their mathematics self-efficacy with males over-reporting at a higher percentage rate than females (Griffin, 2006; Krbavac, 2006; F. Pajares, 2005).

Problems with over-estimating self-efficacy ratings can occur when students are faced with an open-ended assessment. Self-efficacy ratings are typically measured by researchers with a Likert scale. Students are very familiar with multiple choice tests, and when asked to provide a mathematics self-efficacy rating that is correlated to a multiple choice test, students' judgments are fairly reasonable (F. Pajares, 2005; F. Pajares, 1996). However, if students are asked to rate their mathematics self-efficacy on open-ended mathematics problems, the correspondences and relationships are not as predictable. This could be due to students being very familiar with multiple choice assessments and better having the ability to judge their performance outcome on those assessments. They typically overrate their mathematics self-efficacy when the performance assessment is an open-ended format; therefore, the self-efficacy researchers suggest it might be important to inform the students prior to giving a self-efficacy assessment that the correlating mathematics assessment will be open-ended if that is the case (F. Pajares & Miller, 1997).

According to the literature, technology has a role in mathematical efficacy as well. If one has less experience with technology, it is likely that person will have a less positive mathematics attitude, and will suffer more anxiety or negative attitudes toward technology (F. Pajares & Miller, 1997). A student who understands technology reports higher mathematics self-efficacy scores (Rees & Noyes, 2007). Significant male and female differences in computer anxiety and computer self-efficacies have been documented (Ellington, 2003). As early as kindergarten, boys indicate more positive attitudes about computers than girls, and the separation continues through high school. As recently as 2003, incoming freshman were asked about their reactions to computers. Females continue to be significantly less comfortable with computers than males. Girls' interest in computer applications has improved, but females still use computers less outside of school than males do, and they have a considerable amount of discomfort about computers (Barkatsas et al., 2009; Cooper, 2006; Kay, 2006).

Gender stereotypes have prevailed in technology, leading the general public to believe that computers are for men and boys. The stereotypical threat of participating in a male domain creates computer anxiety as well. No inherent differences exist between females and males that cause girls to experience a low self-efficacy with computers. Females generally feel less confident of their ability with computers than males.

Computer ability is tied to mathematical achievement, and though research studies actually show no difference in mathematical achievement between males and females; females still perceive their computer ability at a lower level than do males (Cassidy & Eachus, 2002). One exception is a research study from the University of Alabama that involved 59 sixth grade students and found no gender differences in computer-efficacy, yet there were many limitations to the study (Bain & Rice, 2006; Cooper, 2006; Isiksal & Askar, 2005; Kay, 2006) .

Calculator Efficacy

Calculator efficacy is an extension of computer attitudes and self-efficacy. One who has strong calculator efficacy thinks that he/she has the skills to accomplish a given task on the calculator. One of the important findings of research is that students who use a calculator during mathematics instruction reported a better attitude in mathematics (Bain & Rice, 2006). Gender specific research has been limited, but in two studies, males and females reported no significant difference in the confidence rating on calculators used as a result of a planned intervention (Ellington, 2003). Griffin conducted a study of middle school students and calculator efficacy involving an instructional program known as “Math Seminar”. The Math Seminar program was successful in increasing the technology efficacy of the experimental group. The program was self-paced, and the students expressed in qualitative responses that they enjoyed going at their own pace and setting their own goals (Griffin, 2006). Gender differences in calculator research studies also indicate that males enjoy using calculators more than females though an efficacy survey was not part of the study (Hanson, Brown, Levine, & Garcia, 2001). Though females enjoy using a graphing calculator, they are also more likely to associate guilt feelings with using a calculator instead of doing the calculation analytically on paper. As with most technologies, girls situate themselves with calculators as a tool to enhance their educational process.

Calculators and Technology in Education

The use of graphing calculators in the mathematics classroom offers a rich form of technology that is more cost efficient and easily available than laptop computers. Calculators can enhance student learning through concept development, discovery learning and problem solving skills (NCTM, 2006). With the use of a graphing calculator, students are able to see visual representations of many graphs quickly, analyze data in seconds, and create equations from the data where before the same processes would have taken days and possibly been omitted from the curriculum. Students' mastery of calculator skills requires teacher time and attention just as time and attention is required to teaching mathematical concepts. A lack of time and assistance may explain why females do not have a positive attitude toward technology and graphing calculators (Forgasz & Griffith, 2006; Kohler, 2008). Technical understanding of the calculator requires teaching routines necessary to meet basic computation and graphing requirements studied, defining mathematical commands and syntax, and defining actions required to adjust window. Females indicate they are often in competition for access to the technology and receive less teacher assistance. Without the time to practice and extra assistance, the technology potential of females may not be realized (Barkatsas et al., 2009; Groendal-Cobb & Patterson, 2002; Isiksal & Askar, 2005).

Finding a good methodology for teaching the technical aspects of the calculator is difficult. Though much of the mathematics curriculum is still taught in a traditional manner, the use of graphing technology lends itself to socio-cultural interaction that is the essence of Vygotsky's theory (Charnitski & Harvey, 1999). Teaching by transmission, which is often the mode for calculator education, fails to engage the student, whether one is using graphing calculator technology or studying pure mathematics. When teaching in a choral situation, one of the negative effects that can occur is when a student fails to become involved and begins playing independently with his/her calculator. Teaching with a graphing calculator naturally offers the opportunity for students to work independently and in a social setting of groups to become more confident in their abilities. The use of the social arrangement allows for students to share screens, collaborate about processes and support one another when technical difficulties arise. In a large class, many "teachers" become part of the education process when Vygotsky's social learning setting is used because one teacher cannot address all the individual questions that will occur when performing new functions on the calculator (Charnitski & Harvey, 1999; Crawford, 1996).

Technology Experiences by Gender

Recognizing differences based on gender in receptiveness to using technology and teaching methodology is critical if we seek parity among learners. Unfortunately, technology is still considered a male domain (Kaino & Salani, 2004). When females begin school, they have less experience with calculators and computers than their male counterparts. Though females have less experience, the calculator is an impressive tool that can be used to enhance the educational experience. The lack of experience often puts the females at a distinct disadvantage that has to be accounted for and remedied.

Many studies have indicated that calculator usage can enhance education and impart knowledge; yet questions arise concerning how one actually learns to use a graphing calculator or information and communication technology (Bryson, Petrina, & Braundy, 2003; Forgasz & Griffith, 2006; Isiksal & Askar, 2005; Williams, 2007). There is some evidence that females enjoy using calculators less than males, but all students in the study expressed some indifference (Bosco, 2004). True learning requires ascertaining the competency level of the student initially with the technology. Calculator concept development can be nurtured through confidence building and social interaction.

Frequent studies have also been conducted with a primary focus on technology and student achievement (Kaino & Salani, 2004). Functional literacy with graphing technology can lead to improved understanding of many mathematical concepts, so it is critical to help all students achieve this competency (Ellington, 2003). According to Forgasz (2009), teachers' also believed that boys were more competent and confident with computers. Boys were more likely to believe that computers would improve their mathematical understanding while girls exhibited a lack of confidence and a lack of initiative. Though boys and girls interact differently with the computer, both males and females indicated that the computer made mathematics more enjoyable (Forgasz, 2009).

Additionally, research indicates that students who use a graphing calculator with regularity during instruction, but not necessarily testing develop a deeper understanding of mathematical concepts. Students received the most benefit when the calculator was used over a long period of time- approximately nine weeks or longer. When calculators were included in testing and instruction, student experienced improvement in operational skills as well as in the analytical skills needed to correctly complete the concepts on a test. For testing and instruction, students benefit from short term instruction of 0 to 3 weeks or long term instruction (Isiksal & Askar, 2005).

Technology is the new domain of interest in which a gap involving gender appears (Hollar & Norwood, 1999). Gender and mathematics achievement have been studied for years, but since the literature indicates the gap in mathematics achievement on certain tests has started to decline and the enrollment of females in higher level courses at the secondary level has increased, concern regarding gender in mathematics has also declined (Williams, 2007). Yet with the closing of the gap in mathematics achievement, a new gap appeared in technology between males and females. The review of literature indicates a chasm in specifically studying females and calculator fluency. Gender has often been used as a demographic variable, but not as the main variable in a study (Ackerman, 2006; American Association of University Women, 2001; Anderson, 2002; Fennema, 2002).

Technology is at the forefront of education, yet for girls, their participation in technology related courses lags behind males (Burrill et al., 2002; Ellington, 2003; Kaino & Salani, 2004; D. Kohler, 2008). Technology's role in mathematics education should allow for content contextualization, collaboration and communication. Since technology is a key component of education as well as business, for females to strive and be competitive in technology fields, it is important to empower them early to be successful with technology. Graphing technology is one component of technology used in mathematics classrooms. Achievement gains have been linked to graphing calculator usage (American Association of University Women, 2000). Connections have been identified between calculator efficacy, mathematics self-efficacy and achievement (Ellington, 2003).

Gender Differences in Technology

Literature alludes to major differences based on gender between elementary children and their experience with computers (Vale & Leder, 2004). Girls and boys use computer- based technology differently, and therefore bring different experiences to the classroom (Griffin, 2006; Isiksal & Askar, 2005). Though girls have made great progress in mathematics achievement, they are underrepresented in the technological fields including computer science and engineering. Girls are taking more advanced mathematics classes, yet among the students who took the SAT in 2005, 5% of boys planned to major in computer science, while only 1% of girls chose that field. Engineering was the choice of 10% of boys but only 2% of girls. Though girls are closing the achievement gap in mathematics, there is not a concurrent rise in mathematics related careers (Kelly, 2002).

A key contributing factor of the inequity involves access to computers via the home. When females begin school, they have less experience with computers and calculators than their male counterparts (American Association of University Women, 2000; American Association of University Women, 2001; Bryson et al., 2003; Klein, 2007; Leder, 2004). When students enroll in middle school, they often are at a disadvantage and are made to feel “stupid” because of a lack of some requisite knowledge (Forgasz & Griffith, 2006). Due to a lack of experience, females are not as proficient with computers or hand-held technology as their male counterparts. This lack of experience follows them through high school and into college (Leder, 2001).

Girls are not media illiterate. Most females can operate cell phones with expertise including all of the advanced features that they contain (Klein, 2007). However, other uses of technology by females differ substantially from males. Studies have shown, for example, different gender perceptions of computers. Females view the computer as a tool, while males view the computer as a toy to be used for fun (Rees & Noyes, 2007). In educational settings, much of the software was initially created to be similar to video arcade games, and for years no one realized that females did not like the competitive nature of the game or the destruction that many games involved (Bain & Rice, 2006) . Another study actually showed statistically different characteristics for males and females that are associated with electronic textbooks (Cooper, 2006) . Girls' post test scores were associated with characteristics in the navigation and the presentation of information on the screen. Design of information and self-assessment were associated for girls. Information for electronic textbooks that does not fill the entire screen allows for students attention to wander away from the key information on the screen. The boys' post test scores was only associated with the percentage of symbols and formulas in the text (Mikk & Luik, 2005). Girls are willing to use computers in the educational environment when engaged in a learning situation such Vygotsky's social learning groups that allow for interaction and peer support.

The focus of much media has been to try to encourage girls to enjoy the same computer programs and faculties that boys enjoy. Competitive environments, rough games, and fast movement are all facets of the boy-toy computer culture. Yet for females, a disinterest in computer functions related to competition, fighting and arcade-type games occurs. Instead of trying to retrain girls to enjoy the technology and programming that boys enjoy, research can look at ways to enhance the learning of girls by using the learning styles girls find most effective. The complexity of gender and computer literacy is to create culturally appropriate technological applications so that both genders will thrive in appropriate ways (Mikk & Luik, 2005).

Gender differences in technology applications exist because females do not have the same level of computer proficiency as males do (Williams, 2007). Though many studies exist, a vast majority study the ability to use a computer program or use the Internet in multiple capacities. Computer proficiency includes knowledge about the operating system, communication, World Wide Web, word processing, spreadsheet, database, graphics, multimedia, Web page creation and programming. Though females may not lack skills in all these areas, they possessed deficit skills in many of these areas (Kay, 2006). The resulting problem is the lack of utilization of a huge natural resource (females) for information technology careers. Though females represent approximately 46% of the workforce, they only represent 24% of the engineering jobs. Their participation in computer science degrees declined from 28.6 % in 1994 to 27.6% in 2001 as reported by the National Science Foundation (Kay, 2006). The proportion of women in information technology careers represents 25% to 30% of the workforce, while only 9% of the mid-level to upper level management is comprised of women.

Graphing calculators contain the ability to program, much like computers. Since graphing calculators are a form of technology, using calculators effectively in the classroom could be considered a logical extension of technology use. Calculator operational ability or calculator literacy is the study of the ability of a student to carry out mathematical exercises correctly on the calculator. Only one study in Canada investigated the calculator literacy of students, and its main purpose was the development and analysis of an instrument that was linked to national standards for that country (Klein, 2007).

Computer technology has changed society. Much of what students and adults experience can be tied to technology. Children's toys are replete with technology, and they experience technology through everyday life experiences-at grocery stores, through toys as well as surfing the internet. The access to technology allows for a diverse learning experience. Students use computers in mathematics and graphing calculators often in their mathematics lessons. Technology can be linked to social and cultural contexts very easily in classroom instruction. By so doing, the discourse and social interaction allow for a more diverse experience and students have the ability to move fluidly through learning levels to achieve maximum proficiency (Wu, 2004).

Technology and Student Achievement

Research and literature indicates that technology has resulted in pedagogical changes in the mathematics classroom, and has had a decisive impact on what is taught in the mathematics curriculum (Charnitski & Harvey, 1999). Two major issues have been the central theme of calculator studies: achievement and student attitudes. Though calculator type was not shown to be significant, in a meta-analysis those who use a calculator with regularity in testing do better than students with no calculator. When comparing methods of assessment, the studies in which calculators were used during assessment provided results that were statistically significant and stronger than studies in which calculators were not a part. It is also worthy to note that achievement has not been negatively impacted by the introduction of calculators. Operational skills, computational skills, problem solving skills and conceptual skills were found to have statistically significant gains with the use of a calculator. Of critical importance were studies that indicated that the average student that had access to a calculator during instruction had mathematics achievement scores that were 57% higher than students that did not have a calculator during instruction (Ellington, 2003; National Council of Teachers of Mathematics, 2000). Relevant also, was that the calculator was not an important factor in testing. When calculators are used for instruction, the ability to select appropriate problem-solving strategies improved for participating students.

Studies systematically report that the use of the calculator during instruction results in significant differences in achievement. Students who used a graphing calculator as a part of their mathematics instruction when learning factoring or inverse trigonometric functions also showed a significant difference in posttest scores from the control group (Ellington, 2003). Results have also shown a correlation between increased instructional time given with handheld graphing calculators and higher test scores of students in Algebra I (Khoju, Jaciw, & Miller, 2005).

Some studies indicate that calculators used during instruction have no impact on student achievement or have a negative impact on student achievement. In the meta-analysis of calculator usage, no significant difference was found based on treatment length and achievement. Students who used calculators during instruction were neither helped nor hindered by calculators in testing (Heller, Curtis, Jaffe, & Verboncoeur, 2005). Another exception to the research studies found that students who attended Johns

Hopkins University and were in elementary mathematics courses had negative effects from calculator usage prior to attending college. According to the study, students enrolled in Calculus I, II, III and Linear Algebra who also said they were “emphasized and encouraged” to use a calculator in high school had grades that were 0.20 lower, and the difference was statistically significant (Ellington, 2003). All the courses were very large courses, and admission to John Hopkins is highly competitive. Students were analyzed by their college course grades, response to high school calculator usage, and their SAT scores.

According to a recent study by Forgasz (2009), there is concern that the use of the CAS calculator may be contributing to a regressive trend in mathematics achievement and course taking among females. Students from 2002 to 2008 could take Mathematical Methods with a graphing calculator or with a CAS graphing calculator. Males outperformed females at the highest level of achievement on the end of course examination in both Mathematical Methods and Mathematical Methods CAS. There was also a greater decrease in enrollment in Mathematical Methods CAS for females than for males. According to Forgasz (2009),

> Based on the findings from the two studies reported here, it appears that technology use for mathematics learning may be implicated in the various patterns of gender difference noted, with girls losing out. This is not to say that computer and CAS calculator use for mathematics learning should be abandoned – that would be a retrograde step. However, as found in this study and in previous research, the mathematics education community needs to be aware that some girls may be less confident than boys in using computers. (p. 297)

Both males and females are taking the mathematics courses that require the CAS graphing calculator at a lower rate, but the difference is statistically significant. Noteworthy is the concern that calculator literacy, not calculator abandonment is of vital importance. Identifying the exemplary practices in the use of technology that will engage all students and further their mathematical understanding with the calculator is identified as “imperative in order to provide equitable opportunities for all students’ mathematics learning to flourish” (Forgasz, 2009, p. 297).

Calculator Achievement

A review of literature indicates that the practice of teaching mathematics has changed as a result of the availability of technology and calculators. Technology has resulted in many changes in the mathematics classroom (Wilson & Naiman, 2004) . The study of algebra and calculus was previously limited to problems that could be solved with simple calculations manually. Computer algebra systems allow for solving complex problems quickly and allow students to make connections that were not previously possible between subjects. Students also show increased achievement on the calculator portion of the AP Calculus AB exam when CAS (computer algebra system) has been integrated into their mathematics instruction (National Council of Teachers of Mathematics, 2000).

Calculator achievement is the ability to accurately perform mathematical computations and functions on a graphing device. Research studies on graphing calculators have primarily focused on student achievement, not the ability to accurately use a calculator. A single research study developed a graphing calculator literacy test and scientific calculator literacy test in Canada (Brady, 2006; Khoju et al., 2005). Comparisons were made between the two calculator groups, and the primary purpose of the study was to create a calculator literacy test that was aligned to the curriculum standards of the Mathematics 12 Program. A recent study in Australia indicates that advances made in achievement in mathematics may be regressing based on gender as a result of more advanced hand-held technology and a lack of experience (Forgasz, 2009). One of the recommendations of the research was to determine methods conducive for students to learn the functionality of the graphing calculator or the CAS graphing calculator so that the calculator did not hinder the students' mathematical progress. Calculators are important tools for learning, but as with other tools, students need instruction to learn to operate the equipment accurately and be successful.

Summary

The review of literature indicates a major gap in studying females and calculator achievement and efficacy. Societal views may be one cause for the lack of women in technology and their lack of interest in technological applications including calculators. Studying females and their calculator achievement and efficacy in the lens of Vygotsky's learning theory and grouping or social learning will allow an analysis if this technique supports any differences in learning between males and females and will help close a gap in the research. Since most of the studies on calculators use gender as a descriptive variable, but do not study gender and calculator achievement, a gap prevails. In a previous pilot study, one of the findings indicated that females rated themselves moderately high on calculator ability, yet when they actually used the calculator, they had difficulty if more than one or two steps or programming the calculator were involved. Simply being exposed to the calculator does not ensure that students will learn or achieve the greatest benefit from the calculators. The nature of calculator usage allows for collaborative work and real-life applications imbedded in the socio-cultural setting; and supporting this collaborative work may benefit females.

This chapter provided a review of literature on calculator self-efficacy and calculator achievement between males and females. Additionally, the first section explored prior research on social-cognitive learning theory. Gender theory research was then discussed to identify sociological differences between males and females and to situate both males and females in the educational setting. Prior research into self-efficacy, mathematics confidence and technology confidence as well as calculator efficacy were then presented. The roles of graphing calculators and technology in education and relevant gender studies were also reviewed, as well as the possible linkage to types of intervention necessary for students to learn how to use graphing technology.

Chapter 3 will provide a description of the methodology for this study, including the research design, the selection of participants, instrumentation, data collection and data analysis. Chapter 4 will provide an analysis of the data gathered, and Chapter 5 will provide conclusions and implications.

CHAPTER 3

METHODOLOGY

The primary goal of this chapter is to present the methods and procedures for determining if relationships or differences exist between males and females in calculator self-efficacy and calculator achievement. Separate instruments were used to measure this efficacy and achievement. The organization of the chapter includes the following topics: (a) research questions, (b) research design, (c) setting, (d) sample population, (e) instrumentation, (f) data collection procedures, (g) data analysis, and (h) summary.

A review of scholarly and professional literature as well as dissertations from EBSCO data base, Academic Search Premier, Dissertation Abstracts International, Kennesaw State University Library and Digital Commons at Kennesaw State University indicated that females have made great strides in the field of mathematics, yet gaps still remain in their technology efficacy and achievement. In some cases, the only significant difference between males and females was a lack of confidence, while in other cases, males showed higher proficiency in skills with technology (Cooper, 2006; Leder, 2004).

Research Questions

The purpose of this study was to determine what relationships or differences exist between males and females in calculator self-efficacy and calculator achievement, and if social learning groups better support females in calculator achievement and efficacy. This study investigated the following research questions using the results of this research study as well as three pilot studies involving qualitative data and quantitative data:

Pilot Study Questions

Question 1: Can Griffin's (2006) original efficacy survey be adapted to develop a reliable high school Calculator Self-Efficacy Survey (CES) as determined by a measure of internal consistency?

Question 2: Utilizing a panel of knowledgeable high school teachers, can positive agreement be established using inter-rater reliability for wording, face-validity and comprehensibility for the Calculator Self-Efficacy Survey?

Question 3: Utilizing a panel of knowledgeable high school teachers, can positive agreement be established using inter-rater reliability for wording, face-validity and comprehensibility for the Calculator Achievement Test?

Question 4: How do females view their graphing calculator capabilities?

Main Study Research Questions

Question 5: Do calculator assessment scores as measured by a teacher-developed assessment test differ based on gender?

Question 6: Are all calculator skills required on the test items equally performed by males and females including one-step, two-step and multiple-step calculations?

Question 7: Do personal self-efficacy ratings match actual calculator performance for all students?

Question 8: Is there a relationship between the number of years owning a graphing calculator and operational ability as defined by the test score?

Question 9: Does working in collaborative groups based on Vygotsky's social learning theories versus students working independently increase the performance level of students?

Research Design

The purpose of this study was to determine if relationships or differences exist between males and females in calculator self-efficacy and calculator achievement and if social learning grouping better support female calculator efficacy and achievement. Three pilot studies were conducted including quantitative and qualitative measurements to inform this study (D. Kohler, 2008; D. Kohler, 2008). The current study was a quasi-experimental section which involved a Pre-Test and Post-Test Calculator Efficacy Survey and Calculator Achievement Test administered to all students. Three classes served as treatment groups, and one class served as a control group. In all classes, students were randomly assigned in their seating arrangement, so they were not seated with their friends and partners. One Vygotsky design had students seated in rows in which the main focus was Vygotsky's use of discourse in the social learning setting (McNair, 2000). Students were in close proximity to each other and could easily communicate and discuss calculator questions in context. For the other two treatment groups, the students were randomly assigned to social learning groups or cooperative learning groups and stayed in the social learning groups for the entire treatment period. All students were administered the Calculator Efficacy Survey and the Calculator Achievement Test prior to the social learning group intervention. The control group was randomly assigned to sit in equally spaced vertical rows where discourse was not a part of the daily routine. During the intervention period, students were taught graphing calculator functions in context with the curriculum for four weeks. The social learning theory classes had friends and partners to work with and ask questions. The control group did not have friends or partners in close proximity to ask questions, and they did not receive the encouragement to do so. They were also be taught by a different teacher. All classes received similar teacher demonstrations of how to use the calculator and perform the functions using the TI-Smartview Calculator Emulator Software. After four weeks, the post- Calculator Achievement test and post-Efficacy survey were given.

Three prior pilot studies served as a foundation for this study which included a qualitative section. The first pilot study involved qualitative and quantitative measures. The study was an ex post facto investigation of calculator achievement based on gender, using quantitative and qualitative evaluation. Due to the necessity of correlating calculator efficacy and calculator fluency, students were assigned a random code to be used on all surveys in the study. The researcher assigned these codes to all surveys.

Students were given a demographic questionnaire and an attached self-efficacy survey. They completed both of these at the beginning of study. The calculator fluency survey was inclusive of about 75% of the curriculum for a basic advanced algebra and trigonometry class which included linear, polynomial, rational, logarithmic and exponential functions, and graphing, trigonometry, and basic statistics, so the training period included about eight weeks of study into the second semester.

After the intervention period, the researcher cleared the memory of all the calculators and the calculator survey was given. Students were required to use the class set of calculators provided by the instructor with the cleared memory. Clearing the memory deleted any previous keystrokes of another student, as well as any stored programs that a student could use to help himself write a program. The test consisted of twenty open-ended items, and students were given 55 minutes to complete the test. The calculator fluency survey was graded for accuracy, but four questions had two distinct parts, so there were actually twenty-four answers on the test.

The next phase of the study involved interviewing three female students who volunteered. Though the three females were volunteers, they represented different levels of calculator achievement as self-reported when asked to describe their own calculator achievement. Two males, also volunteers, were added to the qualitative portion of the study, and they were also volunteers. The interviews were conducted with the five students who provided informed consent for case-study analysis and comparison of males' and females' attitudes about calculators (see Appendix A). The interview sessions were also audio taped. The interview included six open-ended questions that focused on their calculator skills and the importance of calculators in mathematics.

The second pilot study involved two focus groups of females (see Appendix B). The population of interest was females who use the Texas Instruments Graphing Calculator, also known as the TI-83+ or TI-84. All the females in three Algebra III classes, as well as females in Advanced Placement Calculus and Advanced Placement Statistics at a suburban high school were invited to participate in one of two focus groups. Volunteers were self-selected, so no interested female was denied access. To maintain anonymity, all subjects were assigned pseudonyms for the purposes of discussing the research and presenting the findings. Institutional Review Board approval was obtained by the county as well as the university involved. All students who participated were given consent forms that were signed by a representative and were kept on file for two years. The students were in grades ten through twelve and were ages fifteen to eighteen. Most students owned TI-83+ or TI-84 graphing calculators, but all students at the school had access to a graphing calculator daily if they did not own one. The volunteers from the classes were part of a focus breakfast or lunch group. After a meal, each focus-group was audio taped by the principal investigator who facilitated the questions as an active participant. The questions served as guidelines, but when meaningful dialogue arose and presented the opportunity for other important information, additional questions were asked.

The main purpose of each study was to gather qualitative data on female students' views of calculator efficacy and calculator achievement. Questions for this study were developed after reviewing literature and assessing information obtained from prior research on calculator efficacy and achievement (D. M. Kohler, 2008). Specifically, questions were designed to identify specific attitudes and understandings of females about using graphing calculators. They were also amended following a pilot study involving interviews in order to obtain rich information from the participants. The overarching purpose guiding the questions was to identify the female voice in determining if a difference existed in females' and males' calculator efficacy and achievement.

Auto-ethnographic narratives that illustrated the practical applications of the research concepts pursued were developed based on the qualitative data obtained.

The third pilot study was conducted to field test the final calculator achievement study instrument when adjustments had been made to the instrument. Informed consent was obtained for participants in the pilot study. Two classes of AP Calculus took the Calculator Efficacy Survey and Calculator Achievement Test to determine if both instruments were comprehensible for high school students, and to determine if both could be completed in one class period.

Setting

This study was conducted in a suburban metro Atlanta area school. The school had approximately 15% of students who are economically disadvantaged and approximately 2% who were English language learners. The students' ages ranged from 15 to 18, and though most students were white, a number of students were enrolled in the courses from other countries including students from Nigeria, Russia and Columbia. All of the students in the four classes for the study have been in the United States for a sufficient number of years to have proficient knowledge of the English language, and there were no English language learners in the classes. However, one hearing impaired student was enrolled in one of the Advanced Algebra and Trigonometry classes.

Sample Population

The sample for this research was a convenience sample. The participants in this research were high school students from one high school in Canton, Georgia, a suburb of Atlanta. There were a total of 87 students who qualified for the study and 67 students completed the study. These students were in grades ten through twelve and all have taken Algebra I, Geometry and Algebra II. The students were enrolled in either Advanced Algebra and Trigonometry or Honors Analysis with two different instructors. Many of the students who were enrolled in the Advanced Algebra and Trigonometry class, which is a regular college preparatory track, were originally on the course sequence to take Honors Analysis and dropped levels to a non-honors mathematics sequence.

Permission for this study was granted by the head administrator at the participating high school as well as the district office personnel responsible for research at the county level. Permission was also granted by Kennesaw State University IRB to pursue this research. All participants were given consent forms and were required to return them to be considered participants in the study (see Appendix C).

Instrumentation

The Calculator Self-Efficacy Survey (see Appendix D) was adapted using Dr. Griffin's (2006) previously developed Mathematics and Technology Efficacy Survey (see Appendix E). Dr. Griffin gave her permission to allow the adaptation of her questionnaire for use in this study (see Appendix F). Dr. Griffin suggests her questionnaire was developed using a review of literature, and structuring items similar to items found in a computer self-efficacy scale (Cassidy & Eachus, 2002). Items for the Calculator Self-Efficacy Survey were modified to say “calculator” instead of “computer”, and the wording was made appropriate for high school students.

Face validity is defined as how a measure or procedure appears and is not dependent on established theories for support (Fink, 2003). To examine face validity, Griffin’s (2006) Calculator Efficacy Survey (CES) was piloted using 25 eighth grade girls and boys. They all completed the questionnaire in 5 to 8 minutes and only one issue arose with the CES. It dealt with a calculator activity students did not know how to complete due to a lack of knowledge. This knowledge was considered part of the high school curriculum and was included in the adapted version for the high school. The original CES was sent to 15 high school mathematics teachers in the county, and eight responded. The CES was slightly altered for the final study to account for single step, two step and multi-step equations. The new CES was revealed at the Georgia Council for Teachers of Mathematics. Twenty teachers took copies of the CES and Calculator Achievement Test. The one problem that was reported with the survey indicated a need to define one-step, two-step and multi-step calculations within the text of the Calculator Efficacy Survey, and the problem was corrected prior to implementation (see Appendix G).

To determine reliability, Cronbach’s alpha coefficient was calculated. Cronbach’s alpha is a measure of the internal consistency that determines if the instrument always determines consistent and reliable responses even if questions were replaced with similar questions (Wiersma & Jurs, 2008). Dr. Griffin’s survey was given as a pre-test and the adapted Calculator Efficacy adapted survey was given as a post test in pilot study 1 in

2008. The Spearman's Rho correlation coefficient was 0.80 and the Kronbach's alpha coefficient was 0.8484 (D. M.Kohler, 2008). Results that high in education are considered excellent.

The Calculator Achievement Test (CAT) (see Appendix H) was created after an extensive review of literature revealed only one calculator test that was written for high school students (Wu, 2004). This calculator achievement test was developed using the curriculum content of the Algebra III course, and questions were constructed similar to Wu's study, but content was specific for a typical 11^{th} grade Georgia student. Therefore, the test is appropriate for any student who is in Algebra III, Advanced Algebra and Trigonometry or Honors Analysis.

After creating the Calculator Achievement Test (CAT), it was sent to 15 teachers in the county to again examine for face validity. They read the instrument for content, word length, and sentence length, as well as comprehensibility by the intended participants. Curriculum content was evaluated as well by the teachers to ensure that all questions were appropriate for students in a course of Algebra III or above. All comments were used to adjust the test for comprehensibility. Adjustments were made on the Calculator Achievement Test (CAT) for the current study to ensure that there were 5 problems each for three levels of calculator tasks (one-step, two-step and multi-step tasks). The new CAT (see Appendix I) was discussed at a session of the Georgia Council for Teachers of Mathematics in which 20 teachers participated in reviewing the test for face-validity. There was positive agreement among the teachers regarding the wording and comprehensibility of the questions for high school students in an Algebra III course or equivalent curriculum.

Data Collection Procedures

The treatment classes were two Advanced Algebra and Trigonometry classes and one Honors Analysis class. The control group consisted of an Honors Analysis class taught by a different instructor. The Honors Analysis teacher collaborated weekly with the principal investigator on lessons to prepare for teaching the coursework, and students typically took the same tests. The methods and pedagogy of the two teachers were very similar.

Two Advanced Algebra and Trigonometry classes and an Honors Analysis class were the treatment classes. All classes were taught by the same teacher. For these treatment groups, students were randomly assigned to sit in social learning groups in two classes. These students had friends or partners in their groups to ask questions about calculator usage. The last Advanced Algebra and Trigonometry Class sat in vertical lines but collaborated with one another through discourse in partners instead of in structured social learning groups. After four weeks, the calculator efficacy survey and calculator post-test was given.

In the control group, students were sitting in rows, and they were taught in context specific calculator functions using interactive software for demonstration purposes (TI-Smartview). They were able to see the calculator emulator on the whiteboard, but they faced the front of the room, and they did not have friends or partners sitting close to them to ask questions. These students took the pre-test initially, and after four weeks, the calculator efficacy survey and calculator post-test was given. Prior to each administration of the calculator achievement test, the memory of the calculator was cleared to ensure that each student's results are valid.

The independent variable was the grouping based on Vygotsky's social learning theory. The calculator achievement test was measured by percentage accuracy as well as analysis by questions. Gender responses and accuracy rates were be matched and compared. Individual item analysis was also completed and compared to the above variables. The dependent variable, calculator efficacy, was measured using a Likert-type scale of 1-6. Gender differences were separated to determine likenesses and differences. An analysis was conducted comparing self-reported calculator efficacy rating with actual calculator achievement as measured by the calculator achievement test.

Data Analysis

Background information was collected on all students including age, number of years owning a calculator, gender, grade in school and how often the student used a graphing calculator. All data on numerical variables was entered into MINITAB (2007) or SPSS (2009) and summarized. SAS (2009) was used for linear regression and interaction analyses. A table was prepared that allowed for analysis of individual questions, as well as determining the mean achievement scores between males and females. A chart was also made for the post calculator self-efficacy score with a mean value for each item on the scale. This allowed for comparison between the males and the females.

To determine if teaching method had a role in determining if males and females were equal in graphing calculator achievement, a mean number correct was determined, and then an independent samples t-test was conducted. A problem was counted correct or incorrect for the quantitative portion of the analysis. Fifteen was the maximum number for the calculator achievement value. Age was coded in years. Length of time a calculator was owned was coded in years as 0, 0.25, 0.5, 1, and 2. Gender was coded as male = 1 and female = 0. Grade in school is coded as 9, 10, 11, and 12. Do you own a calculator was coded as 0 for no and 1 for yes, and "How often do you use it" was coded as 7 for every day; 4 for 3 – 5 times per week; 2 for 1-2 times per week, and 0 for less than once a week.

Questions 1 and 2 were: "Can Griffin's (2006) original efficacy survey be adapted to develop a reliable high school Calculator Self-Efficacy Survey (CES) as determined by a measure of internal consistency?" and "Utilizing a panel of knowledgeable high school teachers, can positive agreement be established using inter-rater reliability for wording, face-validity and comprehensibility for the Calculator Self-Efficacy Survey?" Question 3 was "Utilizing a panel of knowledgeable high school teachers, can positive agreement be established using inter-rater reliability for wording, face-validity and comprehensibility for the Calculator Achievement Test?"

To determine if the Calculator Efficacy Survey has face-validity and to establish inter-rater reliability, a grid with comments from raters was constructed. Wording, comprehensibility and appropriateness of questions for high school students were required of raters. A Cronbach's alpha of at least 0.80 to measure the internal consistency and reliability of the CES was required for the CES.

Question 3 involved a panel of expert and knowledgeable high school teachers evaluated the wording, comprehensibility and appropriateness of each question on the

Calculator Achievement Test (CAT). In addition to the panel of high school teachers, the CAT was given as a pilot test as well to two groups of high school students in a beginning Calculus class to evaluate the test for comprehensibility, wording of the questions, and face validity.

Questions 5 and 9, were “Do calculator assessment scores as measured by a teacher-developed assessment test differ based on gender?” and “Does working in collaborative groups based on Vygotsky’s social learning theories versus students working independently increase the performance level of students?” To determine if calculator assessment scores differed based on gender and to determine if working in collaborative groups based on Vygotsky’s social learning theories versus students working independently increased the performance level of students used two methods of data analyses. An independent samples t-test was conducted to determine if there was a significant difference in the mean change in males’ and females- on calculator achievement scores. A linear regression analysis was also conducted with an interaction comparison of gender and teaching method. If interaction had been found, post hoc analysis would be conducted to determine which particular associations differed significantly.

Question 6 indicated “Are all calculator skills required on the test items equally performed by males and females including one-step, two-step and multiple-step calculations?” Chi-square analysis was used to determine if significant differences exist in item analysis. An independent samples t-test was used to determine if significant differences exist between males and females according to level of difficulty in the calculator test. ANOVA was also be used to determine if there are significant differences between lengths of ownership based on gender as hypothesized in question 8.

Question 7 was “Do personal self-efficacy ratings match actual calculator performance for all students?” This question used Pearson’s correlation coefficient to determine if students’ personal self-efficacy ratings match their actual calculator performance. Pearson’s correlation coefficient was also used to determine if students’ technology efficacy ratings for specific questions match their performance for one-step, two-step and multiple step calculator problems.

Question 4, “How do females view their graphing calculator capabilities?” was the qualitative portion of the study. Analysis of themes and cross-case analysis was used to establish patterns among answers to interview questions, and themes were established regarding the attitude of high school females toward calculator usage (Creswell, 2007). Themes among females were compared to themes among males taken from the interviews. Perceptions and views of easiest, hardest, roles in education, and proficiency were identified.

Data analysis for the second pilot study involved two focus groups of female students. Female students were used in the focus groups to ascertain their views in a non-threatening, socio-cultural environment. Patterns were established regarding their calculator ability, coded by categories and specific relationships were developed. Students in the second study were enrolled in Algebra III or AP Calculus. Questions were designed to identify the more specific attitudes and understandings of females and to allow females to have their own voice. Field notes were written up within hours of the focus groups. For the breakfast focus group, the notes were reviewed within two hours during the researcher's planning period. The lunch focus group notes were reviewed within three hours of the session. They were also cross-referenced with transcription of the audio tape. Transcription of the focus groups was also done. Following transcription and collection of all the data, Excel was used for coding, categorizing and searching for findings and patterns. The findings were integrated with current and past research on the reasons for a lack of prominence of females in technology fields and their lack of participation and comfort with calculators. Themes and patterns that were established were described and ethnographic vignettes were written using students from both pilot studies (see Appendix J).

Ethical Considerations

All the quantitative procedures were planned and did not involve the researcher on a personal level. The interviews and focus groups that were a part of the pilot studies allowed for the researcher to become a part of the study as the one who led each discussion or interview. Since I discussed calculators with students, I did not expect sensitive information to be revealed, but should that have happened, proper notification would have occurred.

Summary

This chapter restated the purpose of this research and presented the research questions. The 67 participants were chosen through a convenience sample of four high school mathematics classes from a local high school of population approximately 1500. The design of the study and the instrumentation including information regarding reliability and validity were presented. Data collection procedures were identified and outlined and a time frame was specified. Data analysis procedures necessary to analyze each of the research questions, as well as the software packages necessary for analyses were discussed. Chapter 4 will present the results and implications of this study on calculator achievement and efficacy by gender. Chapter 5 will include a discussion with conclusions, recommendations and implications.

CHAPTER 4

FINDINGS

This study intended to investigate the effect of Vygotsky's social learning theories on calculator efficacy and calculator achievement by gender. Gender and treatment were the two main factors that were investigated to determine the effects and differences on students' calculator efficacy and calculator achievement scores. The purpose of the study was achieved by examining the results obtained from a pre-test efficacy score, a pre-test calculator score as well as post-test efficacy scores and post-test calculator scores by treatment or control groups. This chapter presents the results of the data analysis for each of the nine stated research questions.

The descriptive statistics including demographic information and mean number of calculations correct by treatment and by course are reported. Pre-test calculator and efficacy scores were summarized and evaluated for comparison in the hypotheses. An independent samples t-test was used to answer question 5 and to determine if calculator assessment scores differed by gender as measured on the teacher developed test. The post-test score and the net gain in calculator score are both used to assess this question. To determine if calculator skills are performed equally by males and females as question 6 asserts, chi-square analysis was used. Pearson's correlation coefficient was used to determine if there was a significant association between the post-test calculator score and the post-test efficacy score which is question 7. Analysis of variance was used to determine if gender, ownership, and achievement were related. To answer questions 8 linear regression was used to determine a model for Post-test scores and net gain in calculator scores using treatment and gender as variables to answer question 9, “Does working in collaborative groups based on Vygotsky’s social learning theories versus students working independently increase the performance level of students?”

Pilot Study Results

Three research studies were conducted in a suburban neighborhood school in the northwest crescent of Georgia and serve as pilot studies for the main study. In the first study, all students were enrolled in an Algebra III course. Students in the first study were given a demographic questionnaire, as well as the calculator efficacy survey. After an intervention period, they were given the calculator achievement test. The second study involved two focus group sessions with only females.

After adjustments were made on the Calculator Achievement Test and Calculator Efficacy Test, a third and final pilot test was given to two classes of AP Calculus students to check for face validity of each instrument. The final Calculator Achievement test had five fewer questions and was constructed to allow five questions of three different levels.

Question 1

Question 1: Can Griffin’s (2006) original efficacy survey be adapted to develop a reliable high school Calculator Self-Efficacy Survey (CES) as determined by a measure of internal consistency? Study 1 was conducted to pilot the Calculator Efficacy Instrument. As a measure of internal reliability, Cronbach’s alpha was selected for the exploratory analysis phase of the study to determine if responses were consistent and reliable. This statistic is often used when administering an evaluation instrument with rating scales. Alpha coefficients range from 0 to 1 and values greater than 0.7 are considered to be acceptable reliability in the literature (Trochim, 2006). The Cronbach's alpha coefficient for the 45 students in study 1 was 0.8484. An alpha coefficient that is closer to 1 indicates greater internal consistency on the scale. This measurement also met the commonly used criterion of at least 0.7.

Though the first study was determined to be a successful pilot, three additional questions were added to the efficacy survey to account for changes in the structure of the Calculator Achievement test. Two classes of AP Calculus students were administered the test to check for face validity, and no problems were found. The new CES was administered in the spring of 2010 and had a Cronbach's alpha score of 0.8468, successfully surpassing the minimum score criterion of 0.7.

In both the pilot test and the current study, the new Calculator Efficacy Survey was determined to be reliable for internal consistency as measured by Cronbach's alpha. Individual item analysis did not indicate that deletion of any specific item would increase Cronbach's alpha by any significant amount. Furthermore, the deletion of questions on a survey should be justified by factors other than the desire to simply increase the alpha score. Since the Cronbach's alpha score was above the minimal criterion, it can be determined that the CES is reliable for internal consistency.

Research Question 2

Question 2: Utilizing a panel of knowledgeable high school teachers, can positive agreement be established using inter-rater reliability for wording, face-validity and comprehensibility for the Calculator Self-Efficacy Survey?

A panel of high school teachers from a northwest county in Georgia reviewed the Calculator Efficacy Survey and found no problems with wording, comprehension or sentence structure. The CES was considered appropriate for a high school student in a mathematics class of Algebra III or higher. No problems or adjustments were suggested for face validity.

Due to a change in the study, the CES required the addition of three questions to account for a students' efficacy of one-step, two-step and multi-step equations. Prior to piloting the new efficacy instrument, it was taken to the Georgia Council for Teachers of Mathematics and used in a presentation. Teachers who participated in a session on the use of calculators were asked to take a CES and CAS and read them for wording, comprehensibility and any problems that they thought students might have encountered. The one suggestion that four teachers gave indicated the need to define the meaning of one-step, two-step and multi-step calculator tasks. This was done before the CES was piloted with students.

The purpose of the final pilot with students was to determine if the CES and CAT had face validity and to ensure that students could complete the surveys in one period. The CES was completed in 5 to 8 minutes. The CAT took approximately 30 minutes to complete but students had no difficulty understanding the questions or what they were instructed to do.

Positive agreement was attained on the new CES, and it was determined that inter-rater reliability had been met for the Calculator Efficacy Survey. When the additions were made to the survey, students completed the survey in the actual study with no questions and no problems. Wording, face-validity and inter-rater reliability was established for the CES.

Research Question 3

Question 3: Utilizing a panel of knowledgeable high school teachers, can positive agreement be established using inter-rater reliability for wording, face-validity and comprehensibility for the Calculator Achievement Test? A panel of high school teachers from a northwest county in Georgia reviewed the Calculator Achievement Test, and several adjustments were made. For one question, students were asked to solve a trigonometric function and give the answer in radians, but the domain was given in degrees. The question was not meant to trick students, so an adjustment was made. Another question indicated to graph for one full period, and the function was not periodic. One teacher indicated that Algebra III students at his school were not allowed to use graphing calculators. His responses were still determined to be accurate for face validity. Four other teachers indicated that the first problem was too easy and could be completed without a calculator, so it was adjusted for the final study to reflect a question of the same type with more difficult numbers to prompt students to use the calculator.

The new Calculator Achievement Test was taken to the Georgia Council for Teachers of Mathematics and used in a presentation. Teachers who participated in a session on the use of calculators were asked to take the CAT and read it for wording, comprehensibility and any problems that they thought students might have encountered. Twenty teachers took the CAT, and no suggestions were made for changing the wording of the questions for comprehensibility. The Calculator Achievement Test (CAT) was piloted with two AP Calculus classes at a suburban high school in northwest Atlanta to ensure that it had face-validity and comprehensibility for students. Although all students could not do all questions correctly, they finished the CAT and there was no confusion regarding questions or comprehensibility of what was written.

Positive agreement using inter-rater reliability was attained from a base of knowledgeable teachers. Wording, face-validity and comprehension of the teacher developed CAT was established by the panels of high school teachers and pilot study of high schools students. The goal of research question 3 was successfully met.

Research Question 4

Question 4: How do females view their graphing calculator capabilities? Interviews with three females and two males from study 1 and the results from two focus group sessions in study 2 with females revealed patterns and themes among females concerning calculator efficacy and performance. All names used for this research are pseudonyms. Initially for the interviews or the focus groups, students were asked their thoughts about graphing calculators. Four themes occurred in the interviews in the two pilot studies. The most prevalent theme was that a calculator improves one's ability or makes math easier. Ellen indicated that "I couldn't do half the stuff I do without the calculator." Erica also said that having a calculator was important because it was "easy to go back" [and check your work].

For both females and males, when asked about the importance of calculators, an enthusiasm and support for the use of calculators in the mathematics curriculum was apparent. Importance was a major theme. The students all stated that calculators were needed in harder classes, and they are important because of the many functions they can do. Felicity stated that for simple problems like evaluating, “it helps you move faster instead of having to do it in your head and write it out. And for the hard ones….it just helps out a lot.” Colin said that “basically it is a necessary tool to do a lot of mathematics.” Helpful was another theme for female students’ thoughts about calculators. Several students commented that the graphing calculators were very important because they do so “many things” and are needed in harder classes. Xin said they were “important for science and long calculations,” so cross-curricular information was noted as well. Lila liked the fact that you could find roots and “stuff that I can’t figure out by hand,” while Kara stated that it was convenient to check your work on a calculator as well as by hand. Linda said “it makes it [math] a lot easier because you can find out things faster.” In years past, calculators were optional. Now, they are being seen as valuable and necessary for learning (Forgasz & Griffith, 2006).

Students were asked to indicate if the calculator replaced knowledge? Students felt very strongly about knowledge and calculators, and one major theme among students appeared along with one outlier. Overall, both the females and the males felt that one still needed the knowledge to be able to use the calculator. Several students indicated that at times, the calculator had allowed them to forget simple mathematics. Kathy said she forgot some simple facts, like multiplication tables. Kara also indicated that it was very easy to forget mental math facts and use the calculator for simple calculations instead of using your brain. Julie said you must still be able to do the function without the calculator to know what to put into the calculator. The following quote of Matt’s opinion was insightful and is supported by the literature that indicates that calculators enhance learning but do not replace knowledge (Ellington, 2003). As Matt indicated:

> First of all you must be smarter than your calculator. Second of all, you need to understand the concepts and why things are done, and why they are done in what way, in that way. So you need to learn how to work a concept before you actually work it in the calculator (D. M., 2008).

One student, Felicity, emerged with a contrary theme that the calculator does indeed replace knowledge. When asked if she thought that the calculator replaced knowledge, she responded as follows, “Yeah I do actually. It kind of makes you numb towards what you are doing cause this calculator’s going to give you the answers. You don’t have to work so hard and remember and keep that renewal you know.” There were fewer students who felt that the calculator replaced knowledge than students who felt that it enhanced the educational process. Missy said, “You still have to have knowledge with the calculator because you have to know how to work it, and you have to be able to know how to do different formulas,” and Matt stated “You have to be smarter than your calculator”.

Following the transition question about thoughts on graphing calculators in general, each student was asked which calculator questions were the easiest to complete. In study 1, students had completed the Calculator Achievement Test (CAT) as a pilot test, but the focus group students had used their calculators in class regularly and had not taken the CAT. A theme readily emerged from this question. Most of the females immediately identified problems that were simple and did not involve many steps on windows on the calculator. They included the “evaluate” problems, or the basic four functions on the calculator (See Table 1). Missy stated, “The easiest were the ones where you just plug in different numbers for the letters, or finding determinants and just the simpler questions." It is interesting to note that she identified the determinant, because that was also a pattern as well among the females. Determinants and matrices do not come from the direct menu on the calculator. To find a determinant, one must know two or three steps, so the females were able to remember some complex functions on the calculator, and they found them to be easy. I also asked the students if any questions were easier than expected, and the graphing theme emerged. However, graphing requires two steps to be complete unless the window must be changed. Yet, for two girls, graphing and changing windows was mentioned as easiest to complete. For the other girl, graphing and changing a window was mentioned as easier than expected.

Table 1

Female and Male Concerns with Calculator Fluency

Type of Concern/Item	Mentioned by Whom
Easiest Problems to Solve	
Evaluate	Missy, Julie, Felicity, Matt
Determinant	Missy, Felicity, Mary
Simpler Questions	Missy, Julie, Matt, Kara,
Graphing	Julie, Colin, Elease
Easier to Work Than Expected	
Graphing	Missy, Julie
None	Sarah, Colin
Most Difficult Question	
Convert to degrees, minutes, seconds.	Missy, Sarah
Writing a program	Missy, Sarah, Colin, Xin, Kathy
Solve an equation, find zeros	Julie, Matt, Erica, Linda, Mary
Menus	Anna, Xin, Elease

Though not a theme, two girls mentioned advanced functions as easy to themselves. One female student liked programming, and it was easy for her, so that is what she announced as her easy function. Another student had taken AP Statistics the previous year and had learned a lot about statistical distribution functions, and listed those as being easy for her. Statistical distributions are two steps, but once a student reaches the correct screen, they also have to know the correct information to put in for the calculation to operate, or they must have the ability to operate the catalog help function on the calculator that will prompt them on what to put in for each distribution. Obviously this student had mastered an advanced concept if she identified statistical distributions as easy for her, but it was not a theme.

Students were also asked to identify which calculator tasks were most difficult to complete. One theme involved the use of tables on the calculator. Determining how to use the tables and set up the calculator so that one could input specific values for the independent variable was listed by several students. Elease said, “Using the tables—how you store it and how you can change it.” Several steps are involved in making the change so that the student can select any value for x in the table. Many students have not changed their table set-up, and changing the set-up is a pre-requisite to actually using the table. Finding zeros was a theme among the female students. It requires graphing a function and then going to another menu to find the zero. Once the student gets to the menu that indicates “find a zero,” they must move the cursor to the left of the zero, to the right of the zero and guess the zero before the zero is found. If a mistake is made and the cursor is not moved to the correct location, an error is given and students will sometimes give up.

Another theme that emerged as the most difficult problem came from problems that required multiple menus in the calculator. Finding all the menus and remembering where they were was difficult for many of the girls. Sarah discussed her ability to write a program, one of the more difficult tasks on the calculator. “I simply forgot. I knew how to get to the program and make a program. I just didn’t know which things to select.” Anna said that menus that are in lists confuse her because she originally had a different brand of calculator, and she had difficulty getting accustomed to the sub-menu type lists. Elease said that there should be a menu button that indicates – “go to this, go to that. I know those four buttons at the top, but those four buttons, they serve as another one, two, so there’s like 8 up there and then even from there, there’s two other Vars or APPS. The TINspire has a menu button, and I really like that.” [Author note – there are five buttons across the top of a TI-84 graphing calculator.]

No apparent theme prevailed among the males that were interviewed; however, when students were asked to describe the importance of calculators, a theme emerged from all of the students. Calculators are very important for learning in the classroom, and they make learning easier and more efficient. Matt stated that a calculator was essential. He also said without one, “everything would be so long and tedious.”

Students in both studies were asked to rate their calculator fluency. A theme that was prevalent was the need for improvement. The three females in the first study rated themselves as mediocre using words such as “ok” and “pretty good,” and the males used similar ratings. All the students indicated that they knew the basics and could get better. The second study asked each student to rank themselves on a scale of 1 to 10. The average score of the students was a 6.21 which is higher than average. A theme that was prevalent was that each student knew more than many other students, but they also knew there was more that they could learn. The females indicated that they would remember going over something in class and not recall how to do it at home immediately.

I asked the focus groups, “Are the genders equally proficient using the calculator?” Two very different and divergent themes occurred. In the first theme, one group of girls said that the boys were better than the girls on the calculator, and when I probed for why, it dealt with a lifestyle issue. Linda commented, “I feel like because guys enjoy it more and they play games you know, play with it more, they find out stuff that’s on it, and they’ll remember it and so. Girls don’t really play with the calculator as much as guys do and so I feel like guys have more of an advantage with it”. Mindy also stated, “I think guys are better at it. They know where the shortcuts and when it comes to typing stuff in, they are faster at it. Whereas, I take a second to like think about where the button is.” PJ added, “I think maybe it has something to do with pride–because they want to be better than girls, because in a society that requires people like Sarah Palin and Hillary Clinton–no preference to either of them. When a girl becomes more competitive, they want to become more equal to them. They want to keep that upper level thing so they try to know more than us.” The divergent theme was in the second focus group. Even with probing, the girls did not want to answer the question. They kept evading the issue. Not all females believed that males were more proficient than females. Many girls believed that girls were equally proficient on the calculator as males and rated themselves as equal with males. For several of the females, it was based simply on bringing the calculator to class and using it at home. Kathy said, “I think girls tend to use it more because boys forget, because boys are very forgetful sometimes. So girls *bring* their calculator and remember, then they are going to use it more than boys that forget." Elease also added that both genders are "pretty equal but guys seem to enjoy it more and spend more time doing it, but if we learn in class, both genders can learn it equally." One interesting note is that the lunch focus group was more diverse and was composed of AP Calculus students and Algebra III students. As the AP Calculus students acknowledged that they did not know everything possible about the calculator, it seemed to give "permission" to the Algebra III students to be more open and honest with their comments. For the morning focus group, all students were Algebra III students, and none of the students actually answered the question, even when prompted further, about which gender was more proficient.

An unexpected outcome of the focus group was how students learn calculator functions, which is a topic that came as a result of the gender equality proficiency questions. A theme readily emerged that involved teaching. Students noted that daily use and instruction was vital for calculator fluency. Kara said, "I'm pretty sure we use it more than like other students cause well you show us like different ways to get around you know, ways in your calculator to make it easier on us". Another comment by Linda added, "This is the most I have ever used a calculator for and everybody in my class pretty much uses it the same as me and so think there's an increase of calculator use in Algebra III". A comment by Kara was, "I know with you, you'll teach us how to do it, then you'll teach us how to do it in the calculator, so you'll teach both paper and calculator, so it makes the level of education go up like if you have a problem and do it two ways." Morgan indicated that teaching students how to program made things a lot easier as well, and plugging into TI-Navigator was another way in which students were taught calculator skills that increased usage and involvement.

Females have a lot of pride, and they work very hard with their calculators. They indicated that the calculator was very important in mathematics and was needed in the harder classes, so they see the need for the graphing calculator though they recognize their own limitations and the need to improve their knowledge. They were also quite fluent in identifying their strengths, weaknesses and viewpoints on the importance of the calculator in the mathematics curriculum. Females in the interviews indicated that they had learned more in the class they were in because they were being directly taught. Girls enjoyed the calculator, but frustration seemed to arise when they got to menus and sub-menus and could not remember what to do.

Main Study Results

Demographic Information

Background data were gathered on all students who participated in the calculator fluency and efficacy social learning project. Students were asked to indicate their age, grade and model of calculator they owned. If they did not own a calculator, they were asked to indicate that information. Length of ownership and how often the calculator was used for homework assignments was given by each student also. The results are given in Table 2. There were 32 males and 35 females that completed the study and two teachers participated in the study as well. Students were enrolled in Advanced Algebra and Trigonometry (AAT) or Honors Analysis. Most of the students who were in AAT were qualified to take Honors Analysis but opted for the easier curriculum of AAT. Most students that were a part of this study owned their own calculator. Forty students owned a TI-84 or TI-84 Silver Edition, 19 students owned TI-83 calculators, and only 8 students did not own a graphing calculator.

Table 2

Demographic Means and Standard Deviations for Students in the Calculator Achievement Study

	Female			Male		
	n	*M*	*SD*	*n*	*M*	*SD*
Age	35	17.143	0.733	32	16.969	0.647
Grade	35	11.514	0.505	32	11.313	0.535
Length Ownership	35	1.579	0.683	32	1.359	0.795
Usage	35	5.686	2.166	32	4.438	2.2395

Descriptive Statistics Prior to Implementing Socio-Cultural Teaching

Two classes of Honors Analysis and two classes of Advanced Algebra and Trigonometry (AAT) were chosen to be used by a convenience sample for this study. Three of the classes, two AAT and one Analysis class were taught by the principal researcher, and the fourth class was taught by a collaborating teacher. The principal investigator and the collaborating teacher worked closely together throughout the year planning lessons, and for this research the collaborating teacher was given training on how to teach calculator skills in the context of the lesson. The collaborating teacher is also highly fluent with the graphing calculator which is the additional reason why she was chosen as the teacher for the fourth class. The principal investigator did not have four equivalent classes in which to conduct the study, and therefore it was necessary for a second teacher to be involved for the quasi-experimental study. The final study was completed by 50 students in the principal investigator's classes (treatment) and 17 students in the collaborating teacher's class (control). Descriptive statistics of the mean pretest score, 1-step calculator score, 2-step calculator score, multi-step calculator score, programming score, as well as analysis by teacher are given in Table 3. The control class was an honors class, which may contribute to the higher pre-test mean scores that are exhibited in the table. The treatment classes include honors and non-honors classes, and most of the mean scores are lower than the control class.

Table 3

Pre-Test Means and Standard Deviations Overall and by Treatment

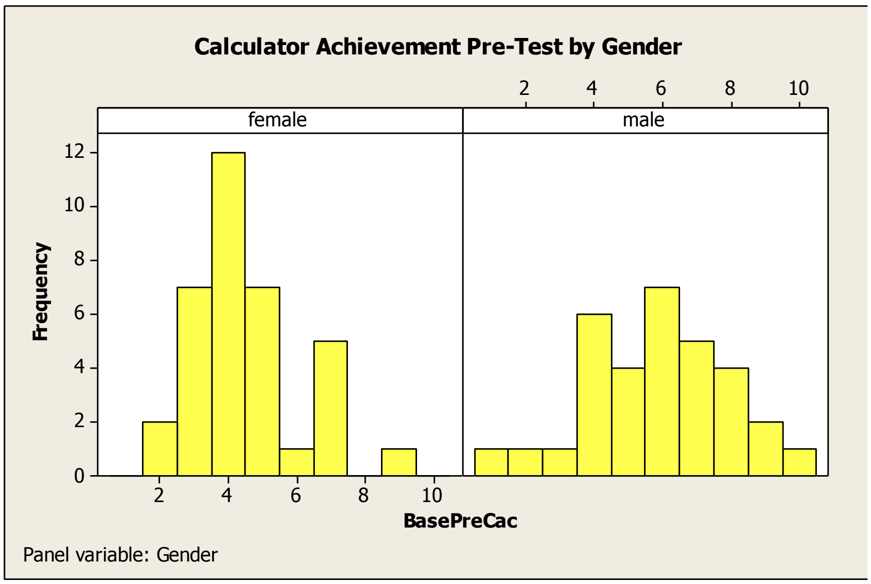
	Overall			Treatment			Control		
	n	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*
Pretest	67	5.149	1.94	50	5.020	1.964	17	5.529	1.875
1-Step	67	3.299	1.059	50	3.200	1.125	17	3.588	0.795
2-Step	67	1.358	0.933	50	1.300	0.886	17	1.539	1.068
Multi-Step	67	0.5075	0.7462	50	0.540	0.762	17	0.412	0.712
Programming	67	0.0597	0.2387	50	0.080	0.0470	17	0.000	0.000

Students who were in Analysis also exhibited higher mean scores on the pre-test than students that were in Advanced Algebra and Trigonometry. There were 33 students in AAT, and overall their mean pre-test score was 4.242 while the 34 students that were in Analysis had a mean pre-test score of 6.029. Students in AAT had a mean of 2.909 while the Analysis students scored on average 3.696 on one-step calculations. Two step calculations showed a slight difference as well with the AAT mean being 1.091 and Analysis students' mean being 1.618. Neither group scored well on multi-step calculations, which are calculations that involve more than two sub-menus. The mean of the AAT students was only 0.2727 while the mean of the Analysis students was 0.735.

Though the mean of the Analysis students was higher than the mean of the AAT students, one of the main outcomes was to determine the net gain, so it is not critical that the AAT students started at a lower point.

Figure 1

Histogram for Calculator Achievement Pretest Score by Gender



There are statistically significant differences between males and females on the pre-test. The histograms in Figure 1 show that the pretest for females has less spread and a very high peak with 4 questions correct. For males, there is more spread among the scores, and the graph could be considered approximately normal for the limited number of students in the survey. An independent sample t-test for the difference in pre-test scores between females and males was statistically significant, t (48) = -2.93, p = 0 .005. On average, females scored between 2.238 to 0.421 questions lower than males on the pretest. Analysis of variance was used due to cell count limitations to determine if significant differences existed between males and females on individual calculator item analysis. Four calculations exhibited gender related differences on the pretest as displayed in Table 4. The questions that were significant involved solving a matrix equation (3), finding the smallest minimum (6), programming the calculator (12) and simplifying an imaginary number (12).

Table 4

ANOVA Results for Pre-Test Calculator Item Analysis for Significant Findings

	SS	*df*	*MS*	*F*	*Sig*
Question 3	0.422	1	0.422	4.694	0.034
Question 6	0.901	1	0.901	4.968	0.029
Question 12	0.422	1	0.422	4.694	0.034
Question 14	1.281	1	1.281	5.543	0.022

There was no significant difference between males and females on the Pre-Calculator Efficacy score, or on the student's ability to ascertain their competency in accurately completing certain types of calculator questions. The mean score of males was 59.09 out of a possible 78 with a standard deviation of 9.55. The mean score of females was 58.11 with a standard deviation of 7.95. The results do not indicate a significant difference in self-reported calculator efficacy scores between males and females. One efficacy question was statistically significant in the pre-efficacy survey. Males were more likely than females to indicate "I will probably choose a career that requires me to know a lot about computers and computer programming," $F(1, 67) = 7.846$, $p = 0.007$. All other efficacy items showed no statistical significance based on gender.

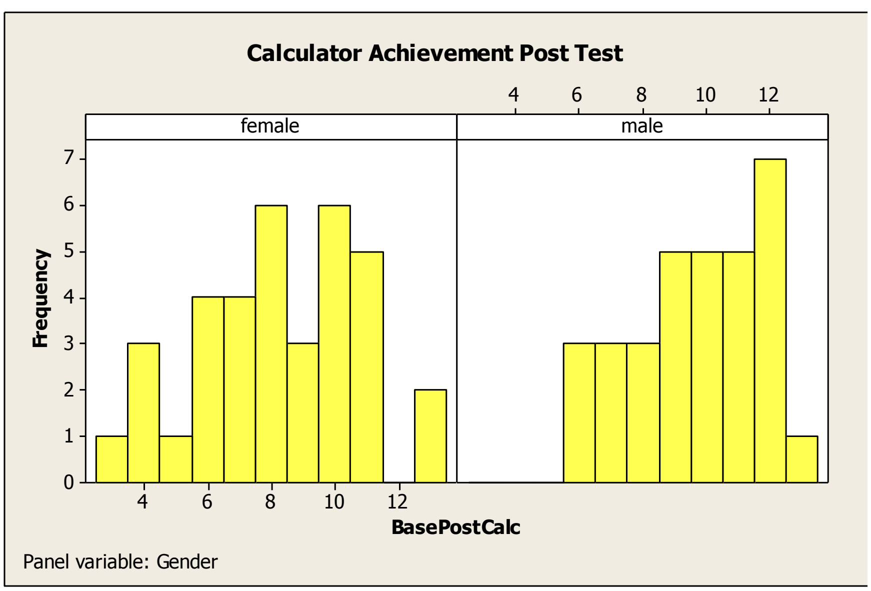
Research Question 5

Do calculator assessment scores as measured by a teacher-developed assessment test differ based on gender?

The purpose of this question was to determine if students differed in their calculator skills based on gender. It was measured using the pre-test score, post-test score and the net gain in calculator skills. Two specific measures were used to answer this question - the posttest calculator score and the net gain in calculator skills which is the post test minus pretest score. An inspection of the data indicates that both of the histograms for the males and the females appear to be slightly skewed left toward lower scores. This reveals that as the students were taught in context they learned more calculator skills and achieved a higher calculator score, and more students achieved higher scores on the calculator achievement post test as Figure 2 displays.

Figure 2

Histogram of Calculator Achievement Post Test Scores by Gender

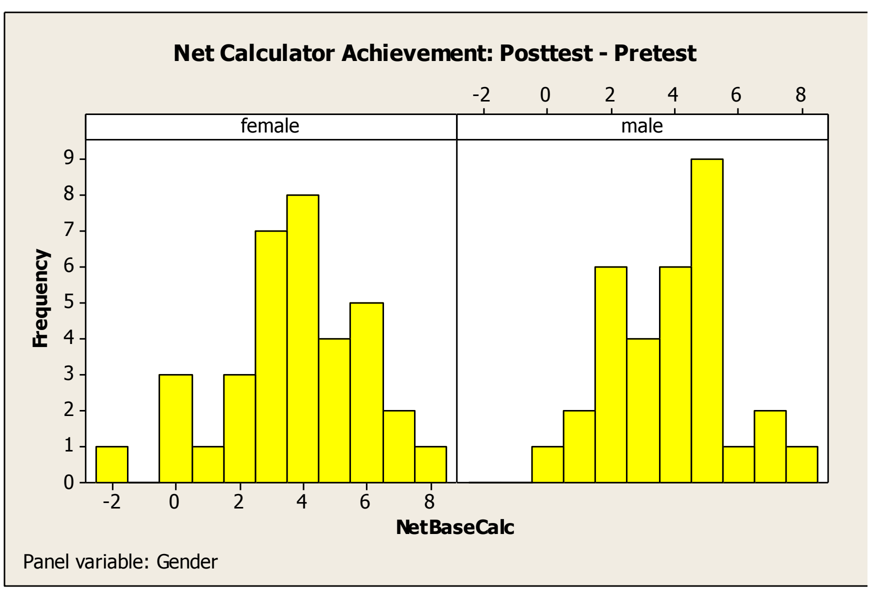


To determine if the males and females scored equally on the post test calculator skills a two-sample independent t-test was used. The mean score of males was higher with an average of 9.69 questions out of 15 correct compared to females who scored an average of 8.23 questions correct. Males scored higher than females on the post-test at a statistically significant rate, t (63) = -2.58, p = 0.012. According to this data, the mean scores of males and females were significantly different using a two-sided test. On average, females scored 2.587 questions to 0.331 questions lower than males.

Calculator achievement is also assessed by the net gain or loss in calculator scores as measured by post test score minus pretest score. The graph of the data indicates that males and females are approximately the same. Both graphs appear to be approximately normal though males have a higher peak than females. The graph of the females is also more symmetric than the males, but there are no major differences in variation, minimum or shape (see Figure 3).

Figure 3

Histogram of Net Calculator Achievement by Gender



To determine if calculator assessment scores differ based on gender, the net gain in calculator achievement score was determined also (See Table 5). On average, males gained 3.84 points, and females gained 3.71 points. The independent samples t-test 95% confidence interval for the difference in female net calculator achievement scores and male net calculator achievement scores contains 0 which indicates that the net gain in calculator achievement between males and females is not statistically significant. The 95% confidence interval for the difference in net gain indicates that on average females score between 1.127 questions lower to 0.868 questions higher than males.

Table 5

Two Sample t-test for Net Calculator Achievement

	N	$\bar{x}$	SD	SE Mean
Gender				
Female	35	3.71	2.22	0.37
Male	32	3.84	1.87	0.33

*p = 0.796 df = 64

This question's purpose was to determine if calculator assessment scores as measured by a teacher-developed test differed by gender. The results of this hypothesis were mixed. The post-test score was significantly different based on gender with males scoring higher on the post-test than females by an average of 1.46 questions. The second method to determine if calculator assessment scores differed by gender was to determine if the net gain on the calculator achievement test differed significantly. There was no significant difference by gender in net gain. Though females score lower, they are gaining at approximately the same rate as males.

Research Question 6

Are all calculator skills required on the test items equally performed by males and females?

There were several sub-questions associated with this question. Each one will be addressed separately. This question investigates individual items on the calculator assessment test as well as problems that require one-step, two steps or multiple steps when using the calculator. Four different sub-questions were associated with this research question. Chi-square analysis was used to determine if significant differences existed between males and females in the item analysis as well as by level of difficult. Cramers' V was used to give the strength of the relationship.

Do males and females differ in calculator functional ability using individual test item analysis and rankings of difficulty? Tables 6 and 7 present the individual item analysis for the post calculator achievement test. To determine changes that occurred, the pretest was analyzed to determine which questions showed significant differences between males and females. It revealed four questions with significant differences between males and females using Chi-square. Of the same fifteen items on the post- test, only one item showed a significant difference between males and females. Question 14 involved simplifying a quotient with imaginary numbers and was statistically significant, $\chi^2(1, N = 67) = 7.583$, $p < 0.01$. The Cramer's V is 0.113 and is considered weak. Males and females showed some difference in the ability to program a calculator which was question 12, but it was not enough to reject the null hypothesis, $\chi^2(1, N = 67) = 3.309$, $p = 0.069$. Therefore, though most questions showed no significant difference between males and females in calculator functional ability, one cannot say there are no differences in calculator functional ability since at least one item did show a significant difference.

Table 6

Individual Calculator Item Analysis of Post Calculator Achievement Test

	Female		Male				
	Incorrect % (n)	Correct % (n)	Incorrect % (n)	Correct % (n)	χ^2	p-value	Cramer's V
1. Evaluate $\frac{54*22+6}{30-32}$	8.57 (3)	91.43 (32)	9.38 (3)	90.63 (29)	0.013	0.908	0.000
2. Find $\csc\left(\frac{3\pi}{5}\right)$.	34.29 (12)	65.71 (23)	40.63 (13)	59.32 (19)	0.287	0.592	0.004
3.Solve: $-x - 3y + z = 54$, $4x + 2y - 3z = -32$, $2y + 8z = 78$	77.14 (27)	22.86 (8)	59.38 (19)	40.62 (13)	2.452	0.117	0.037
4. Convert to degrees, minutes & seconds 126.78°	31.43 (11)	68.57 (24)	15.63 (5)	84.38 (27)	2.297	0.130	0.034
5. Find a window: $f(x) = 2x^5 - 2x^4 - 62x^3 + 50x^2 + 300x$	40.00 (14)	60.00 (21)	28.13 (9)	71.88 (23)	1.046	0.307	0.016
6. Find the smallest minimum: $f(x) = x^4 - 2x^3 - 9x^2 + 2x + 8$	60.00 (21)	40.00 (14)	43.75 (14)	56.25 (18)	1.769	0.183	0.026
7. Solve: $\cos(x) = 0.348$	34.29 (12)	65.71 (23)	18.75 (6)	81.25 (26)	2.053	0.152	0.030

Table 6 (continued)

Individual Calculator Item Analysis of Post Calculator Achievement Test (continued)

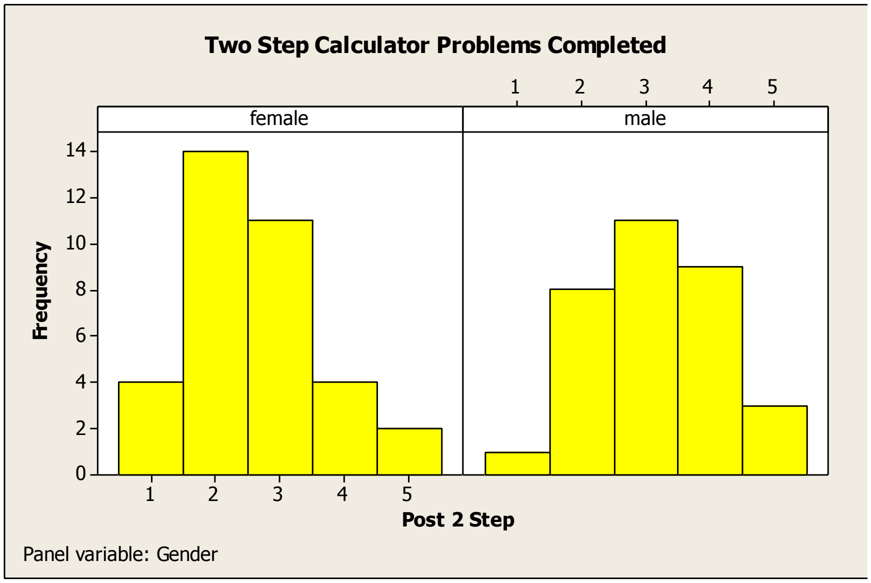
	Female		Male				
	Incorrect % (n)	Correct % (n)	Incorrect % (n)	Correct % (n)	χ^2	p-value	Cramer's V
8. Solve: $3^{x+2} = 5^x$	80.00 (28)	20.00 (7)	78.13 (25)	21.88 (7)	0.036	0.852	0.000
9. Evaluate: $ln\left(\frac{3}{.28}\right)$	8.57 (3)	91.43 (32)	3.13 (1)	96.87 (31)	0.883	0.347*	0.013
10. Find the partial sum: $\sum_{i=3}^{23}(24-4i)$	25.71 (9)	74.29 (26)	18.75 (6)	81.25 (26)	0.467	0.495	0.007
11. Find the sample standard deviation.	42.86 (15)	57.14 (20)	31.25 (10)	68.75 (22)	0.963	0.326	0.014
12. Write a program to find the slope.	77.14 (27)	22.86 (8)	56.25 (18)	43.75 (14)	3.309	0.069	0.049
13. Sketch the graph of f(x) = $0.2x^3 - 4x^2 - .78x - 5.8$	62.86 (22)	37.14 (13)	62.50 (20)	37.40 (12)	0.001	0.976	0.000
14. Simplify: $\frac{3+2I}{4-5I}$	42.86 (15)	57.14 (20)	12.50 (4)	87.50 (28)	7.583	0.006	0.113
15. Find the least squares regression line for the data.	51.43 (18)	48.57 (17)	53.13 (17)	46.88 (15)	0.019	0.890	0.000

Are all calculator skills required on the test items equally performed by males and females, including one-step, two-step and multiple-step calculations? The next part of the question to be addressed is the ability of students to perform one-step calculations. There were five questions on the calculator achievement test that were single step problems, so the possible score for a student was between 0 and 5. The mean score or number correct for females on one step calculator problems was 3.80 while males averaged approximately 4.156 correct. Using a two sample t-test for independent samples to compare means, this was not a statistically significant difference, $t(64) = -1.40$, $p = 0.083$. Though this p-value is close and may warrant further investigation, there is not sufficient evidence to say that there is a difference based on gender in the completion of problems on the calculator that involve only one step, or require a student to use just the main screen of the calculator.

Do males and females perform equally on two-step calculator problems? Two-step problems were the next part of this question to be analyzed for differences between males and females. Two-step calculator problems are problems that involve at least one step and at least one sub-menu. There were also five questions on the calculator achievement test that were identified as two-step calculator problems. Figure 4 shows the distribution of problems accurately completed by students. The graph appears to be approximately normal for male students. The histogram is slightly skewed right for female students with a peak at two questions correct, showing a difference between males and females.

Figure 4

Histogram of Two-Step Calculator Problems Completed for All Students

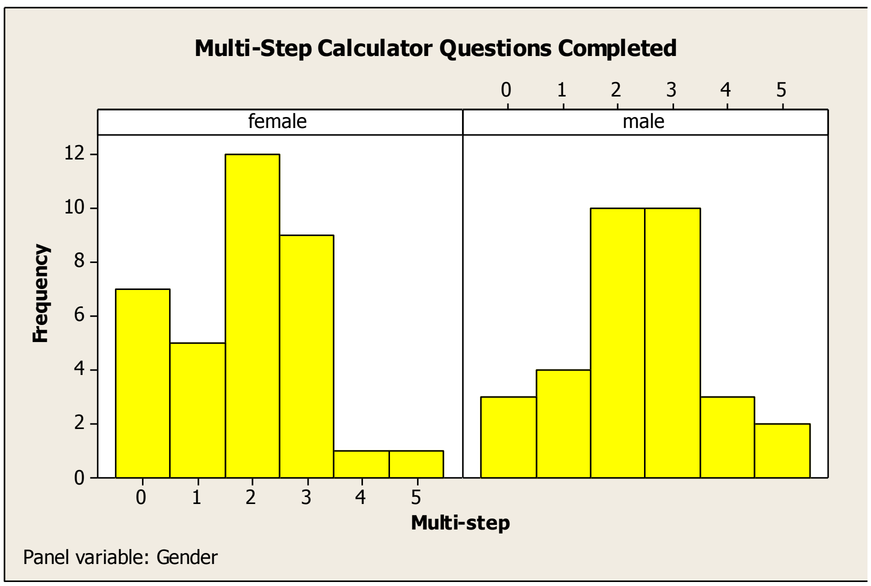


On average, females in this study correctly answered 2.60 questions that required two-steps on the calculator, or a step and a sub-menu. Males correctly answered 3.156 such questions. Using a two sample independent means t-test to test if females scored less than males, a significant difference was found, $t(64) = -2.21$, $p = 0.015$. Based on this result, there is a significant difference in achievement of males and females on two-step calculator problems. These results indicate that males and females do differ in their ability to accurately complete two step calculator problems. The mean score of the males was higher than the mean score of the females, and this difference was statistically significant indicating that the males performed at a higher level on this test with two-step calculator tasks.

Do males and females perform equally on multi-step calculator problems? The last phase of the question involves multi-step calculator problems. Multi-step problems require more than two-steps and also require students to use two or more sub-menus. Five questions were multi-step problems, and the range of abilities of students to complete these skills was quite large. The graph for the females shows more females with lower scores while the graph for the males appears to be approximately normally distributed (see Figure 5).

Figure 5

Histogram of Multiple Step Calculator Achievement Problems by Gender



The mean number correct for females was 1.857 while the mean number correct for males was 2.375. The mean score of males is higher than females, and the results of the two-sample t-test gives a value marginally close to significant, t(64) = -1.66, p = .05. It is difficult say there is no difference between males and females. Since the p-value equals the α level of significance, it appears that there is a difference between males and females with females scoring lower. Using p=0.05, indicates that results such as these would only occur 1 out of 20 times by chance, so females do not appear to be performing multi-step calculations at the same mean rate as males.

A further calculation in which two-step and multi-step calculation were collapsed and compared for males and females was pursued to determine if a significant difference occurred above the one-step level. The mean number of two-step and multi-step calculator tasks correct for males was 5.53, while the mean number correct for females was 4.43. A one-way independent two-sample t-test showed that the females' score was significantly less than the males' score, t (64) = -2.51, p =0.007.

The purpose of question 6 was to determine if males and females functioned equally on calculator skills required on the test items. The question had five sub-questions that were answered. The item-analysis indicated that there was only one question with a significant difference. One-step questions indicated no significant difference between males and females, but two-step equations were significantly different for males and females. Multiple-step calculator tasks were slightly less than significant, yet when the p-value is as close as this situation, further investigation is warranted, and this is also significant with a higher α level. Collapsing two-step and multi-step calculations also indicated that females were performing at a level lower than their male counterparts.

RESEARCH QUESTION 7

Do personal self-efficacy ratings match calculator performance for all students?

Calculator efficacy and calculator achievement is the subject of the third question. Pearson's correlation coefficient was used to determine the correlations.

Post-achievement test and post efficacy test as well as four specific measures from the efficacy survey are correlated with three summation measures from the calculator achievement test.

The mean score for each of the thirteen technology efficacy questions by gender is given in Table 7. Most questions show a very small spread between the males and the females. Although technology and calculators is typified as a male domain, females scored only 0.27 points lower than males on the question, “I need a lot of help with calculators.” The question with the widest difference was “I will probably choose a career that requires me to know a lot about computers.” Males rated the question 3.53 out of 6 while girls rated it 2.20, and it was the one of two question that showed statistical significance by gender, $t(65) = 4.119$, $p < .001$. The other question in which males and females differed was “I am comfortable with graphing calculators.” Males rated the question on average as a 5 while females on average rated the question as a 4.57, and this difference was significant, $t(65) = 2.039$, $p = .046$.

Table 7

Means and Standard Deviations for Post Calculator Efficacy Test Items

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Using technology like computers and graphing calculators makes learning more interesting	male	32	4.81	1.061	.188
	female	35	4.49	1.067	.180
Other students usually come to me for help with the graphing calculator	male	32	3.12	1.238	.219
	female	35	3.09	1.147	.194
I need a lot of help with technology.	male	32	4.53	1.077	.190
	female	35	4.26	1.039	.176
I think working with computers and calculators is very frustrating	male	32	4.88	1.040	.184
	female	35	4.77	.973	.164
I am capable of accurately completing one step calculator tasks	male	32	5.62	.609	.108
	female	35	5.83	.382	.065
I am capable of writing a calculator program	male	32	4.22	1.518	.268
	female	35	3.69	1.323	.224
I am capable of completing accurately two step calculator tasks	male	32	4.91	.928	.164
	female	35	4.74	1.067	.180
I am comfortable with computers	male	32	5.34	.865	.153
	female	35	5.29	.710	.120
I am comfortable with graphing calculators	male	32	5.00	.803	.142
	female	35	4.57	.917	.155
I am capable of producing a graph and adjusting the window.	male	32	5.41	.756	.134
	female	35	5.11	.963	.163
I am capable of finding the roots of an equation on a graphing calculator.	male	32	4.84	1.051	.186
	female	35	4.86	.944	.160
I am capable of accurately completing multiple step calculator tasks.	male	32	4.56	1.076	.190
	female	35	4.60	1.168	.197
I will probably choose a career that requires me to know a lot about computers.	male	32	3.53	1.545	.273
	female	35	2.20	1.023	.173

Figure 6 indicates the scatter plot of the technology efficacy score of females and males for the post-Calculator Achievement Test score. A very scattered pattern is apparent for both males and females, though males are centered more upward and to the right. The females show a positive, upward trend, and it is very weak. The correlation for the post Calculator Self Efficacy and post-test for females is r = 0.2759 which concurs with the visual representation.

Figure 6

Scatter plot of Calculator Achievement Test and Calculator Self Efficacy Scores by Gender

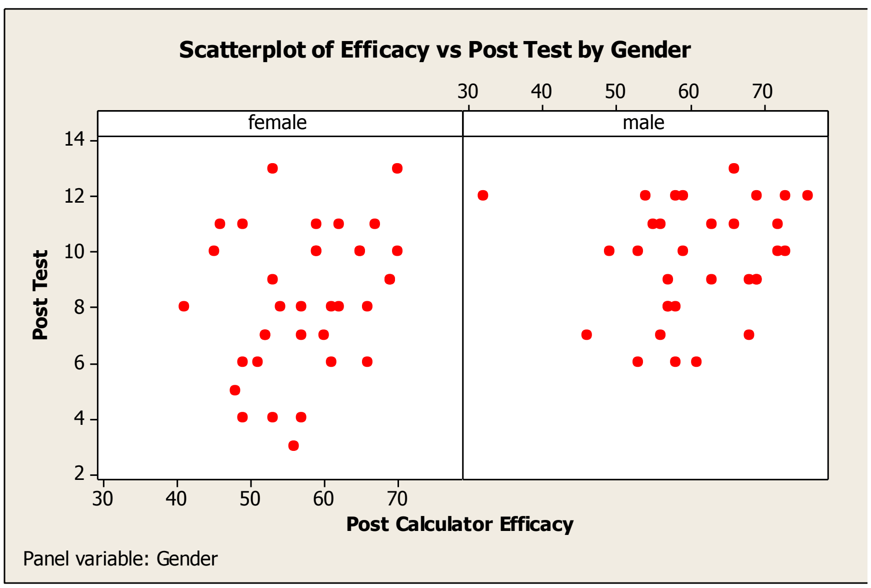


Table 8 displays the correlations between achievement scores and efficacy scores that were delineated in question 3. Using Pearson's correlation coefficient, the post-test achievement score and the post-test efficacy score correlation was statistically significant, $r = .260$, $p < .05$. Though the amount of variation that is explained by the least squares line of post test by calculator self-efficacy score is only about 6.76%, it is enough to be considered significant. Though many students did very well on one-step equations, the correlation between one-step equations and their one-step efficacy prediction was poor. They were also weak in predicting their ability to complete two-step calculator equations and multiple-step calculator equations. However, when asked about their ability to program, students' predictions were more accurate and statistically significant. The correlation between the ability to program efficacy and the actual ability to program was $r = 0.364$, $p < .01$.

Table 8

Pearson's Correlation Coefficients for Calculator Efficacy and Calculator Achievement by Levels for All Students

Pearson Correlation Coefficient R	Post-Test Achievement (p-value)	1 Step Calculator Skills (p-value)	2 Step Calculator Skills (p-value)	Multi-Step Calculator Skills (p-value)	Ability to Program Calculator (p-value)
Total Post Efficacy	.260 *(.034)				
Ability to complete 1-step skills		-0.072 (0.561)			
Ability to complete 2 step skills			0.1200 (0.332)		
Ability to complete multi-step skills				0.162 (0.189)	
Ability to program calculator					0.364 **(0.002)

*p < .05 ** p < .01

Female students did not have strong correlations between their calculator self-efficacy scores and their post test scores, though a fairly strong correlation exists between pre-test efficacy scores and post-test efficacy scores, $r = .6608$, $p < .0001$. They also did not have strong correlations between their calculator self-efficacy scores and their post test scores or between individual efficacy measures that were matched with level of calculator skills (see Table 9). A weak correlation existed between post calculator efficacy scores for females ($r = .2759$) and the post calculator achievement test though it was not statistically significant. Females did quite well on one step calculations but the efficacy survey was a Likert-type scale with values 1 through 6, and a negative correlation very close to zero existed between the high values that the females ranked themselves and their actual post-test scores. Two step calculations also exhibited the same pattern in which students felt confident they could complete the problems accurately but were not actually able to do so on the calculator achievement test. A slightly positive correlation between multi-step calculations and self-reported ability to complete them was found, but not significant. Calculator programming and calculator self-efficacy were the only variables that had a statistically significant association for females, $r = 0.444$, $p < .01$. Hence, the correlations indicated no meaningful relationships between any of the variables except between the ability to program a calculator and the calculator efficacy associated with programming.

Table 9

Pearson's Correlation Coefficients for Calculator Efficacy and Calculator Achievement by Levels for Females

Pearson Correlation Coefficient R	Post-Test Achievement (p-value)	1 Step Calculator Skills (p-value)	2 Step Calculator Skills (p-value)	Multi-Step Calculator Skills (p-value)	Ability to Program Calculator (p-value)
Total Post Efficacy	0.276 (0.109)				
Ability to complete 1-step skills		-0.0150 (0.932)			
Ability to complete 2 step skills			-0.120 (0.420)		
Ability to complete multi-step skills				0.279 (0.105)	
Ability to program calculator					0.444 **(0.008)

** $p < .01$

This question also had mixed results because there were several embedded questions within the main research question. The overarching question–using the post-test calculator achievement score and the post-test efficacy score had a slightly positive correlation that was statistically significant. Also, the ability to program had a positive correlation and was statistically significant. These two results may lead one to determine that there is an association between calculator self-efficacy rating and calculator ability score. However, correlations of the other three ratings for one-step calculator skills, two-step calculator-skills and multi-step with calculator self-efficacy were not statistically significant. Therefore, these findings were mixed.

RESEARCH QUESTION 8

Is there a relationship between the number of years owning a graphing calculator and operational ability as defined by the test score or by gender?

The purpose of this question was to determine if length of time owning a graphing calculator contributed to proficiency and accuracy using the calculator. Analysis of variance was used with length of ownership measured in intervals of 0, 0.25, 0.50, 1 or 2 or more years. Gender was also used as a factor in the model. Table 10 displays the results from the analysis of variance procedure for the calculator post-test. Length of ownership was not significant in predicting post-test score, though gender was. The ANOVA model using gender and length explained about 15.2% of the variation in post-test calculator scores, but if gender is removed, only about 6% of the variation in test scores is explained by length of ownership.

Table 10

ANOVA Post-Test Calculator Achievement using Length of Ownership and Gender

ANOVA	Df		SS	MS	F	Pr > F
	5		59.1235	11.8247	2.19	0.0669
	61		329.5034	5.4017		
	66		388.627			
Predictor	**df**	**ANOVA SS**	**MS**	**F Value**	**Pr > F**	
Length	4	23.5431	5.88577	1.09	0.3697	
Gender	1	35.5804	35.5804	6.59	0.0129*	

*significant p < .05

Length of ownership was also not significant in predicting net gain in calculator achievement scores as Table 11 shows. These data seem to show no relationship between ownership and calculator fluency. The amount of variation in post-test calculator scores explained by length of ownership is only 4.08% (when gender is removed) and only 4.1% when gender is left in the model.

Table 11

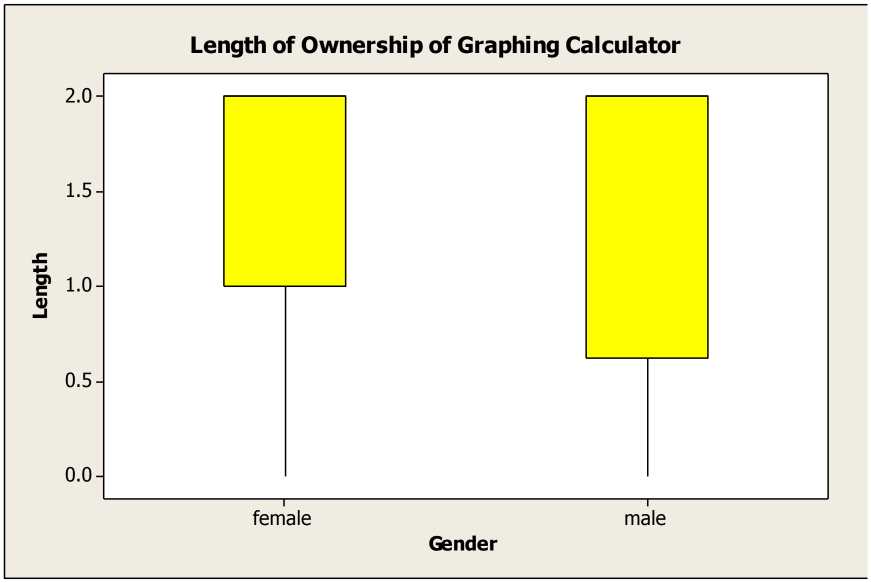
ANOVA of Net Gain in Calculator Achievement using Length of Ownership and Gender

ANOVA	Df		SS	MS	F	Pr > F
	5		11.54835	2.3097	0.53	0.7501
	61		264.0934	4.3294		
	66		275.64175			
Predictor	df	ANOVA SS	MS	F Value	Pr > F	
Length	4	11.26816	2.81704	0.65	0.6286	
Gender	1	0.280183	0.280183	0.06	0.8000	

A large proportion of males and females in this study owned graphing calculators as is exhibited by Figure 7. For both males and females, the median, quartile 3 and the maximum are all 2 years. The interquartile range is smaller for the females than for the males, with about 75% of the females owning a calculator between 1 and 2 years but the same percentage of males owning a calculator between 0.625 to 2 years.

Figure 7

Length of Time in Years Students Have Owned a Calculator



The females in the study owned a graphing calculator on average 1.579 years while males in the study owned a graphing calculator an average of 1.359 years. A one-way ANOVA of length of ownership versus gender was not significant $F(1,66) = 1.47$, $p = 0.229$. Mean length of ownership of calculators between males and females showed no statistical difference between males and females.

The purpose of question 8 was to determine if there was a relationship between length of ownership of a calculator and operational ability as defined by the calculator achievement test score. Length is not significant in any of the models. No significant differences existed between males and females based on length of calculator ownership and calculator mean calculator achievement score. This data is sufficient in concluding that there appears to be no association between length of ownership and post-test calculator achievement and length of ownership by gender.

RESEARCH QUESTION 9

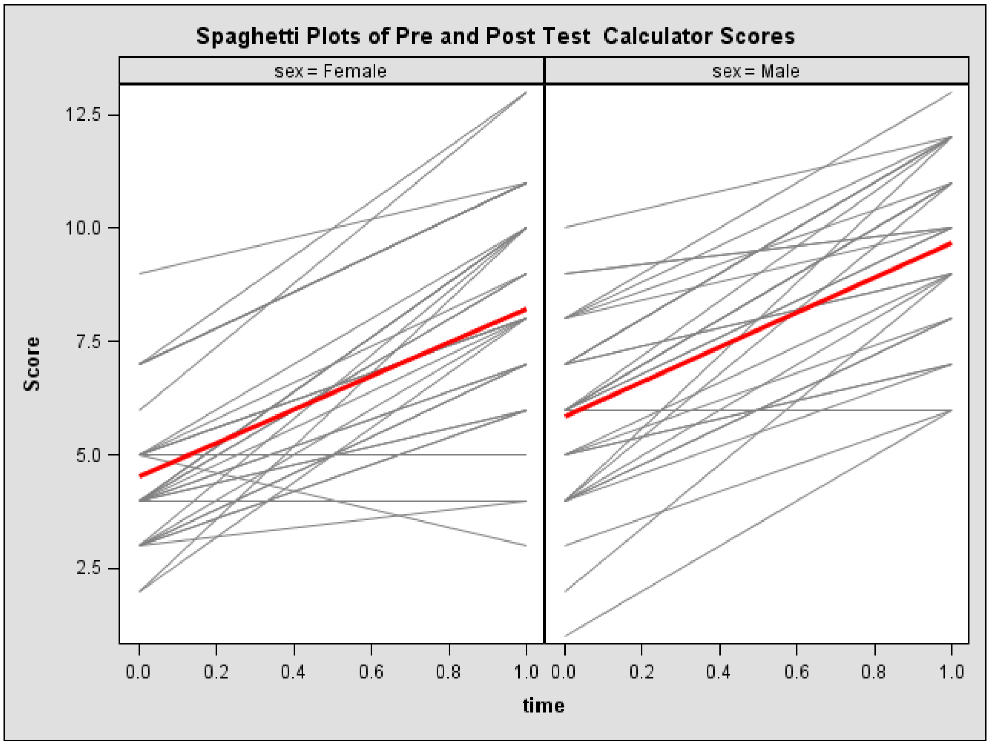
Does working in collaborative groups based on Vygotsky's social learning theories versus students working independently increase the performance level of students?

The purpose of this question was to determine if Vygotsky's learning theories aided in helping students learn calculator concepts as a result of the social discourse on social learning groups. Linear regression was used to assess the research question. The groups were divided into treatment groups and control groups. All of the treatment groups were engaged in Vygotsky's learning theories through discourse, social interaction and/or social learning groups.

Determining achievement based on treatment and gender was conducted using regression analysis as well as an inspection of graphs. Pre-test and post-test scores of all students were evaluated, and spaghetti plots of each of the students' scores are shown in Figure 8.

Figure 8

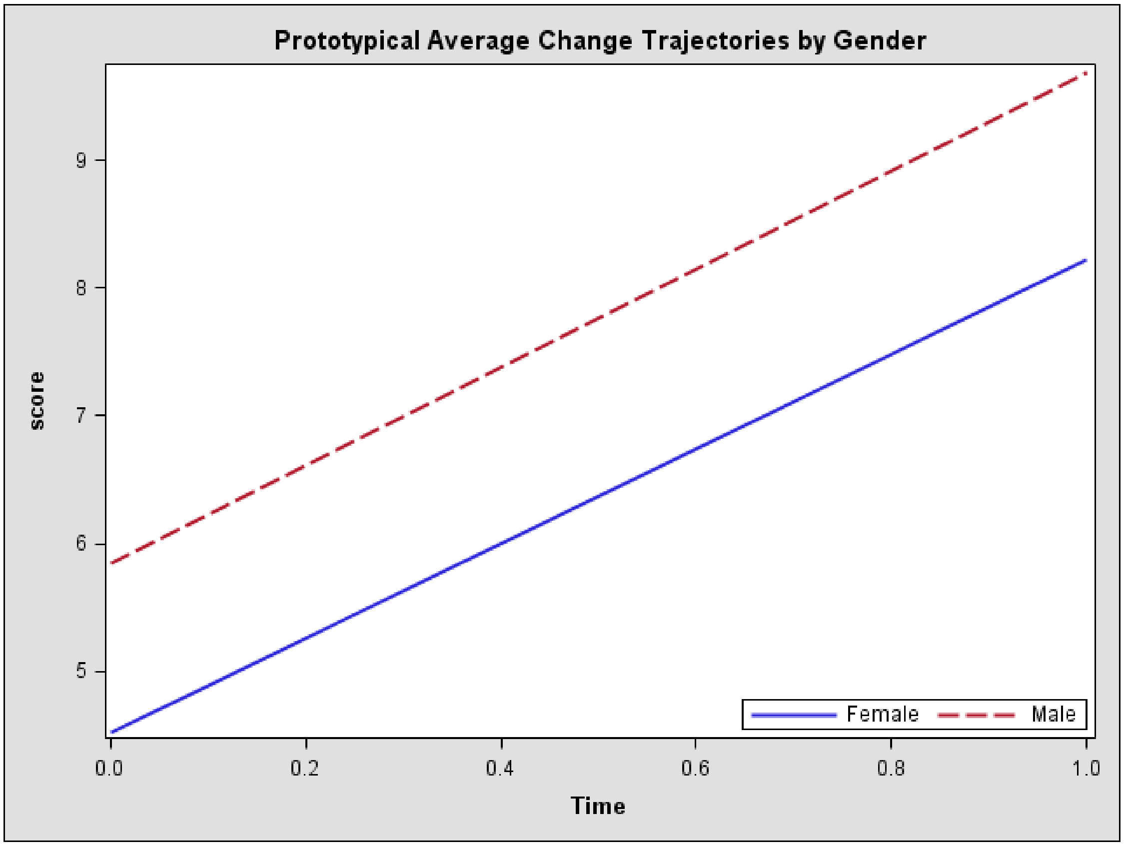
Spaghetti Plots of Calculator Achievement Pretest and Posttest Scores by Gender



The slopes of the males' and the females' mean growth trajectory in red appear to be very close. Males seem to show more variation in their plots than females, but several females have little growth or negative growth. Figure 9 displays a graph of the prototypical average change trajectories by gender and reveals that females start at a lower mean score than males, but their rate of growth over time is approximately the same, indicating that their slopes are approximately the same.

Figure 9

Prototypical Average Change Trajectories of Males and Females



Interaction of gender and treatment could affect the results of the study, so a term was created to test for interaction. A regression analysis that modeled post-test scores using gender, treatment, and a term for the interaction of gender and treatment revealed that there was no interaction between gender and treatment. Table 12 shows the results of the linear regression in which gender and treatment were significant but the interaction term was not, so it was dropped from the first regression model.

Table 12

ANOVA Linear Regression Model for Posttest = Gender, Treatment and Interaction of Gender and Treatment

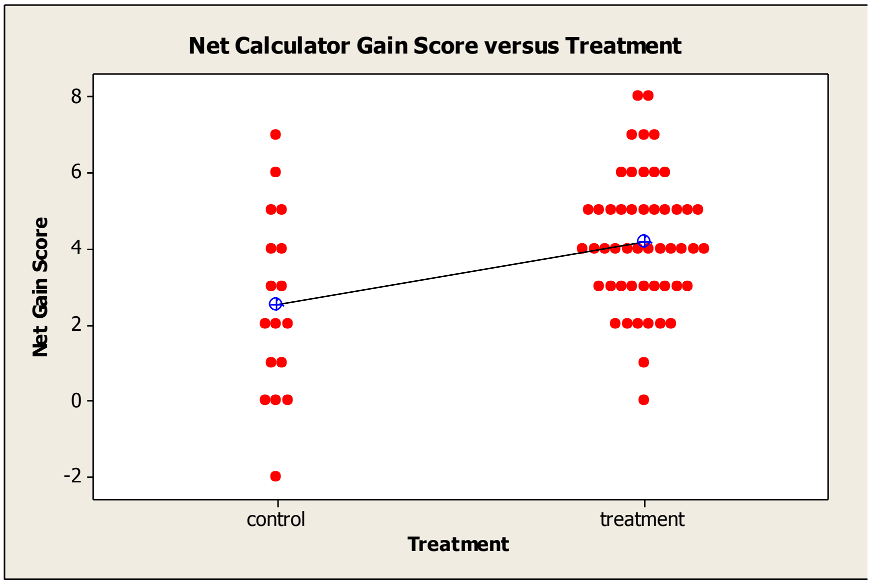
Predictor	Coefficient	SE Coefficient	t	p-value	
Intercept	7.1667	0.66159	10.83	< .0001	
Gender	1.6159	0.81612	1.96	0.0131	
Treatment	3.0333	1.21990	2.49	0.0156	
Treatment*Gender	-2.22335	1.38241	-1.61	0.1128	
ANOVA	Df	SS	MS	F	p-value
Model	3	57.72864	19.2488	3.66	0.0169
	63	330.89823	5.25235		
	66	388.62687			

The mean posttest score for the treatment group was 9.22 while the mean posttest score for the control group was 8.0588. When the interaction term of treatment with gender was removed, treatment and gender were still significant but the model does not provide as good a fit, F (2, 66) = 4.10, p = 0.0211. The R^2 adjusted declined to .0859 indicating that only 8.59% of the variation in posttest scores is explained by the least squares regression line using gender and treatment. The original equation had an R^2 adjusted of 0.1080 indicating that the least squares regression line of post test scores explained 10.8% of the variation in post test scores based on gender, treatment and the interaction of gender and treatment. Therefore, the original model is better. The treatment of Vygotsky's social learning theory resulted in higher posttest scores for the treatment group versus the control group.

Post-test scores are only one aspect of determining the effectiveness of Vygotsy's social learning theory. Another important aspect to determine the effectiveness of the social learning theory is the net gain in calculator achievement score. An independent samples t-test between the treatment groups and the control groups indicated a significant difference between the two groups t (21) = -2.61, p = 0.008. Figure 10 shows a plot of the net gain scores for students in each group with the means plotted for each of the groups connected.

Figure 10

Net Calculator Gain Score for Students in Control and Treatment Groups



The mean net gain in calculator achievement score for students in the treatment group was 4.20 questions while the mean gain for students in the control group was 2.53 questions. The linear regression analysis concurred with the findings of the two independent sample t-tests. Using net calculator gain and the model score = gender, treatment and the interaction term for gender*treatment, only one factor was found to be statistically significant F (3,66) = 3.19, p = 0.0295 for the linear model. Treatment was significant, t (1) = 2.66, p = 0.0098 and gender was not significant t (1) = 0.10, p = 0.9235.

The model was refined until the best fit model with the highest R^2 adjusted was found. The results are given in Table 13. Treatment is significant, and treatment explained 11.5% of the variation in least squares regression line of net gain in calculator scores based on treatment.

Table 13

Linear Regression Model for Net Gain in Scores = Treatment

Predictor	Coefficient	SE Coefficient	t	p-value	
Intercept	2.52941	0.46627	5.42	< .0001	
Treatment	1.67059	0.53975	3.10	0.0029	
ANOVA	Df	SS	MS	F	p-value
Model	1	35.40650	35.40650	9.58	0.0029
	65	240.23529	3.69593		
	66	275.64179			

Both the linear regression model and the t-test concur that there is a significant difference in the net gain in calculator skills gained between the treatment group and the control group. One would reject the null hypothesis that there is no difference in achievement of students on the calculator achievement test after working in collaborative learning groups based on Vygotsky's social learning theories. Students who were a part of the group experiencing Vygotsky's social learning theories had higher net gain scores in calculator achievement than students in the control group. These differences were statistically significant at the $\alpha = 0.01$ level. Students in the treatment group were more successful in learning calculator concepts in context than students in the control group.

Females' Experience with Vygotsky's Learning Theories

Females that were a part of the treatment group outscored the control group on all calculator achievement measures, though all differences are not statistically significant. On average, the 95% confidence interval for the control group's post-test was between 3.87 questions lower to 0.64 questions higher than the treatment (Vygotsky) group. Though this was not statistically significant $t(14) = -1.54$, $p = 0.073$, there appears to be a difference. The mean for the treatment group was 8.78 questions while the mean for the control group was 7.18 questions. With the calculated p-value, further investigation with a larger group should be conducted because the data indicated that only 7 times out of 100 would a result like this happen by chance.

One step calculations were easy for all students, but students in the treatment group had a mean score of 3.957 which was slightly higher than the mean of 3.50 in the control group. This was not statistically significant $t(14) = -1.13$, $p = 0.137$. The females, like the males, did very well on one step calculations on the calculator.

Two step calculations on the calculator were very easy for females in the treatment group and females in the control group. Again, females in the treatment group scored slightly higher than females in the control group. The mean score of females in the treatment (Vygotsky) group was 2.6089 while the mean score of females in the control group was 2.58. There was no statistical significance in the two-step calculations $t(13) = -0.05$, $p = 0.479$.

Multiple step calculator problems included programming problems, adjusting the calculator window, finding a linear regression window, finding a sample standard deviation and solving a system of equations. These were the most challenging problems to complete on the calculator and on average the 95% confidence interval for control minus treatment group indicates that on average the control group completed 2.033 to 0.322 questions less than the treatment group. The mean number of questions completed (out of 5) for the control group was 1.08 while the mean number of questions completed for the treatment group was 2.26. This difference in means was statistically significant $t(21) = -2.86$, $p = 0.005$. The social learning group was especially effective in helping females increase their proficiency with multi-step problems as compared to the control group of females. Since performing the harder tasks is the main problem females have difficulty with, this finding is of particular importance.

One of the main purposes of this study was to determine a method in which females could master calculator skills easily and develop calculator efficacy. Since there was no significant difference by gender, it was important to look within gender to determine if any differences occurred by treatment within the females. In all calculations, the scores of females in the Vygotsky treatment group were higher than females in the control group. Also, females were able to be more successful on multiple step calculator skills which are the hardest for females to master. Females in the Vygotsky treatment group had a higher net gain than females in the control group. Therefore, though the treatment did not result in changes for each question, one would reject the idea that the achievement of both the control and treatment group on the calculator achievement test is the same. Female students who were a part of Vygotsky's learning theory groups were more successful at two-step and multi-step questions than the control females.

Additional Analyses

Honors Analysis versus Advanced Algebra and Trigonometry (AAT)

Most of the students in AAT had been in Honors Algebra II, so they actually qualified to take Honors Analysis but according to the students, chose to take AAT due to the lesser demands of the course. Motivation could be a factor in learning in the course as well as the calculator, so analyses were conducted to determine if there were significant differences between the two courses in post-test scores and net-gain scores. The mean score for the AAT students on the post calculator achievement test was 8.97 while the mean score for the Analysis students was 8.88 and there is no statistical difference as Table 15 indicates.

Table 14

Post-Test t-test on Calculator Achievement Test by Class

	N	$\bar{x}$	SD	SE Mean
Class				
AAT	33	8.97	1.88	0.33
Analysis	34	8.88	2.89	0.50

*p = 0.884 df = 56

For the net gain in calculator achievement, the mean score for the AAT students was 4.73 questions while the mean score for the Analysis students was 2.85 questions. It is important to note that the mean pre-test score for AAT was 4.242 and the mean pre-test score for Analysis was 6.029. There was a significant difference between the two classes in net gain in calculator achievement, but not in post-test score as Table 15 shows.

Table 15

Net Gain Scores t-test on Calculator Achievement Test by Class

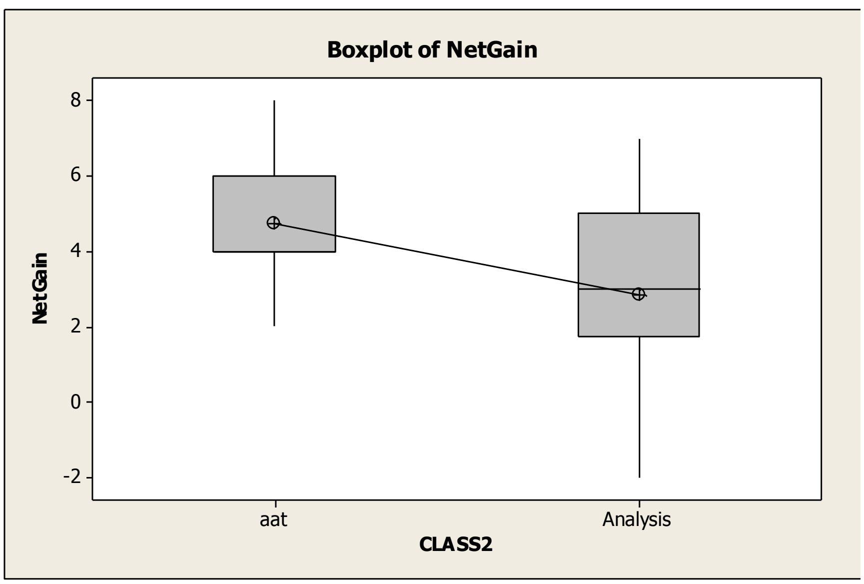
	N	$\bar{x}$	SD	SE Mean
Class				
AAT	33	4.73	1.53	0.27
Analysis	34	2.85	2.08	0.36

*p = 0.000 df = 60 (two-sided)

Both the AAT classes and the Analysis classes' distribution appeared to be approximately normal when the box plots were inspected (See Figure 11). The Analysis classes had more variation in net gain than did the AAT classes, and actually had a negative score, which was not a mistake. This could have been due to student participation and a lack of commitment to the research project and trying one's best to achieve.

Figure 11

Boxplot of Net Gain in Calculator Skill by Class



AAT and Analysis classes were not significantly different on one-step calculations or two-step calculations. For multi-step calculations, the AAT students had an average number correct of 2.36 while the analysis students had an average number correct of 1.85, $t(63) = 1.64$, $p = 0.053$. This is not statistically significant, but is close enough to warrant further investigation.

SUMMARY

Statistical tests that were used for each of the questions were repeated. Results from the first question indicate that males and females differ significantly on their post-test scores but not on their net gain scores. Item analysis indicated that males and females do not perform significantly different on most questions. Only one question involving imaginary numbers met the significance test. All students performed well on one-step equations, but ANOVA results indicated that males performed better than females on two-step equations. The mean score of males was also higher for multi-step equations, but the p-value was slightly too high for significance. Efficacy scores for males and females were also very similar with two exceptions related to use of technology and technology and careers. Both males and females had difficulty accurately predicting their calculator efficacy because their calculator efficacy and calculator post-test scores sub-scores did not correlate well for most items. One of the major findings of this study is that working with Vygotsky’s learning theories results in higher post test scores and higher net gain scores in calculator achievement. For females in the Vygotsky social learning theory group, every calculator measurement score was higher than the control group score, though the differences were not always statistically significant.

For females and males, when asked about the importance of calculators, an enthusiasm and support for the use of calculators in the mathematics curriculum was apparent. Importance was a major theme. The students all stated that calculators were needed in harder classes, and they are important because of the many functions they can do. When asked if a calculator divide existed, or which gender seemed to be more proficient, a large proportion of the females stated that males are more proficient, and connected the proficiency to males' computer game playing. The auto-ethnographies (see Appendix J) reveal information about classroom activities involving the use of calculators in the context of the classroom. Conflict with student feelings, inability to operate, giving up, and actually learning are all processes that students go through when they learn to operate a calculator. Being successful in the classroom and carrying that knowledge to college, or becoming a leader is the ultimate success, and several students' stories are given.

The next chapter will give a summary of this study on calculator efficacy and achievement using Vygotsky's learning theory. A discussion of the findings and implications will be given. Recommendations for further research will be explored and concluding remarks will finalize the chapter.

CHAPTER 5

SUMMARY, DISCUSSION, AND CONCLUSIONS

In the previous chapter, the data were analyzed and reported. This chapter presents the findings and the results of the study that included a quasi-experimental study and mixed method pilot studies regarding calculator efficacy and calculator achievement using Vygotsky's learning theory. This chapter is presented as an introduction, a summary of the study, a discussion of the findings, the limitations, the implications for practice, and recommendations for further research and conclusions.

Summary of the Study

Though females have made great strides in the mathematics classroom, they lag behind in the area of technology. Technology and the graphing calculator play a critical role in learning mathematics and are vital components of NCTM's National Standards for Mathematics (NCTM, 2008). Research has demonstrated that students that use graphing calculators with regularity were found to perform at a statistically significant higher level than those who did not use them (Ellington, 2003). Operational skills, computational skills, problem solving skills and conceptual skills were all found to improve significantly when students had access to a calculator during instruction (Ellington, 2003). Students also develop a deeper level of understanding of mathematical concepts when using a graphing calculator (Hollar & Norwood, 1999). Technology and calculators in the classroom are especially useful in aiding students to achieving mastery of mathematical concepts and allows them to discover concepts more easily (Forster, 2006). Yet in this age of technology, a gender disparity involving the use of technology exists between males and females and is well documented (Dyer, 2004; Forgasz & Griffith, 2006). The educational system may be inadvertently contributing to the inequity between males and females in regard to calculator achievement and efficacy.

The purpose of this study was to determine what relationships or differences exist between males and females in calculator self-efficacy and calculator achievement, and if social learning groups better support females in calculator achievement and efficacy. To accomplish this purpose, this study : (a) examined one-step, two-step and multi-step calculations, (b) examined collaborative partners and groups' outcomes as compared to students working independently according to Vygotsky's social learning theory, (c) and compared student demographic background information to determine what if any effect they have on the outcome.

The following research questions were addressed by this study:

Question 1: Can Griffin's original efficacy survey be adapted to develop a reliable high school Calculator Self-Efficacy Survey (CES) as determined by a measure of internal consistency?

Question 2: Utilizing a panel of knowledgeable high school teachers, can positive agreement be established using inter-rater reliability for wording, face-validity and comprehensibility for the Calculator Self-Efficacy Survey?

Question 3: Utilizing a panel of knowledgeable high school teachers, can positive agreement be established using inter-rater reliability for wording, face-validity and comprehensibility for the Calculator Achievement Test?

Question 4: How do females view their graphing calculator capabilities?

Question 5: Do calculator assessment scores as measured by a teacher-developed assessment test differ based on gender?

Question 6: Are all calculator skills required on the test items equally performed by males and females including one-step, two-step and multiple-step calculations?

Question 7: Do personal self-efficacy ratings match actual calculator performance for all students?

Question 8: Is there a relationship between the number of years owning a graphing calculator and operational ability as defined by the test score?

Question 9: Does working in collaborative groups based on Vygotsky's social learning theories versus students working independently increase the performance level of students?

This study involved the use of demographic data including age, grade, course, years owning a calculator, teacher, and how often the graphing calculator was used for homework (See Appendix K). Quantitative data was collected from a Pre-Calculator Efficacy Survey and a Pre-Calculator Achievement Test, as well as post-tests of each. The Calculator Efficacy Survey (See Appendix G) was used to measure attitudes toward calculators, calculator problems and technology and was adapted from an efficacy survey used by Dr. Linda Griffin (Griffin, 2006). The data from the efficacy survey was used to compare efficacy scores of males and females and to determine correlations between calculator efficacy and calculator achievement.

No graphing calculator achievement instrument was available to use in the study. The calculator achievement test was developed using a literature search and a calculator fluency test from Canada developed by Wu (2002) as well as using the curriculum content of the Algebra III course. It was piloted in 2008 and again in 2009 (See Appendix H). The data from the calculator achievement test were analyzed to determine differences in achievement between males and females, as well as between treatment and control groups.

In addition, the principal investigator wrote auto-ethnographical vignettes that describe many of the learning obstacles, processes and interactions that are encountered in learning to operate a graphing calculator. Student failures are portrayed. Frustrations are revealed. Finally successes are accomplished, and students feel the triumph of accomplishment.

Pilot Study Questions

Research Question 1

Can Griffin's original efficacy survey be adapted to develop a reliable high school Calculator Efficacy Survey (CES) as determined by a measure of internal consistency? Reliability analyses of the pilot study indicated that the ten items on the CES had internal reliability. The Cronbach's alpha coefficient was 0.8484 and exceeded the minimum criterion level set by the literature of 0.7 (Huck, 2008). Three questions were added to the pilot survey to account for a change in the Calculator Achievement Test so a correlation would be present. Scores taken from the study reflected that the Pre-Calculator Self-Efficacy and Post Calculator Self-Efficacy Survey had a Cronbach's alpha of 0.8468. The objective to develop a Calculator Self-Efficacy Survey with a meaningful internal consistency was accomplished.

Research Question 2

Utilizing a panel of knowledgeable high school teachers, can positive agreement be established using inter-rater reliability for wording, face-validity and comprehensibility for the Calculator Self-Efficacy Survey? Positive agreement was established for comprehensibility for the Calculator Self-Efficacy Survey. A panel of eight high school teachers reviewed the pilot calculator efficacy survey for face validity, and there was 100% agreement that the survey was written appropriately for high school students. The CES was slightly altered for the final study to account for single step, two step and multi-step equations. The new CES was revealed at the Georgia Council for Teachers of Mathematics. Twenty teachers took copies of the CES and Calculator Achievement Test. The one problem that was reported by four teachers required defining one-step, two-step and multi-step calculator tasks, and the problem was corrected prior to implementation. For the final pilot, two classes of AP Calculus students took the CES, and there were no questions regarding wording or comprehensibility, so face-validity was established.

Research Question 3

Utilizing a panel of knowledgeable high school teachers and a pilot study, can positive agreement be established using inter-rater reliability for wording, face-validity and comprehensibility for the Calculator Achievement Test? Inter-rater reliability was established for the Calculator Achievement Test. For face validity, the original survey was sent to 15 high school mathematics teachers in the county, and eight responded. There was 75% agreement that the questions were appropriate for students in Algebra III and above. Two teachers made suggestions that dealt with wording of the questions, and those changes were made. The test was piloted again with 2 AP calculus classes, and there were no problems with comprehension or wording issues. Therefore, positive agreement using inter-rater reliability was established for the Calculator Achievement Test.

Research Question 4

How do females view their graphing calculator capabilities? Females believe that the easiest functions to complete, on average, are the ones that involve the main menu of the calculator or those with fewer steps. They also felt that the calculator was an important tool in the mathematics classroom, and that it had improved their mathematical abilities. Females also indicated that calculators were convenient because they allowed you to check your work. They also indicated that in some cases, the calculator became a crutch, and allowed one to forget simple facts such as the multiplication tables.

When asked to identify functions or processes that were difficult, females listed programming the calculator, solving for zeros and working with tables. Each of these functions requires multiple menus on the calculator. One female was very specific in giving guidelines for how the calculator should be set up in order to make it user friendly in her opinion.

Many girls felt equally proficient with males, but many girls felt that males knew how to operate their calculator better. One female indicated that a calculator was similar to a video game, and since guys are so proficient at video games, it only makes sense that they would be more proficient at using the calculator. Another girl indicated that guys just wanted to do everything fast, and a calculator simulated that playing fast idea.

Most girls rated themselves above average on their proficiency level on the graphing calculator. An interesting comment was made indicating that using the calculator every day helped increase their proficiency. Another student indicated that being taught with the calculators and using devices such as the TI-Navigator aided in learning how to use the graphing calculator.

Main Study Research Questions

Research Question 5

Do calculator assessment scores as measured by a teacher-developed assessment test differ based on gender?

The findings from this question were mixed. When measuring calculator assessment scores with only the Post-Test Calculator Achievement Score, there was a significant difference between males and females. However, there was no significant difference in the Net Gain Score between males and females as measured by the difference in the post-test minus the pre-test. This may appear to be contradictory, but there are possibilities as to why this could occur.

Two factors could account for why males score significantly higher than females with no significant difference in the net gain in calculator achievement score. Males and females had different mean pre-test scores initially. Therefore, they started at different levels of knowledge of the calculator. Essentially, the males, on average, knew how to complete more calculator functions than the females did.

The second factor that contributed to this difference was that males and females grew at approximately the same rate. The linear regression equation indicated that the factor for gender was not statistically significant, meaning that the slopes are the same.

Therefore, if the males started at a higher point and were learning at the same rate as females, they were going to end at a higher point. Likewise, if females' average starting point was lower, but they learned at the same rate as males, they would finish at a lower point than males. To overcome this problem, the growth rate for females would have to become steeper than the growth rate for males so the females could reach the same level as males.

Research Question 6

Are all calculator skills required on the test items equally performed by males and females including one-step, two-step and multiple-step calculations? Chi-square analysis for items indicated that males and females showed no significant differences on most questions on the calculator achievement test. One question was significantly different by gender. This question involved simplifying an imaginary number that involved a quotient, χ^2 (1, N = 67) =7.583, $p < 0.01$. A second question on programming, though not significant, was close enough to warrant further investigation, χ^2 (1, N = 67) =3.309, $p = 0.069$. Males and females differed somewhat on programming a calculator. There was no significant difference between males and females on one-step calculations, but there was a significant difference in two step calculations. Multi-step calculations produced a p-value of 0.05 which equals the α level for rejection. However, with a

p-value equal to 0.05 there appears to be a difference between males and females. A further test of two-step and multi-step tasks combined indicated that there was a gender related difference which was significant.

Research Question 7

Do personal self-efficacy ratings match actual calculator performance for all students? The Post-Calculator Achievement Test and the Post-Calculator Efficacy Score was used to produce a correlation for all students to determine if their self-efficacy ratings matched their calculator performance ratings. There was a weak positive correlation (r = .260) for all students between efficacy and achievement. Students typically rated themselves very high on their ability to complete any calculator task.

Females had a slightly higher score on their ability to complete one-step calculations, but the correlation between the efficacy score and the calculator score was not statistically significant. On two-step calculations, males scored slightly higher, while females scored slightly higher on multiple-step calculations. Though both of these had a slightly positive correlation, neither was statistically significant. Students were able to accurately predict their ability to program the calculator. Males' predictions were higher than females', but this positive correlation was statistically significant.

Research Question 8

Is there a relationship between the number of years owning a graphing calculator and operational ability as defined by the test score? There was no significant relationship between lengths of ownership and operational ability as defined by the test score. The post-test calculator score and the net gain in calculator achievement score were not impacted by the length of ownership. Two possible reasons may account for this lack of significance.

As stated before, students must be taught how to use the calculator, and they must practice the technical skills. Students must learn syntax, sub-menus, commands and location of each of the sub-commands. Knowing procedures also means they must know how to debug if they get an error, which often causes major distress for students. Students may have the calculators, but until the time is taken in class to teach and monitor the skills, students will not have the operational ability on the calculator.

Years of ownership does not translate into operational ability. A lack of significant exercises or projects that require the use of the calculator could account for the lack of association between lengths of ownership and calculator proficiency. If students had to complete projects or assignments on a calculator, they would have to become more proficient. To deal with equity issues, online simulator calculators are available that could be used at libraries.

Research Question 9

Does working in collaborative groups based on Vygotsky's social learning theories versus students working independently increase the performance level of students? The four week treatment period using Vygotsky's learning theory made an impact on the post-test scores and on the net gain scores of the treatment group. Students that were in the treatment group showed significantly higher post-test scores and significantly higher net gain in calculator achievement scores. Gender was a significant predictor in the linear regression model for post-test scores with treatment but was not significant for net gain in calculator achievement scores. Females in the treatment group also scored higher on all measures than students in the control group, though all differences were not statistically significant.

There are two factors that could account for the differences in learning between the control group and the treatment group. The arrangement of the class could account for part of the ability to learn. The treatment group was arranged in social learning groups for two classes and in four short lines in which the students had partners next to them in which they could collaborate or easily turn to and discuss if they were having a calculator problem. In the control group, the students were also in lines, but they were not close enough to have partners to work with and were not encouraged to do so. The second factor that could have contributed to the differences in learning was the socio-cultural learning methods.

Additional Analyses Findings

The mean pre-test Calculator Achievement Score of the Analyses Classes was significantly different from the mean pre-test Calculator Achievement Score of the Advanced Algebra and Trigonometry (AAT) classes. Most of the students in the AAT classes had qualified for Analyses, but chose to take AAT. On the Post Calculator Achievement Test, there was no significant difference in scores between the two classes. However, when comparing net gain in Calculator Achievement Test, the AAT students had a higher mean score than the Analysis students, and it was significant at $p < .0001$. AAT students also scored higher than Analysis students on multi-step calculations. There are two possible explanations for these phenomena.

Analysis students began the study with a higher mean Calculator Achievement Score. Therefore, it was harder for them to learn everything and make the same or a higher net gain score than the AAT students. Their scores were approximately normally distributed, so there was a wide range of scores. Also, three students from the two classes were failing, and it is possible that they did not put much effort in their post test. At least one person had a negative score, which could have impacted the net gain score of the group.

The second possible factor is motivation. The AAT students enjoyed using the calculators and learning more about them, so it is possible that this was the first year that they had gotten a lot of information and teaching regarding the calculator. They never verbally indicated they wanted to outscore the Analysis class, so this was an unexpected outcome, but it is likely that they were ready to learn, and like sponges they absorbed the knowledge – especially with the aid of the Vygotsy's learning theories.

Discussion of Findings

Bandura (1986) introduced the concept of self-efficacy as the belief that one is able to engage in a certain behavior successfully (Bandura, 1986). Self-efficacy affects behaviors, choices, goals, effort, persistence, learning and achievement (Bandura, 2001). Since Bandura introduced the concept of self-efficacy, the idea has broadened to include mathematics self-efficacy, computer self-efficacy and calculator self-efficacy (Cassidy & Eachus, 2002; Griffin, 2006; F. Pajares, 2005; F. Pajares, 1996a; F. Pajares, 1996b; F. Pajares & Miller, 1997; F. Pajares & Graham, 1999). This study was successful in adapting Griffin's Math and Technology Efficacy Survey to create a Calculator Self-Efficacy Survey (CES) that was internally consistent. This was accomplished by measuring the instrument for internal consistency for high internal consistency reliability (Huck, 2008). Reliability is defined across the parts of the survey in which the parts are considered to be the individual questions. According to Huck (2008), the extent to which they "measure the same thing" or "hang together" is known as internal reliability as evidenced by Cronbach's alpha. (p. 79) The Calculator Self-Efficacy Survey had a Cronbach's alpha of 0.8463 on the last administration which indicates that it has internal reliability.

Both the CES and the Calculator Achievement Test (CAT) were teacher constructed instruments that needed to have face-validity assessed. A panel of 15 high school experts evaluated both of the instruments for inter-rater reliability. One method to determine an index of inter-rater reliability is a percent-agreement measurement (Huck, 2008). Eight teachers returned the original surveys and there were no additions or deletions to the original CES, so there was 100% inter-rater reliability. Two teachers made suggestions that were accommodated before the next pilot of the CAT. The Calculator Self-Efficacy survey required the addition of three questions due to a change in the study, so a new panel of 20 teachers was obtained at the Georgia Council for Teachers of Mathematics. Four teachers indicated that one-step, two-step and multi-step equations needed to be elaborated, so though the percentage was high for inter-rater reliability, the change was made and a pilot study was administered to students. Both the CAT and the CES were administered, and there was 100% agreement on wording of the questions and face validity.

Females' views on the graphing calculator mirror what is found in the literature regarding their view of technology. The females in the study enjoy using the graphing calculator and see many practical applications for it. However, to females, the calculator is a tool, not a toy. This parallels the views of women toward technology in everyday life. Women position themselves differently with respect to technology (Kelan, 2007). For females, technology serves as a tool to be used, where for males, technology is a toy.

Girls reject violence and even in computer games make the game socially interactive by involving their peers (American Association of University Women, 2000; Walkerdine, 2006). This study confirmed that females view their calculators as tools. One student indicated that “some of the boys in my class use it (graphing calculator), but I don’t think they use it when they get home. Like they just use it in class because they are supposed to, but I don’t know if they use it at home, but I know I use it at home”. The females view the calculator as a vital tool in the learning process and embrace it, but it is not a toy to them. On gender equality with calculator achievement, one student said “They’re pretty equal but guys seem to enjoy it more and spend more time doing it, but if we learning in class, both genders can learn it equally”. This student recognized that females are equally capable and embraced the idea.

Calculator Achievement Test scores differed based on gender. This is a field that has little research because there is only one other calculator achievement or literacy test that was found in a literature review (Wu, 2004). Prior research indicates much research on calculators and achievement, but the study of gender is absent. In this study, there was a significant difference in the Post-Test Calculator Achievement Score with males scoring higher than females. Achievement can be measured in several ways. Females started with a mean score that was lower than the males’ mean score. When the net gain in Calculator Achievement Test score was measured, there was not a significant difference between the males and the females. The enigma is why are males scoring higher than females, and why aren’t females catching up to the males’ score? One factor that could contribute to this discrepancy is that the intervention period was brief. According to Wiegand (2007) stronger students learn calculator concepts very easily, but weaker students need more help and guidance. More help and guidance translates into more time. The addition of more time and practice could have resulted in higher post-test scores for the females.

Males and females are not performing equally, yet they are coming closer as these results indicate. There were five questions each for one-step, two-step and multi-step calculations. Two possible reasons could contribute to the difference in significance. The majority of students did well on one-step calculation problems. Males' and females' differences on multi-step problems barely met any definition of significance ($p = 0.05, \propto = 0.10$) but did show a significant difference on two-step calculator problems. This could be a curriculum sequencing issue. The multi-step problems were some of the last problems taught in context, so they were more easily recalled by students, while the two-step problems were a few weeks older. It is also important to note that on multi-step calculations, males scored higher than females, $p = .05$. A p-value in that range warrants further investigation. Also, when all problems that were not one-step problems were investigated, males scored significantly higher than females. As Forster (2006) noted, students must have technical understanding of the artifact (calculator) in great detail in conjunction with their contextual knowledge. A lack of time could have contributed to this factor.

Students' self-efficacy ratings were not consistent in most cases with their calculator achievement test. Two major factors could account for the inability of students to accurately predict their ability to complete certain levels of calculator tasks. According to Pajares & Miller (1997) students have difficulty with self-rating matching an open-ended test. Students have taken multiple choice tests for years and they are fairly accurate at rating their ability to complete problems that are part of a multiple choice test, but do not do as well when the test is an open ended test. Pajares (1997) recommended that students be informed prior to giving the efficacy survey that the subsequent test would be open ended. Students in this study were informed that all the calculator achievement test questions were open-ended. However, they still rated themselves higher than their actual performance when sub-scores were broken down.

The second factor deals with students' self-esteem. Some students have been using graphing calculators for several years. Just pushing the buttons on the main screen indicates to themselves that they know how to do all the problems. Therefore, they rate themselves higher than their actual capability. Secondly, in a previous study, I had a student who told me she knew everything about the calculator (D. , 2008). Invariably when I was teaching something new on the calculator, if she got lost, she would jump up out of her seat and run to the front of the classroom to get me to help her. Helping students understand the mechanics of the calculator does not guarantee that they will be successful in understanding all of the syntax and commands (Forster, 2006). The graphing calculator involves processes and procedures, as well as the interpretation of commands (Forster, 2006). Students must know the mathematics and connect the mathematics to the calculator to be successful.

The graphing calculator has become a tool for learning, and though available as classroom sets, many students purchase their own so they may use them at home. Length of ownership had no significant relationship to any factors. Had this study occurred in a different location in which most students do not have access to a graphing calculator, the results might differ. The majority of the students owned their own calculator and used them on a daily basis for school work, including work in other classes such as science.

The treatment group was organized according to Vygotsky's social learning theory, and their results on the post-test and on the net gain on calculator achievement were statistically significant as compared to the control group. This statistically significant result was for all students, meaning males and females in the treatment group saw an increase in their scores. All students are social, yet to move past the social plane and to the internalization of knowledge, a student must reach the Zone of Proximal Development in which a child's knowledge is able to develop beyond which it would have developed without the aid of a more knowledgeable other (M. Goos et al., 2002; Harvey & Charnitski, 1998; Penuel & Wertsch, 1995). Students learn through discourse in the socio-cultural environment. This may initially take place with the teacher or with another student. As a student becomes more comfortable, he or she may serve as a more knowledgeable other in a partner or social group format, allowing a student to reach a level of knowledge previously not possible. Females have often indicated they learn better in groups due to the social format (El-Haj, 2003). This does not preclude that males learn in a social environment, and the social environment, though not used often, is a supportive environment in which to learn methods of technology, provide support, and allow for technical expertise (Forster, 2006).

Limitations of Findings

This study is limited by the demographics of the school in which the study took place; a school whose student body is not well diversified and whose socioeconomic status are not representative of students nationally. Students who participated in the study were juniors and seniors in either Advanced Algebra and Trigonometry or Honors Analysis for the current study, so many students did not qualify for the study. The sample size of 67 is considered a small sample size which is also a limitation of the study.

The principal researcher conducted the quasi-experimental study in her classroom and another teacher served as the control. The use of two teachers is also a limitation. If multiple teachers were used, the study could have been more diverse, but that could not be achieved for this study.

Recommendations

Implications for Teachers in the Local Context

Females are still lagging behind in calculator achievement, though they have made progress. Females exhibited success in single-step and some multi-step problems, but were significantly different from males on two-step calculations. The growth trajectory of females is about the same as that of males, so the problem is to create a way to increase the slope of the growth trajectory for females. They have the ability to learn, but their mean pre-test score was lower than males, so with the same growth rate, teachers must find a way to help them learn more. Possible ways to increase females' proficiency include spending more time helping them, assigning partners that are more calculator proficient and creating study sessions before and after school. Assigning homework that requires the use of the calculator with regularity is also important. It would be necessary to give students the opportunity to work on this homework in class, during their lunch or before/after school if they don't own a calculator. Also, having a class set of graphing calculators that the students are expected to use daily in class will add to their calculator fluency, even if they do not own a calculator to use at home.

The use of Vygotsky's learning theory which allows for discourse with a more knowledgeable other, in partners and in social learning groups is a critical component for learning how to use the calculator. This research contradicted other research (Orhun, 2005) which indicated learning styles did not contribute to mathematics achievement. However, this was calculator achievement using mathematics problems. The discourse involved students either in pairs or groups and was very successful in helping students learn more about the calculator. Students did not feel like someone was observing them, and they easily had someone at their disposal to ask a question if they could not get something to work on the calculator. One very important factor in creating the groups is to be aware of the students in the groups. It is critical to have at least one student who is calculator fluent in each group, or who learns new functions on the calculator very easily. Teachers must also be available to walk around and help the groups and check their work as well as ensure that no one is entering data or doing the work for another student. Well-meaning students can often make that mistake as well.

Teachers often fear change, yet it is critical to note that inequities exist with women and calculator knowledge. Patience in teaching females and making a classroom environment "woman-friendly" so that students feel comfortable asking questions and learning to use the calculator is critical for them to become fully proficient in its use (Elder, 2001; Holden, 1993). It is also necessary for teachers to give substantive feedback and help on calculator practice. Learning to pause and give students time is critical when learning calculator skills. Being flexible and allowing the use of social learning and different learning modalities helps all students. Recognizing the unique differences of all students will empower the students to learn, grow and be all they can be.

Implications for Leadership

The leadership of schools can provide time and funding for teachers who are not comfortable working with calculators to attend workshops so that they may become proficient with the calculators. Release time so that teachers can observe other teachers effectively using technology with female students is also an important activity. Planning after school or before school study sessions for girls to learn calculator functions would be a first step as well. Girls are often intimidated by boys or those who answer very quickly, and they cannot process how to operate the calculator under those circumstances or get the needed support.

A workshop on Vygotsky's social learning theory and how to apply it to the mathematics classroom and to graphing technology is also critical. There are many students in every school who are calculator proficient. There are also many teachers who are not. Teachers need to learn to handle that situation and learn to respect and use those students to help them help other students. No one will ever know everything so it is in the best interest of all students to harness the knowledge of those students in cooperation with the teacher to provide help to other students in a social learning setting. In a well-managed situation, students learn the mathematical context as well as how to use the calculator and one has created a win-win situation.

Implications for Mathematics Education

Recognizing the power of social-learning theory on helping students grasp calculator proficiency is critical in implementing new standards. NCTM (2008) created standards that included the use of multiple representations in teaching pedagogy. The addition of multiple methods of presentation so that all learners have equal access to technological training is an important facet of this study. Socio-cultural learning was significant for females in that all sub-scores for females in the treatment group were higher than in the control group, though they were not all statistically significant. However, socio-cultural learning produced statistically significant responses that were higher than the control group, so it should be considered as a recommendation for teaching in mathematics and using graphing technology. Many students, especially females, feel ill equipped to operate calculators, and the use of the social-learning groups helps overcome this fear.

Recommendations for Further Research

1. This was a small study involving only two teachers and one school which limits the generalizability of the study. It is recommended to expand the study to a more diverse population including more schools and more teachers. A Vygotskian Scale Test could be created to determine the style of the teacher based on "social learning" before dividing the teachers into control or treatment groups. Those teachers who score high using Vygotskian techniques would serve as the Vygotsky's learning theories group, and the other teachers would serve as the control. Vygotsky's learning theories teachers would be taught the premises of the theories to ensure that the classroom was based on Vygotsky's theories. All teachers would be trained or selected based on their

abilities to work with the TI-84+ calculator and would be trained on the questions to be taught in context.

2. A further recommendation would be to complete this study as a longitudinal study that begins in the fall semester so that the investigator can better determine the growth trajectories of the males and females. It would also allow a better understanding of how much students grow over the period of months instead of weeks and can provide greater information to the researcher about the treatment and its results.
3. A qualitative questionnaire of 5 – 8 questions should be asked at the end of the treatment period so the voice of the males and the females can be heard directly. The researcher is interested in how students felt about the treatment as well as the thoughts of males and females about the use of graphing calculators in general. Though the researcher had taken qualitative data early, it was not a part of this study, and rich information can be obtained from student qualitative data.

Summary

The findings of this study expanded upon the study of previous researchers studying technology and women (Cooper, 2006; Kelan, 2007). Females generally indicate less mastery of certain functions on the computer, though they are computer literate with internet usage and cell phone applications. The graphing calculator is an extension of technology, but this research is seminal in that it specifically measures the capability of males and females in calculator achievement and efficacy. A major difference the study indicated was that males were more proficient at two-step calculations than females. Males also had a higher correlation between their efficacy rating for writing a calculator program and their ability to complete the task than females did. There was weak support for a relationship between the calculator efficacy score and the calculator achievement score, possibly due to the test being open ended (Pajares & Miller, 1997).

A striking result of the study was that working in partner or learning groups was helpful to both males and females in the calculator achievement score and net calculator gain. Studies typically indicate that learning styles do not affect achievement, and most of these studies are about mathematics, but this result does contradict a most recent study (Orhun, 2007). The discourse and the ability to work with a more knowledgeable peer seemed to help students overcome problems they were having with learning the technical aspects of the calculator. Even more importantly, the females did very well in these groups and outscored the control group on all components.

Education is constantly undergoing change, but Vygotsky's theory is not new (Vygotsky,1986). This study indicates that the use of Vygotsky's theory can help create gender equity with the use of technology – an area in which females feel most uncomfortable (Cooper, 2006; Forgasz & Griffith, 2006; Kaino & Salani, 2004). Though females did not score equally with males on all domains, this study showed an improvement over a previous study in which females had difficulty with anything that had two-steps or multi-steps. Integrating Vygotsky's learning theory into the classroom while teaching in context may help students learn the technological skills as well as sharpen other mathematical skills. More research is needed in this area to determine the full effects of the use of these theories on both males and females.

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APPENDIX A

QUALITATIVE INTERVIEW PROTOCAL

STUDY 1

1. What part(s) of the calculator achievement test did you find to be the easiest to complete?

2. Were there any part(s) that surprised you as easier than you expected?

3. What part(s) of the calculator achievement test did you find to be the hardest to complete?

4. How would you describe the importance of calculators in mathematics?

5. Is there a function or aspect of the calculator that you would have desired to be on the test but was not?

6. How well would you rate your own calculator achievement?

APPENDIX B

Focus Group Question Protocol

1. Tell me your thoughts about the use of calculators in mathematics.
2. Explain what you commonly use your calculator for.
3. What functions or processes, if any, did you have difficulty with? Why?
4. Describe your beliefs about your performance using a graphing calculator in comparison with other students.
5. Do males ask an equal number of questions about how to perform calculator functions as females?
6. Describe your calculator performance in comparison with most males in your classroom.
7. If you think one gender outperforms another, explain why. What is your belief based on?
8. How would you rate your own calculator fluency on a scale of 1 (not so good) to 10 (Excellent) and why?

APPENDIX C

INFORMED CONSENT FORMS

CONSENT FORM 2010

I agree for _______________________ to participate in the research project entitled **Calculator Efficacy and Achievement**, which is being conducted by Debbie Kohler, Doctoral Student at Kennesaw State University and Mathematics Teacher at Sequoyah High School, 4485 Hickory Rd. Canton, GA 30115, 770-345-1474. I understand that this participation is voluntary; I can withdraw my consent at any time and have the results of the participation returned to me, removed from the experiment or destroyed.

The following points have been explained to me [and my child]:

1. The reason for the research is to determine if real or perceived gender differences exist in calculator achievement.

2. The procedures are as follows: (1) Students will complete a background information sheet including grade and how long they have owned a calculator (if at all). (2)They will also complete a 13 question survey on the same day. (3) Students will be instructed and trained on specific skills using their calculator. The teacher will do this with the aid of TI-Smartview. All calculator skills are embedded in the curriculum content of the course. (4) A calculator fluency survey will be given. All data will be destroyed at the conclusion of this study, which is longitudinal, and should be complete by 2012.

3. Participation in this study contains no known discomforts or stresses.

4. Participation in this study contains no known risks.

5. The results of this participation will be confidential and will not be released in any individually identifiable form without the prior consent of the participant unless required by law. A code will be assigned to each student and put on the calculator efficacy survey and on the calculator survey. Since they will be given at different times, a list of names will be kept with the codes until after the second survey is given. When the second survey is given, the list will be shredded. This cross-reference will be kept in a locked cabinet.

6. The purpose of this research has been explained and my participation is entirely voluntary. I have the right to stop participation at any time without penalty. Participation in this study does not bear on any grade for any course taken throughout the doctoral program. I understand that the research entails no known risks and that my responses are not being recorded in any individually identifiable form with the exception of one videotaped exit interview, the evidence of which will be destroyed within one year's time of taping. By anonymously completing this survey, I am agreeing to participate in this research project.

____

Signature of Investigator, Date

____

Signature of Participant [or authorized representative], Date

PLEASE SIGN BOTH COPIES, KEEP ONE AND RETURN THE OTHER ONE TO THE INVESTIGATOR

Research at Kennesaw State University that involves human participants is carried out under the oversight of an Institutional Review Board. Questions or problems regarding these activities should be addressed to Dr. Ginny Q. Zhan, Chairperson of the Institutional Review Board, Kennesaw State University, 1000 Chastain Road, #2202, Kennesaw, GA 30144-5591, (770) 423-6679.

CONSENT FORM- Calculator Efficacy and Achievement

I agree for ________________________ to participate in the research project entitled **Gender and Calculator Efficacy**, which is being conducted by Debbie Kohler, Doctoral Student at Kennesaw State University and Mathematics Teacher at Sequoyah High School, 4485 Hickory Rd. Canton, GA 30115, 770-345-1474. I understand that this participation is voluntary; I can withdraw my consent at any time and have the results of the participation returned to me, removed from the experiment or destroyed.

The following points have been explained to me [and my child]:

1. The reason for the research is to determine if real or perceived gender differences exist in calculator efficacy.

2. The procedures are as follows: (1) Students will complete a background information sheet including grade and how long they have owned a calculator (if at all). (2)They will also participate in a 15 – 20 minute focus group. (3) Students will be instructed and trained on specific skills using their calculator. The teacher will do this with the aid of TI-Navigator. All calculator skills are embedded in the curriculum content of the course. (5) Six to eight females will be chosen at random to be interviewed. All data will be destroyed by shredding at the conclusion of this study, which is longitudinal, and should be complete by 2010.

3. Participation in this study contains no known discomforts or stresses.

4. Participation in this study contains no known risks.

5. There are no specific benefits to participation in the study.

6. The results of this participation will be confidential and will not be released in any individually identifiable form without the prior consent of the participant unless required by law. A code will be assigned to each student and a pseudo-name will be used in survey results.

7. The purpose of this research has been explained and my participation is entirely voluntary. I have the right to stop participation at any time without penalty. Participation in this study does not bear on any grade for any course taken throughout the doctoral program. I understand that the research entails no known risks and that my responses are not being recorded in any individually identifiable form with the exception of one videotaped exit interview, the evidence of which will be destroyed within one year's time of taping. By anonymously completing this survey, I am agreeing to participate in this research project.

___________________________________ ___________________________________

Signature of Investigator, Date Signature of Participant [or authorized representative], Date

PLEASE SIGN BOTH COPIES, KEEP ONE AND RETURN THE OTHER ONE TO THE INVESTIGATOR

Research at Kennesaw State University that involves human participants is carried out under the oversight of an Institutional Review Board. Questions or problems regarding these activities should be addressed to Dr. Ginny Q. Zhan, Chairperson of the Institutional Review Board, Kennesaw State University, 1000 Chastain Road, #2202, Kennesaw, GA 30144-5591, (770) 423-6679.

CONSENT FORM- Females and Calculator Efficacy

I agree for __________________________ to participate in the research project entitled **Females and Calculator Efficacy**, which is being conducted by Debbie Kohler, Doctoral Student at Kennesaw State University and Mathematics Teacher at Sequoyah High School, 4485 Hickory Rd. Canton, GA 30115, 770-345-1474. I understand that this participation is voluntary; I can withdraw my consent at any time and have the results of the participation returned to me, removed from the experiment or destroyed.

The following points have been explained to me [and my child]:

1. The reason for the research is to determine if real or perceived gender differences exist in calculator efficacy.

2. The procedures are as follows: (1) Students will complete a background information sheet including grade and how long they have owned a calculator (if at all). (2)They will also participate in a 15 – 20 minute focus group. (3) Students will be instructed and trained on specific skills using their calculator. The teacher will do this with the aid of TI-Navigator. All calculator skills are embedded in the curriculum content of the course. (5) Six to eight females will be chosen at random to be interviewed. All data will be destroyed by shredding at the conclusion of this study, which is longitudinal, and should be complete by 2010.

3. Participation in this study contains no known discomforts or stresses.

4. Participation in this study contains no known risks.

5. There are no specific benefits to participation in the study.

6. The results of this participation will be confidential and will not be released in any individually identifiable form without the prior consent of the participant unless required by law. A code will be assigned to each student and a pseudo-name will be used in survey results.

7. The purpose of this research has been explained and my participation is entirely voluntary. I have the right to stop participation at any time without penalty. Participation in this study does not bear on any grade for any course taken throughout the doctoral program. I understand that the research entails no known risks and that my responses are not being recorded in any individually identifiable form with the exception of one videotaped exit interview, the evidence of which will be destroyed within one year's time of taping. By anonymously completing this survey, I am agreeing to participate in this research project.

____________________________________   ______________________________________

Signature of Investigator, Date   Signature of Participant [or authorized representative], Date

PLEASE SIGN BOTH COPIES, KEEP ONE AND RETURN THE OTHER ONE TO THE INVESTIGATOR

Research at Kennesaw State University that involves human participants is carried out under the oversight of an Institutional Review Board. Questions or problems regarding these activities should be addressed to Dr. Ginny Q. Zhan, Chairperson of the Institutional Review Board, Kennesaw State University, 1000 Chastain Road, #2202, Kennesaw, GA 30144-5591, (770) 423-6679

APPENDIX D

GRAPHING CALCULATOR EFFICACY SURVEY 1

GRAPHING CALCULATOR EFFICACY SURVEY

This questionnaire asks if you agree or disagree with several statements about using technology in mathematics. Your questionnaire answers will be confidential, so please answer honestly.

---

1. Using technology like computers and graphing calculators makes learning more interesting.

Strongly Disagree | | | | Strongly Agree

1 2 3 4 5 6

---

2. Other students usually come to me for help with the graphing calculator.

Strongly Disagree | | | | Strongly Agree

1 2 3 4 5 6

---

3. I need a lot of help when doing new things using technology like the computer or graphing calculator.

Strongly Disagree | | | | Strongly Agree

1 2 3 4 5 6

---

4. I think working with computers and calculators is very frustrating.

Strongly Disagree | | | | Strongly Agree

1 2 3 4 5 6

---

5. I am capable of writing a program for the graphing calculator that will do something I would otherwise have to do by hand in math class.

Strongly Disagree | | | | Strongly Agree

1 2 3 4 5 6

---

6. I am comfortable with computers.

Strongly Disagree Strongly Agree

1 2 3 4 5 6

7. I am comfortable with graphing calculators.

Strongly Disagree Strongly Agree

1 2 3 4 5 6

8. I am capable of producing a graph using a graphing calculator and adjusting the window so the entire graph is visible.

Strongly Disagree Strongly Agree

1 2 3 4 5 6

9. I am capable of finding the roots of an equation using a graphing calculator.

Strongly Disagree Strongly Agree

1 2 3 4 5 6

10. I will probably choose a career that requires me to know a lot about computers and computer programming.

Strongly Disagree Strongly Agree

1 2 3 4 5 6

APPENDIX E

DR. GRIFFIN’S MATHEMATICS AND TECHNOLOGY

EFFICACY SURVEY

MATH AND TECHNOLOGY QUESTIONNAIRE

This questionnaire asks you if you agree or disagree with several statements about doing math and using technology. Your questionnaire answers will be kept confidential. Please give honest answers.

---

1. I have the ability to do well in math classes.

Strongly Disagree					Strongly Agree
1	2	3	4	5	6

---

2. I understand most of the topics I study in math class.

Strongly Disagree					Strongly Agree
1	2	3	4	5	6

---

3. Math is my most difficult subject.

Strongly Disagree					Strongly Agree
1	2	3	4	5	6

---

4. I need a lot of help when doing new things using technology like the computer or graphing calculator.

Strongly Disagree					Strongly Agree
1	2	3	4	5	6

---

5. I usually like to do math problems.

Strongly Disagree					Strongly Agree
1	2	3	4	5	6

---

6. Other students usually come to me for help in math.

Strongly Disagree					Strongly Agree
1	2	3	4	5	6

---

7. Other students usually come to me for help with the graphing calculator.

Strongly Disagree					Strongly Agree
1	2	3	4	5	6

---

8. I can usually find and correct my own errors in a math problem.

Strongly Disagree					Strongly Agree
1	2	3	4	5	6

9. In high school, I want to take the least amount of math that is required.

Strongly Disagree					Strongly Agree
1	2	3	4	5	6

10. Using technology like computers and graphing calculators makes learning more interesting.

Strongly Disagree					Strongly Agree
1	2	3	4	5	6

11. I think working with computers and graphing calculators is very frustrating.

Strongly Disagree					Strongly Agree
1	2	3	4	5	6

12. I am capable of writing a program for the graphing calculator that will do something I would otherwise have to do by hand in math class.

Strongly Disagree					Strongly Agree
1	2	3	4	5	6

13. I am comfortable with computers.

Strongly Disagree					Strongly Agree
1	2	3	4	5	6

14. I will probably choose a career that requires me to know a lot of math.

Strongly Disagree					Strongly Agree
1	2	3	4	5	6

15. I will probably choose a career that requires me to know a lot about computers and computer programming.

Strongly Disagree					Strongly Agree
1	2	3	4	5	6

APPENDIX F

PERMISSION FROM DR.GRIFFIN TO USE MATH

AND TECHNOLOGY EFFICACY SURVEY

Linda B. Griffin - Dissertation Inbox | X

Debbie Kohler to Robert.Fallows — show details 10/27/07 Reply

Dr. Fallows:

I am a doctoral student in Mathematics Education at Kennesaw State University in Kennesaw, GA. I am interested in studying gender and calculator operation ability and efficacy, and I found Linda Griffin's disseration through a dissertation search. I would like to possibly adapt her efficacy survey to use for an action research project this spring. Do you have any method that I may reach her?

Thanks so much!

Debbie Kohler
EdD Student
Kennesaw State University
Mathematics Teacher
Sequoyah High School
Canton, GA 30115
770-345-1474

Reply Forward

Robert Fallows to **Linda**, me — show details 10/29/07 Reply

I am sending a copy of your e-mail to Linda, knowing her I think that she will be pleased to share with you.

- Show quoted text -

Reply Reply to all Forward

from **Linda Griffin** <lindabgriffin@comcast.net> — hide details 10/29/07 Reply
to Robert Fallows <Drfallows@msn.com>,
Debbie Kohler <dkohler88@gmail.com>
date Mon, Oct 29, 2007 at 10:24 PM
subject RE: Linda B. Griffin - Dissertation
mailed-by comcast.net

Debbie,

I am pleased to know that my survey instrument might be of use to you. I have attached a copy to this message. Best wishes to you.

Linda

From: Robert Fallows [mailto:Drfallows@msn.com]
Sent: Monday, October 29, 2007 1:24 PM
To: Debbie Kohler
Cc: Linda Griffin
Subject: Re: Linda B. Griffin - Dissertation
- Show quoted text -

APPENDIX A.doc
35K View Download

Reply Reply to all Forward

APPENDIX G

CALCULATOR AND SELF-EFFICACY SURVEY 2

2010

GRAPHING CALCULATOR SURVEY ID ______________________

This questionnaire asks if you agree or disagree with several statements about using technology in mathematics. Your questionnaire answers will be confidential, so please answer honestly. (For ID, use your period, first two letters of your last name, and last 4 digits of your student number).

---

1. Using technology like computers and graphing calculators makes learning more interesting.

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

---

2. Other students usually come to me for help with the graphing calculator.

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

---

3. I need a lot of help when doing new things using technology like the computer or graphing calculator.

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

---

4. I think working with computers and calculators is very frustrating.

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

---

5. I am capable of completing accurately calculator tasks that involve only one step.

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

---

6. I am capable of writing a program for the graphing calculator that will do something I would otherwise have to do by hand in math class.

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

---

7. I am capable of completing accurately calculator tasks that involve two steps or step and a sub-menu. (Two step problems require a sub-menu not accessible on the main buttons of the calculator).

Strongly Disagree — Strongly Agree

1 2 3 4 5 6

8. I am comfortable with computers.

Strongly Disagree — Strongly Agree

1 2 3 4 5 6

9. I am comfortable with graphing calculators.

Strongly Disagree — Strongly Agree

1 2 3 4 5 6

10. I am capable of producing a graph using a graphing calculator and adjusting the window so the entire graph is visible.

Strongly Disagree — Strongly Agree

1 2 3 4 5 6

11. I am capable of finding the roots or zeros of an equation using a graphing calculator.

Strongly Disagree — Strongly Agree

1 2 3 4 5 6

12. I am capable of accurately completing a calculator activity that involves multiple steps, or multiple screens. (Definition - Multiple step problems require sub-menus not accessible on the main buttons of the calculator. They must be accessed through pushing multiple keys and accessing multiple menus).

Strongly Disagree — Strongly Agree

1 2 3 4 5 6

13. I will probably choose a career that requires me to know a lot about computers and computer programming.

Strongly Disagree — Strongly Agree

1 2 3 4 5 6

APPENDIX H

CALCULATOR ACHIEVEMENT TEST VERSION 1

CALCULATOR ACHIEVEMENT TEST

Please work the following questions using your graphing calculator. Indicate your keystrokes as well as your answer. Work each answer as completely as possible.

---

1. Evaluate: $\frac{4 \bullet 2 + 6}{5 - 3}$

ANSWER_______________

---

2. .Find the determinant using your calculator.

$$\begin{vmatrix} -3 & 2 & 4 \\ 1 & 6 & 3 \\ 5 & 4 & -2 \end{vmatrix}$$

ANSWER_______________

---

3. Find $\csc\left(\frac{3\pi}{5}\right)$ to 2 decimal places.

ANSWER_______________

---

4. Evaluate the expression using your calculator if x = -4 and y = 3.

$$\frac{3x}{x^2 - 2y}$$

ANSWER_______________

---

5. Solve the following system for y only using your calculator.

$-x - 3y + z = 54$
$4x + 2y - 3z = -32$
$2y + 8z = 78$

ANSWER_______________

6. Convert to degrees, minutes and seconds. 126.78°

ANSWER_______________

7. Convert to decimal form: $237^{\circ}28'44''$.

ANSWER_______________

8. Find the zeros of the function: $f(x) = 3x^2 - 7x - 15$

ANSWER_______________

9. Find a window that shows the entire graph of the following function:

$$f(x) = 2x^5 - 2x^4 - 62x^3 + 50x^2 + 300x$$

Xmin__________
Xmax__________
XScl___________
Ymin__________
Ymax__________
YScl___________
ANSWER_______________

10. Solve. Give your answer in degrees cos(x) = .348 [0, π/2]

ANSWER_______________

11. Solve. Give your answer in radians. tan(x) = 3.85 [0, π/2]

ANSWER_______________

12. Evaluate $\arcsin\left(\frac{\sqrt{5}}{4}\right)$.

ANSWER_______________

13. Solve for x: $3^{x+2} = 5^x$

ANSWER_______________

14. Evaluate: $\ln\left(\frac{3}{.28}\right)$

ANSWER_______________

15. Solve the following equation using your calculator. Write down the keys you entered to get your answer.

$x^5 - 7x^3 + 8 = 0$

ANSWER_______________

16. Evaluate: $\frac{8!}{4!(8-5)!}$

ANSWER_______________

17. Using your calculator, find Quartile 1 of the following set of grades:

86, 99, 65, 80, 75, 60, 89, 92,86

ANSWER_______________

18. Write a calculator program that will find the determinant for a 2 x 2 matrix A.

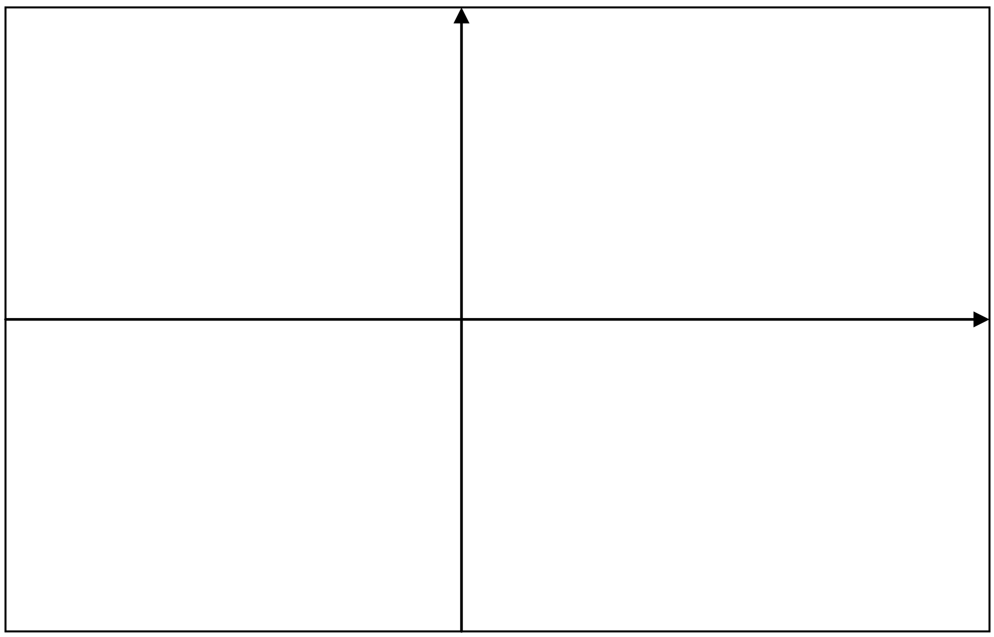
$$A = \begin{vmatrix} a & b \\ c & d \end{vmatrix}$$

Determinant = ad – bc (Use this formula to write your program.)

List the steps of your program below. The teacher will also run the program after the test to check it. Name your program by the test code name on the front of this test.

19. Sketch a graph of the following function for one full period:

$f(x) = 0.2x^3 - 4x^2 -.78x -18$



xMin_____________ YMin____________

xMax____________ YMax___________

20. Simplify with the calculator $(3 + 2i)^3$

Answer________________

APPENDIX I

CALCULATOR ACHIEVEMENT TEST VERSION II

2010

ID____________________
(Period, first 2 letters of last name & last 4 digits of student number)

CALCULATOR ACHIEVEMENT TEST 2010

Please work the following questions using your graphing calculator. Work each answer as completely as possible.

---

1. Evaluate: $\frac{54 \bullet 22 + 6}{30 - 32}$

ANSWER_______________

---

2. Find $\csc\left(\frac{3\pi}{5}\right)$ to 2 decimal places.

ANSWER_______________

---

3. Solve the following system for y only using your calculator

$-x - 3y + z = 54$
$4x + 2y - 3z = -32$
$2y + 8z = 78$

ANSWER_______________

---

4. Convert to degrees, minutes and seconds. 126.78°

ANSWER_______________

---

5. Find a window that shows the entire graph of the following function:

$f(x) = 2x^5 - 2x^4 - 62x^3 + 50x^2 + 300x$

Xmin__________
Xmax__________
XScl___________
Ymin__________
Ymax__________
YScl___________

---

6. Find the smallest minimum: $f(x) = x^4 - 2x^3 - 9x^2 + 2x + 8$

ANSWER_______________

---

7. Solve. Give your answer in degrees cos(x) = .348 [0, 90 degrees]

ANSWER_______________

---

8. Solve for x: $3^{x+2} = 5^x$

ANSWER________________

---

9. Evaluate: $\ln\left(\frac{3}{.28}\right)$

ANSWER________________

---

10. Find the partial sum.

$$\sum_{i=3}^{23}(24 - 4i)$$

ANSWER_______________

11. Using your calculator, find the sample standard deviation of the following set of grades:

86, 99, 65, 80, 75, 60, 89, 92, 86

ANSWER_______________

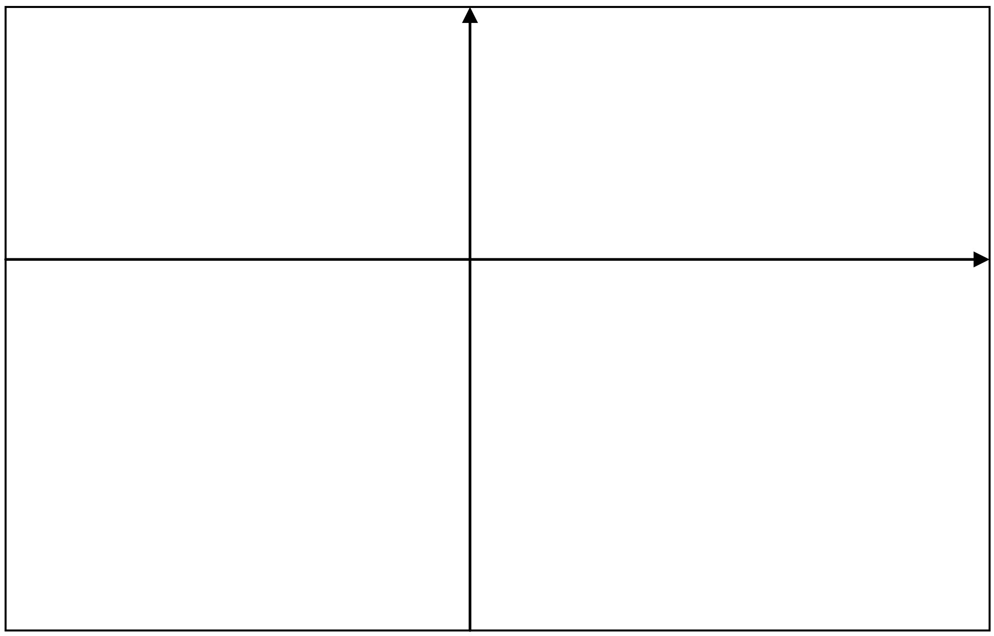
12. Write a calculator program that will find the slope between any two points. The program should display the slope.

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$

List the steps of your program below. The teacher will also run the program after the test
to check it. Name your program by the test code name on the front of this test.

13. Sketch a graph of the following function that displays the entire graph. Please give the window.

$f(x) = 0.2x^3 - 4x^2 -.78x -5.8$



xMin____________ YMin___________

xMax___________ YMax__________

---

14. Simplify with the calculator $\frac{3+2i}{4-5i}$

Answer_______________

---

15. Find the least squares regression line for the following data:

Number of gallons	6	8	10	11
Number of miles	144	243	275	286

Answer_______________

APPENDIX J

AUTOETHNOGRAPHIC NARRATIVES

AUTO-ETHNOGRAPHIC NARRATIVES

Lynn

Lynn was a very happy young lady and did very well in class, but had a poor self concept with calculators. She owned one, but the main thing that she did with it was punch the buttons that were on the main keypad. In my class, we constantly move past the first level into higher level skills, so when we were working on this study, we were trying to find the intersection of two different equations. Something that is very common among females happened. She got lost and gave up. I finished the instructions and asked who needed help and went over to her. She promptly handed her calculator to me, and I did not accept it. I nicely told her I would guide her through what to do, so I sat down beside her and told her each button to push so that she would know what to do.

One of the biggest mistakes that teachers make (including me) with females is the quickest and easiest solution. You literally take the calculator from the student, and "show them" how a calculator activity is done while they are watching. Inherently, they are not able to digest that information because it is not their hands and they are not involved in the activity. For those students to understand and comprehend, they must be the ones involved in the motion. The hardest lesson for me was to learn to keep my hands to myself and to let my voice do the guidance!

During this study, when my students were working in groups and I was supervising them, I had to watch carefully to make sure that other students did not do the same thing. I gently reminded them to guide the other student on how to do it but to please allow the student to do the entire process with guidance. Students certainly wanted to help, but I had to help students learn how to help each other.

Donna

I started this year with an unruly class, but specifically with a very bright young lady that could be called a maverick leader. With the proper direction and guidance, she could be a positive influence to her peers. As it was, she was loud, rowdy and negatively influenced the class. Prior to my class, I had the feeling she had been allowed to be boisterous and rule the class, and that was not going to work for me. I needed her in my class because she was one of the two smartest students and could be very helpful. There was one problem. She hated graphing calculators. She wanted to be a teacher, but I had great difficulty convincing her that she needed to know how to operate the graphing calculator before she left high school. Donna fought me for a long time. I have a class set of calculators that students are allowed to use every day, and I even offered Donna a calculator to take home at night – a calculator to borrow for the rest of the year. It took a long time – two or three months, and a lot of convincing, but Donna finally took the calculator. I explained that the State Department of Education had provided these calculators to sixth grade teachers so that students could use them for exploratory purposes. Even if she planned to teach middle school, she needed to learn how to use it. The learning curve was steep. Donna called me over often, but she was also independent. She worked hard at following me as I taught using the Smart-view on screen calculator, and she would try on her own before she finally gave in and asked for help. Yet she also learned when it was time to ask for help and when it was time to use the graphing calculator. For Donna, there were no frivolous calculations. The calculator was used for hard-core work. She still used her brain for mental math. When she called me over, she was different. She didn't hand her calculator over and say "Do it." Her question was, "Show me how." Soon she was helping her peers use the calculator as well by being a leader.

Giving Up

I'm in the middle of teaching, and I've demonstrated how to solve a 3 X 3 matrix equation using the graphing calculator using the TI-Smart view. Many pauses were apparent to allow students time to "catch up" to me, and often I would erase what I had done and start over to allow those who did not get it the first time to have the opportunity to learn. The mathematical concepts were integrated with the calculator concepts. I would also stop and walk around the room and help out as well. Actually, students were shown the theory initially and solved a system of three equations by hand without matrices. The addition of the graphing calculator was allowing the students to see another method of solving a system of three equations that could be quicker and would allow them to check their work even if they were required to show all of the steps analytically. As we finished the first problem, I identified a problem for the students to work. They were allowed to work with one another and talk about what to do in the calculator, but each student had to produce a solution. At one point in the period, I noticed that Sasha, a student from another country, did not appear focused. I went over by her side and talked to her. "What's up?" She answered and said she just did not remember what do on the calculator. "I cannot do this – it is so many steps." She proceeded to give me her calculator, though I did not take it from her. Sasha was a smart young lady, but due to her circumstances, she had little to no experience with a graphing calculator, though she presently owned one. I patiently sat with her and pointed out each step to guide her through the processes that she needed to take in order to find the solution. Students in her situation may be very capable, but they need a buddy or a more capable partner that can constantly work with them to give them the skills and self-confidence that they need in order to be successful in their calculator fluency skills.

I Hate this Calculator!

As project assignment for my Honors Algebra II course, I assigned them a Multi-Dimensional Graphing Pictures Project. The students had to sketch on graph paper a picture that they could write the equations for, and it could not be centered at (0,0). All conics had to be included which meant parabolas, hyperbolas, ellipses and circles. I also expected logarithmic and exponential functions as lines with all types of slopes. Domain and range had to be given for all of the graphs. Their first step was to write the equations for the functions and determine the restrictions on the domain and ultimately the range. Next we learned how to write a program that would produce the picture in the calculator. The more detailed and creative pictures earned the most credit. Students had to also create a poster of their screen shot from the calculator, color it, and include the program on the poster. This was a process that took a couple of months and even the boys that typically were nonchalant in class participated and got involved. But there were some whiners! The small little screen on the calculator produces problems because it only has so many pixels, so though the student has a correct equation, sometimes it wouldn’t draw the complete graph due to a limited number of pixels and the students would have to problem solve to create a solution in order to get their picture. Many came to me for help and I offered suggestions and told them they had to be smarter than their calculator. The day that the students turned in their final products was one of the most memorable days of my teaching career. One of my best students (who also complained the most) said the following two statements together, “I hated this project.” He then followed that statement with a big smile and the following statement, “I learned so much about the calculator!” Ross is brilliant and was finally challenged just a little bit and I think he was shocked.

Will

Will came to me after having a rough year in his previous class. He started the year with very few smiles and had difficulty completing his work. When those B’s came, I’d see a glimmer of hope and a faint smile. He was very shy. Then I brought out the calculators. Will knows how to work on calculators, and he has no problems helping others. If I taught a concept, and I could not get to everyone, as soon as I had checked off Will’s ability to accurately complete the concept, I could count on him to help me help others. I could also count on a huge smile. Programming is the hardest skill for students to master. Will knew how to program the calculator – a multi-step concept – before I taught it. Though I had to fine tune it for him so that anyone could pick up his calculator and understand how to run his program, he was a great programmer. Will could help his group and finish with them and move on to help another group. One day I went to the assistant principal and asked her if I could send Will to our alternative school trailer to help a student who had been there for eight days. She was a nice student that had something bad happen, and she needed help. I was given the approval and I talked to Will. He was ecstatic! I gave him his assignment – he was to teach this student how to program her calculator and review a couple of items with her that would be on the final.

He came back at the end of the period and asked me if he could go back the next day. He was doing so well in my class that I could not say no. He had progressed from shy and withdrawn to a leader and his calculator skills and confidence had led to that.

Are Boys Better Than Girls on the Calculator and if so, Why?

I posed this question to some of my girls, and the answers were quite interesting. Only two students felt like boys and girls rated equally on the calculator. Most of the girls felt like boys were better. When I asked why, they indicated that boys enjoy calculators more because they play computer games, and a calculator is similar to a computer. They also indicated that not as many girls participated in computer games as boys did. Girls said that boys knew more of the shortcuts and they are more mechanical and high tech, and maybe that makes them better at using the calculator as compared to girls. Jada even indicated that boys being better at using calculators dealt with pride and competitiveness. Also, guys enjoy calculators more and spend more time doing calculator activities. Another girl indicated that a calculator was like a toy to a boy. Girls see it as a means to get the job done.

However, I had some sharp girls with calculator skills this year as well. Part of this is a result of taking AP Statistics last year. Any student that takes AP Statistics learns how to use their calculator very well and is a master by the end of the year. Their confidence has grown significantly because they cannot complete that course without knowing multiple functions and submenus and being capable of finding them quickly. Those particular girls never handed over their calculator to me if they needed help. I watched those girls dig and find the sub-menus and work until they found how to make the calculator function work. If they could not do something, they asked for help, but it was a last resort and they did not ask me to “do it for them.”

Who is better operating the calculator – males or females? Two of my girls said they were equal while six girls said that they guys were better. Statistics indicate technology is a “male” field, but the girls are working hard at catching up and are cognizant to learn what they need to learn in calculator technology. They indicate that they do not want the calculator to replace their knowledge and sometimes they have that concern. They also realize they have more to learn and that’s the first step in reaching the goal of having higher knowledge.

Are You in Over Your Head?

Data indicate that the use of calculators allow students to be more successful on many achievement tests (Ellington, 2003). Yet studies have indicated that girls still see technology as tools and boys see technology as toys (Keelan, 2007). I wrote a grant with our local electric membership corporation to acquire a special type of calculator that has a computer algorithm system in it that would allow me to conduct labs in class and also work with girls outside of class to increase their calculator self esteem. Even with calculator processes, girls constantly fight the battle of boys shouting out answers in class, and it often shuts them down and they give up trying to learn the process. This is not acceptable. The grant allowed me to purchase 17 TI-Nspire Calculators and check them out to my AP Calculus students. We conducted many discovery labs in class. Data have indicated that females learn better when they have multiple learning methods, though those methods have not been significantly associated with mathematics achievement. In my classroom, I tie a very brief discovery learning lab on the TI-Nspire with the theory of that concept. One example involves the derivative of e^x. The derivative of e^x is e^x. It's very easy for me to directly teach that concept. Furthermore, the derivative of e^u is $e^u * \frac{du}{dx}$. That requires more analytical thinking. However, as students use the calculator and see several problems worked for them, they think analytically and determine the rule on their own. Then they remember the rules for the derivatives, and by the end of the class, they know the rules when I go over the theory with them.

The amazing part is the one student who truly mastered that calculator the first year was a girl! I just received a note from her and she is changing her major to mathematics education. Did mastering the calculator play a part in her decision? We'll never know, but I'd like to think so. I certainly told her that year that she was doing a great job with that calculator and she had the best command of the TINspire of anyone in that class!

What's Different?

I expect that when students come into my class, no matter what age or grade I teach, they will use a graphing calculator. That does not mean that every test will involve a graphing calculator. A graphing calculator creates a picture in their minds of what should happen in certain situations. It is the combination of the visual image with the theoretical knowledge that aids in the learning process for students. I cannot imagine teaching students how to transform equations without the use of a graphing calculator. It is the perfect tool for them to discover the process and write a conjecture for me. If they can discover that process before I pull it together for them, they have a higher chance of remembering what happens when they transform equations. It is also much quicker. Why waste an entire period in which the students only graph two or three equations when the entire process can be explored in one period. I've done this for many years, and I have the students "sketch" the transformation using the parent graph first and then moving the points over, up, down, stretched or shrunk. I call these "labs." I inform the students that the calculator is doing most of the work, so it is critical that they answer the questions because the vast majority of their grade will come from the conjecture questions. I also tell them to read and look at the graphs carefully because I expect the correct answer in the conjecture box, not just any answer. It usually takes one or two labs for students to understand I am being honest. Then they realize this is a fun way to learn mathematics and a pretty easy way to earn an A. Calculator labs are also quite helpful in creating mind pictures that will help in the transfer of knowledge. The greatest gift that I receive is when they come back from college and tell me they were well prepared for college. They also tell me they often know how to use their calculator better than their college instructors. My goal is to prepare the students for college mathematics with no remedial courses, so if they come back and tell me they were successful, I know I did it and I know they made it!

It is very interesting that one of my students from one of the pilots e-mailed me to help her with her TI-Nspire. She had learned a lot in my class and learned quite well how to use a calculator to aid in the learning process. Unfortunately, there are two types of that calculator, and when she bought one for her class, she did not realize the one she bought would not do the functions she needed, so she called me. We had a conversation, and she came to see me and I let her borrow a calculator. She did not need any instruction on how to use the calculator, but she needed to borrow one. Her memory of the processes was intact. Girls can accomplish great things!

APPENDIX K

DEMOGRAPHIC INFORMATION QUESTIONNAIRE

GRAPHING CALCULATOR BACKGROUND INFORMATION

1. Gender (circle one) Male Female

2. Age________________

3. Grade in school_______

4. Do you own a graphing calculator? ________________

5. What is the model of the calculator if you own one?_______________(Example- TI-84)

6. How long have you owned a graphing calculator?

   - ☐ LESS THAN 3 MONTHS
   - ☐ 3 – 6 MONTHS
   - ☐ 6 MONTHS TO 1 YEAR
   - ☐ 1 YEAR TO 2 YEARS
   - ☐ OVER 2 YEARS

7. How often do you use a graphing calculator to complete mathematics assignments?

   - ☐ DAILY
   - ☐ 3 – 5 TIMES PER WEEK
   - ☐ 1 – 2 TIMES PER WEEK
   - ☐ LESS THAN ONCE A WEEK

APPENDIX L

PARENT INFORMATION LETTER

Debbie M. Kohler

Sequoyah High School Mathematics Teacher
4485 Hickory Road Canton, GA 30115
770-345-1474

CALCULATOR EFFICACY AND ACHIEVEMENT RESEARCH

Dear Parent or Guardian:

I am currently a doctoral student at Kennesaw State University and am conducting research for a study on gender and calculator fluency. Technology is an important tool in the mathematics classroom, and my research seeks to determine if differences exist between males and females on calculator efficacy and achievement.

Participants in the study will take a calculator-efficacy survey about how much they enjoy using calculators and technology. They will be instructed in class on calculator techniques that relate to the curriculum we are studying, and they will take a calculator fluency test before and after four to six weeks of instruction. The entire research will take about 6- 8 weeks. Each student has been advised the following:

The purpose of this research has been explained and my participation is voluntary. I have the right to stop participation at any time without penalty. I understand that the research has no known risks, and I will not be identified. By completing this survey, I am agreeing to participate in this research project.

Sincerely,

Debbie M. Kohler

THIS PAGE MAY BE REMOVED AND KEPT BY EACH PARTICIPANT

Research at Kennesaw State University that involves human participants is carried out under the oversight of an Institutional Review Board. Questions or problems regarding these activities should be addressed to Dr. Ginny Q. Zhan, Chairperson of the Institutional Review Board, Kennesaw State University, 1000 Chastain Road, #2202, Kennesaw, GA 30144-5591, (770) 423-6679.