TEACHERS AND HAND-HELD GRAPHING TECHNOLOGY: AN EXAMINATION OF CONCERNS

by

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Liberty University

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Education

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April, 2012

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April 2012

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ABSTRACT

The purpose of this nonexperimental causal-comparative study was to examine the concerns of teachers in reference to the graphing calculator, as measured by the Stages of Concern Questionnaire (SoCQ) and compare the results to a combination of levels of concerns between groups. The study participants were high school teachers of mathematics in Northwest Georgia and Southeast Tennessee (n = 128). This study utilized a two-way multivariate analysis of variance (MANOVA) to determine the effect of two independent variables, formal training and experience teaching with a graphing calculator, on seven dependent variables, teachers' Stages of Concern (stages 0-6). Also, a one-way MANOVA was conducted to determine if there was a statistically significant difference in means between the dependent variables, teachers Stages of Concern (stages 0-6), and the independent variable, the state where a teacher was employed (Georgia or Tennessee). The results for the two-way MANOVA were statistically significant for the teaching experience main effect. The one-way MANOVA was found to be significant at stage 0.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

Analysis of Variance (ANOVA)

Concerns-Based Adoption Model (CBAM)

Field Service Center (FSC)

Georgia Department of Education (GDOE)

Institutional Review Board (IRB)

Microcomputer Adoption Survey Instrument (MASI)

Multivariate Analysis of Variance (MANOVA)

National Council of Teachers of Mathematics (NCTM)

Resource Educational Service Agency (RESA)

Southwest Educational Development Laboratory (SEDL)

Stages of Concern (SoC)

Stages of Concern about Computing (SoCC)

Stages of Concern Questionnaire (SoCQ)

Statistical Package for the Social Sciences (SPSS)

Teaching with Technology Instrument (TTI)

Tennessee Department of Education (TDOE)

Use Of and Attitude Toward Graphing Calculators (UATGC)

CHAPTER ONE: INTRODUCTION

Using technology in the classroom to enhance student understanding has become a common pedagogical technique for many teachers. The prevalence of the use of computers, calculators, interactive white boards, and even cell phones in the classroom is due to the fact that technology has become increasingly available in the home and to the student. Not only has technology become more available, but it has also advanced beyond rote instruction, which was its initially intended use (Michael, 2001). No longer do students stare at a screen and click multiple-choice answers. Rather, the technology has come to life. It now has the ability to produce a form of artificial intelligence, analyze errors, and suggest remedial courses of learning. In today's mathematics classrooms, "student learning is assisted by feedback, which technology can supply: Drag a node in a Dynamic Geometry® environment, and the shape on the screen changes; change the defining rules for a spreadsheet, and watch as dependent values are modified" (National Council of Teachers of Mathematics [NCTM], 2000, p. 25).

Computer software designed for the mathematics classroom, such as Cognitive Tutor® and Maplesoft®, along with graphing calculators like the new Texas Instruments TI-Inspire and Casio ClassPad 330, are all advanced tools for displaying a variety of mathematical representations. Both Cognitive Tutor® and Maplesoft® are dynamic software packages that actually use a form of artificial intelligence that detects student errors and supplies remedial teaching for the student. The "graphing calculators have had an effect on the mathematics curriculum in secondary schools in the United States, making popular the rule of three – graphs, tables and symbols [equations] as ways to represent and analyze relationships" (Burrill, 2008, p. 1).

Roblyer (2003) stated that perhaps no other innovation, educational or instructional, has been the focus of as much new development in so many content areas as technology. Yet no single acceptable definition for this term is widely accepted in the field of education. Any mention of technology in education brings to mind the use of some device or set of equipment, particularly computer equipment. Research by the author suggests that the function of educational technology is not about a product or electronic device but, rather, a process. Roblyer stated that useful definitions of educational technology must be focused on the process of applying tools for educational purposes. In other words, technology is not a collection of electronics, but a means of instruction.

NCTM's *Principles and Standards for School Mathematics* (2000) addressed technology by stating that "Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and embraces students' learning" (p. 24). However, NCTM also stated that "technology should not be used as a replacement for basic understandings and intuitions; rather, it can and should be used to foster those understandings and intuitions" (p. 25).

The goal of introducing technology into a classroom is to enhance student understanding of the target skill or concept. There have been many studies over the last ten years that has suggested that for technology to be successful in assisting the student in learning, the teacher should have a positive opinion of the technology (Doerr & Zangor, 2000; Handal, Cavanagh, Wood, & Petocz, 2011; Liu & Huang, 2005; Wozney, Venkatesh, & Abrami, 2006). Often, the teacher is unsure how the technology functions or how the technology integrates into instruction. Therefore, the teacher's attitudes and concerns are less than positive towards the technology (Doerr & Zangor, 2000). Inan and Lowther (2010) found that a teacher's beliefs and readiness positively influenced the integration of technology in learning and that these same beliefs could mediate the indirect effects of learning through the use of technology. The use of the new tools that educators now have access to must be mastered in the pursuit of educational goals that reflect the technological opportunities that are available at this time. The time is right for the examination of technology and its effect on teaching and learning (Heid & Blume, 2008).

The aspect of this study examined the concerns of teachers about a new innovation in the teaching of mathematics, the graphing calculator. Also, this study considered how formal training and teaching experience affect these teacher concerns. Multivariate analysis of variance (MANOVA) was used to test whether mean differences among groups on a combination of dependent variables (Stages of Concern, 0-6) were likely to have occurred by chance.

Background

The NCTM (1974) published a statement urging the use of calculators in mathematical learning. The concept of calculators being used as a tool for Constructivist learning did not become common until the mid to late 1980s, when the graphing calculator was introduced. Until that time, the primary function of the device was most often as a computational and checking tool (Hembree & Dessart, 1986).

While graphing technology was making advances and the cost of the units was decreasing, there were many educators voicing concerns. A common concern reported was that basic skills would be threatened by the displacement of paper and pencil computation (Hembree & Dessart, 1986). Many people believe that every advantage gained by technology is connected to a disadvantage academically. They think that the cost of catching a student's attention with entertaining technology could be the forfeit of serious study (Postman, 1985). Studies have documented the debate about whether graphing calculators have a negative effect on student achievement, and researchers have concluded that graphing calculators do not hinder student achievement on paper-and-pencil items (Acelajado 2001; Guerrero Walker, & Dugdale, 2004; Heller Curtis, Jaffe, & Verboncoeur, 2005; Olson & Clough 2001).

During the 1990s, high school mathematics teachers moved to adopt the graphing calculator into practice mainly due to the low cost and availability of the technology (Doerr & Zangor, 2000). Doerr and Zangor (2000) conducted a study that examined the connection between a teacher's knowledge and pedagogical strategies with the use of the graphing calculator and found that the "role, knowledge, and beliefs of the teacher influenced the emergence of such rich usage of the graphing calculator" (p. 143).

Studies followed that addressed teachers' concerns, finding that, for a new innovation to be implemented, the concerns of the teachers must be considered important, and the teachers' needs must be met (Chamblee, Slough, & Wunsch, 2008). Further professional development for teachers is needed to address the personal concerns about graphing technology (Chamblee et al., 2008). Introducing a new innovation is "a process not an event, developmental in nature and a highly personal experience for the teacher" (Hall & Hord, 2006, p. 185). The work of Chamblee et al. (2008) and researchers Hall and Hord (2006) link the success of technology in teaching and learning, with the role, knowledge, and beliefs of the teacher. This link served as a foundation for this research.

Problem Statement

The effort for higher standards in education as well as greater student understanding has attracted considerable public and scholarly attention. A large number of resources have been devoted to developing a standards-based model for classroom instruction nationwide (Swanson & Stevenson, 2002). Now being considered are the demands that are being placed on teachers as they integrate technology into the teaching and learning of mathematics (Heid & Blume, 2008). One technology that is becoming more sophisticated and available is the graphing calculator. There is much debate concerning graphing calculators (Confrey & Maloney, 2008; Doerr & Zangor, 2000; Laumakis & Herman, 2006). Roschelle, Singleton, Sabelli, Pea, and Bransford, (2008) stated that the "effectiveness of technology depended on how teachers and schools integrate it [technology] into their practices, including planning, instruction, assessment, and reflection" (p.613). Swanson and Stevenson (2002) made the point that "Instructional norms may, therefore, play a key role in promoting change in teaching practices by providing an atmosphere conductive to innovation by teachers within the classroom" (p. 15). The teacher is expected to integrate the graphing calculator into instruction, but, as research has indicated, technology is often not used because of teacher attitudes and concerns (Doerr & Zangor, 2000).

This study focused on a population of teachers of high school mathematics. Teachers' Stages of Concern (stages 0-6) were the dependent variables, and formal training and teaching experience with a graphing calculator were the independent variables for the first research question of this study. Teachers' Stage of Concern (stage 0-6) was the dependent variable and the state where a teacher is employed (Georgia or Tennessee) was the independent variable and for the second research question.

Purpose Statement

The purpose of this study was to measure how a teacher's Stage of Concern is affected by formal training, teaching experience, and the state where the teaching is taking place. Teachers' concerns were examined using the Stages of Concern Questionnaire (SoCQ). The SoCQ was developed from research conducted by Frances Fuller (1969) by the Research and Development Center for Teacher Education at the University of Texas (George, Hall, & Stiegelbauer, 2008).

A portion of the purpose was to determine if means between peak stage scores (stages 0-6) on the SoCQ, or a linear combination of these scores, were the same or different based on a relationship between the amount of teaching experience with a graphing calculator or formal training with the graphing calculator. A two-way multivariate analysis of variance (MANOVA) was conducted to determine if a significant difference could be detected.

Another purpose was to determine if means between peak stage scores on the SoCQ or a linear combination of theses scores were the same or different based on a teacher's state of employment. The state variable was chosen because administrative rules were in effect in the state of Tennessee that allowed the student to be assessed with hand-held graphing technology on state-mandated end-of-course assessments as reported by the Tennessee Department of Education (2011). The state of Georgia did not allow this innovation to be used on similar state-mandated tests as reported by the Georgia Department of Education (2011).

Significance of the Study

There is the need for a more in-depth study of the effect that a new innovation has on teachers' concerns and there is a need for more research concerning the impact that the graphing calculator has on the actual practices of teachers and instruction (Doerr & Zangor, 2000). Furthermore, the question has been asked, "Are teacher's perceptions of their use of technology and assessment of their attitudes towards technology consistent with their actual practices?"(Dewey, Singletary, & Kinzel, 2009, p. 392). More studies are needed to evaluate the value of the calculator as it pertains to teacher attitude, and pedagogy (Confrey & Maloney, 2008).

George et al. (2008) stated that individuals experience many types of concerns at varying levels of intensity. Also, individuals tend to have more intense concerns about things with which a personal involvement is required. George et al. stated that concerns are important aspects to consider when working with individuals who are involved in a change process due to the introduction of a new innovation. George et al. also stated that individuals who have never been exposed to a certain innovation (technology) will experience a different level or stage of concern than individuals who have been working with the innovation for a period of time. An innovation, according to George et al., is a generic name given to an object (like the graphing calculator) or situation (like the graphing calculator being introduced into instruction). This study will contribute to the body of research that measures how the concerns of teachers are affected by an innovation, the graphing calculator, and how certain variables (formal training, teaching experience, and the state where the teaching is taking place) affect teachers' concerns.

Research Questions and Null Hypothesis

Research Question 1**:** Is there a statistically significant difference in a linear combination of teachers' mean stage scores (stages 0-6) based on their experience teaching with a graphing calculator and the formal level of training with a graphing calculator?

Research Hypothesis 1.1: There will be a statistically significant difference in a linear combination of teachers' mean stage scores (stages 0-6) based on teaching experience with the graphing calculator and the formal level of training with a graphing calculator. If this hypothesis is found significant, then hypotheses that examine each dependent variable individually will be tested.

Research Hypothesis 1.2: There will be a statistically significant difference in a linear combination of teachers' mean stage scores (stages 0-6) based on teaching experience with the graphing calculator. If this hypothesis is found significant, then hypotheses that examine each dependent variable individually will be tested.

Research Hypothesis 1.3: There will be a statistically significant difference in a linear combination of teachers' mean stage scores (stages 0-6) based on the formal level of training with a graphing calculator. If this hypothesis is found significant, then hypotheses that examine each dependent variable individually will be tested.

Null Hypothesis 1.1: There will not be a statistically significant difference in a linear combination of teachers' mean stage scores (stages 0-6) based on teaching experience with the graphing calculator and the formal level of training with a graphing calculator.

Null Hypothesis 1.2: There will not be a statistically significant difference in a linear combination of teachers' mean stage scores (stages 0-6) based on teaching experience with the graphing calculator.

Null Hypothesis 1.3: There will not be a statistically significant difference in a linear combination of teachers' mean stage scores (stages 0-6) based on the formal level of training with a graphing calculator.

Research Question 2: Is there a statistically significant difference in a linear combination of teachers' mean stage scores (stage 0-6) according to the teacher's state of employment?

Research Hypothesis 2.1: There will be a statistically significant difference in a linear combination of teachers' mean stage scores (stages 0-6) based on the teacher's state of employment. If this hypothesis is found significant, hypotheses that examine each dependent variable individually will be tested.

Null Hypothesis 2.1: There will not be a statistically significant difference in a linear combination of teachers' mean stage scores (stages 0-6) based on the teacher's state of employment.

Identification of Variables

The following variables are defined for use in this study.

1. Formal Training with a graphing calculator: This variable is categorical and has two levels, eight hours or less of training and more than eight hours of training. For the purposes of this study, formal training was defined as any training experience undertaken by the participants that involved a workshop, seminar, program, or conference, either in a traditional classroom setting or distance learning environment, where the training increased the teacher's knowledge or skills about how graphing calculators are either operated or integrated into mathematics instruction. The variable was measured by estimated hours of training (time hours, not credit hours) self-reported by the participant.

2. Peak Stage of Concern Score (0-6): This was defined as participant's Stage of Concern score by George et al. (2008). The scores could have ranged from 0 to 35, with a higher score indicating a greater intensity for the corresponding stage of concern. Raw scale scores, as recommended by George et al., were used for all quantitative analyses. The SoCQ (see Appendix A) was the instrument used for measuring teachers' Stages of Concern, the dependent variable in this study. Also, a demographic survey, independent of the SoCQ items (see Appendix B), was included with questions relating to teaching experience and the amount of formal training. Copyright permission (see Appendix C) was obtained from the Southwest Educational Development Laboratory (SEDL). The SoCQ is a quantitative instrument that measures the concerns of individuals who are affected by a new process or innovation (George et al., 2008). The participants responded to 35 statements on a 0-7 Likert scale according to how true the item appeared to be at the present time. The SoCQ is a diagnostic dimension of the Concerns-Based Adoption Model (CBAM) that was developed in 1969 by Frances Fuller and others to respond to the introduction of new innovations in education (George et al., 2008). The CBAM (Figure 1.1) is a "Conceptual framework that describes, explains, and predicts probable behaviors throughout the change process" (George et al., 2008, p. 5). George et al. (2008) suggested that the simplest form of interpretation is to identify the peak stage of concern score.

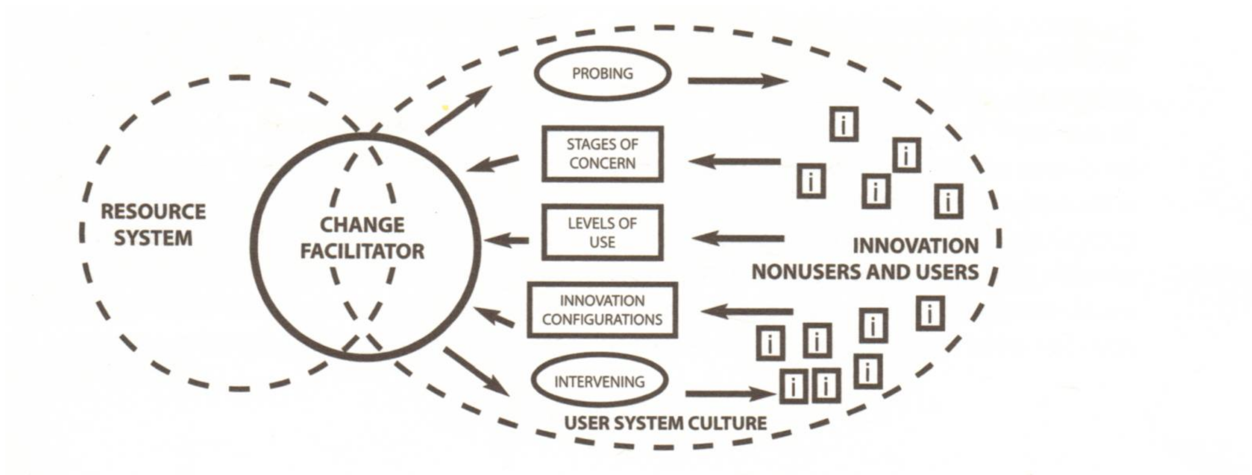

Figure 1.1 The Concerns-Based Adoption Model. Reprinted with permission of SELD. Copyright © 2006 SELD

3. Stages of Concern: Stages of Concern are concerns of individuals who are involved in change. These continuous variables were distinctive, however, they were not mutually exclusive. These stages are identified individually as Stage 0 (unconcerned), Stage 1 (informational), Stage 2 (personal), Stage 3 (management), Stage 4 (consequence), Stage 5 (collaboration), and Stage 6 (refocusing).

4. State of Employment: This identifies the location by state where teachers participating in the study provide instruction in mathematics to students in grades nine through twelve (Georgia or Tennessee).

5. Teaching Experience with a graphing calculator: This variable is categorical and has three levels, novice (0-5 years), moderate (6-10 years), and experienced (11 years or more). For the purpose of this study, teaching experience was defined as the number of complete, nine-month, academic school years that the participants

spent teaching mathematics in grade levels nine through twelve using a graphing calculator.

Definitions

The definitions provided are based on previously published research, whenever possible, and references are included. Some terms, however, had to be defined by the researcher to reflect the procedures used in this study.

1. Concerns: Concerns are feelings, thoughts, and reactions individuals have about a new program or innovation that touches their lives (Hord, Rutherford, Huling, & Hall, 2006).
2. Concerns-Based Adoption Model (CBAM): The CBAM was derived from the research conducted by Fuller (1969) in response to new innovations being introduced to education. CBAM sets the foundation for the investigation of the multiple dimensions of a change process using three diagnostic instruments- SoCQ, Innovative Configurations, and Levels of Use (Hord et al., 2006).
3. Constructivism: This is the theory that individuals construct their own meanings in education. This theory is consistent with curricula and instruction that encourage students to make decisions about what to study and how to study it (Marsh & Willis, 2003).
4. Educational Technology: Educational Technology is defined as a combination of the processes and tools involved in addressing educational needs and problems,

with an emphasis on applying the most current tools: computers and related technologies (Roblyer, 2003).

5. Graphing Calculator: For the purpose of this study, a graphing calculator is defined as an electronic computing device that can carry on scientific computations for both higher algebraic and trigonometric functions and which displays graphics of these functions. Also, the graphing calculator is a Constructivist learning tool used by students to construct new leanings (Doerr & Zangor, 2000).
6. Innovation: Innovation is a program, process, or practice, new or not, that is new to an individual (Hord et al., 2006).
7. Multivariate Analysis of Variance (MANOVA): Multivariate analysis of variance evaluates differences among composite means for a set of dependant variables (Tabachnick & Fidell, 2007).
8. Peak Stage of Concern: Peak Stage of Concern is defined to be the CBAM stage with the highest score (0-35) on the SoCQ and is also considered to be the most intense, primary concern of the teacher (George et al., 2008).

Assumptions

George et al. (2008) stated that SoCQ is designed solely to diagnose the levels of concern of individuals affected by a new innovation and that the instrument is not intended to evaluate personnel. George et al. continued to clarify this point when they stated, "Concerns are neither good nor bad, and it is inappropriate to analyze them in those terms" (p. 55). Following the previous recommendation of George et al, this study was limited to the measurement of teachers' Stages of Concern and other factors that are hypothesized to affect teachers' levels of concern. The findings of this study were not intended to judge teachers' concerns as either good or bad.

George et al. (2008) reported that the SoCQ is found to be valid and reliable with individuals who have experienced different levels of exposure to an innovation. Validity was established by examining the relationship of SoCQ scale scores with variables that are related to concerns theory. Intercorrelation matrices, interview data, and confirmation of group differences over time were also used to investigate the validity of the SoCQ scores. The internal reliability for individual scales range from $r = .64$ to $r = .83$ (George et al., 2008). A more detailed discussion concerning the instrument's validity and reliability is available in Chapter Three.

This study was designed to provide some understanding of the Stages of Concern of teachers of mathematics toward the use of hand-held graphing technology, but there were issues that existed that may limit the ability to generalize results. Demographic information was collected to assist in the comparison of one region to another; however, the study is limited to a select region of the Southeastern United States, and results may not be representative of all states. Also, the self-reporting method of this study could create some degree of misrepresentation that should be considered. Teachers' perceptions of their concerns toward an innovation may not be consistent with actual practices during instruction.

Summary

NCTM (2000) recommends the use of hand-held graphing technology as a way for students to better understand specific content, such as multiple representations of functions. However, the calculator has not made the instructional impact that was predicted when the technology was first introduced (Dewey et al., 2009). The roles, attitudes, and beliefs of the teachers may be the mediating variables that are responsible for the lack of instructional success of the graphing calculator (Doerr & Zangor, 2000). Cavanaugh, Wood, and Petocz (2011) stated that some teachers have reservations about using graphing calculators during instruction because of a fear that students might become de-skilled.

Researchers have reported that teaching experience with the graphing calculator and formal training can affect the attitudes of teachers and increase the level of use of graphing calculators in instruction. Overbaugh and Lu (2008) stated that "technology must become personally meaningful before faculty can use it to help others" (pp. 43-44). Their results indicated that professional development "did help the participants gain competence and confidence in instructional technology integration' (p. 51). Cavanaugh et al. (2011) further stated that "personal expertise, positive attitude, and faculty support in using GCs [graphing calculators] are vital to adoption (p. 354). Inan and Lowther (2010) also stated that "school-level factors (availability of computers, technical support, and overall support) positively influenced teachers' beliefs and teachers' readiness (p. 146). Last, Wozney et al. (2006) reported that "technology implementation is a dynamic process mediated by subjective teacher characteristics and by conditions within the school" (p. 192) and that the amount of technology-related in-service training affected teachers' characteristics and was significantly related to the use of technology during instruction.

Hord et al. (2006) stated that, for change to be successful, school administrators must recognize that only individuals can bring about change. Also stated was that this change occurs by altering behaviors. However, behaviors cannot be altered before they are understood; the primary route to any change "lies in its human, not its material, component" (pp. 6-7). This study asked if means between peak stage scores (stages 0-6) on the SoCQ, or a linear combination of these scores, were the same or different based on a relationship between the amount of teaching experience with a graphing calculator or formal training with the graphing calculator. In addition, this research reports findings that could be useful to school administrators and teachers for improving student learning of mathematics.

CHAPTER TWO: REVIEW OF LITERATURE

Introduction

This review of literature first discusses Kuhn's (1962) *The Structure of Scientific Revolutions*. Next, the theoretical framework that examines the concerns of teachers is reviewed. Finally, of the empirical literature that connects an innovation, graphing technology with the noncognitive variables of attitude and concern will be addressed. All of these parts collectively present the knowledge base upon which this study was built.

The Revolution of Change

Technology has had a significant effect on how society functions, and, as new technology becomes available (e.g., digital cameras, laptop computers, wireless readers), individuals make decisions whether or not to integrate these devices into everyday life (Gbomita, 1997). However, research suggests there is a lack of evidence that technology is being eagerly or willingly accepted into the classroom and, if there is resistance to the adoption of new innovations for learning (graphing calculators), then the potential for a deeper, richer learning experience might not be realized (Atkins & Vasu, 2000; Gbomita, 1997; Handal et al., 2011; Snider & Gershner, 1999).

Thomas S. Kuhn (1962) discussed resistance to new discoveries and inventions in a given field of study in *The Structure of Scientific Revolutions* (1962) and made a logical argument for the emergence, testing, and finally acceptance of a paradigm in the scientific community. Kuhn is also credited with redefining the term *paradigm* to mean "universally recognized scientific achievements that for a time provide model problems and solutions to a community of practitioners" (p. x).

Kuhn (1962) reported that when scientific experiments fail to perform in the expected manner repeatedly, an anomaly is revealed. This anomaly leads to inquiry, and paradigms begin with inquiry and a collection of "mere facts" (Kuhn, 1962, p. 17). Kuhn also stated that "To be accepted as a paradigm, a theory must seem better than its competitors, but it need not, and in fact never does, explain all the facts with which it can be confronted" (pp. 17-18).

Kuhn (1962) examined paradigm changes that result from inventions. These inventions, according to Kuhn, are the result of existing theory failing, and this failure in turn brings about crisis. The acknowledgement of a crisis is important to change because "a profound awareness is a prerequisite to all acceptable changes of theory" (p. 67). Kuhn continued with "a novel theory emerged only after [there was] a pronounced failure in the normal problem-solving activity. . . . .The novel theory seems a direct response to crisis" (pp. 74-75).

Kuhn (1962) avowed that crisis creates a requirement for change and the emergence of a new theory and suggested that as long as an older paradigm continues to function to an acceptable degree, scientists would continue to use the theories (tools) supplied by that paradigm. Kuhn made the point that "As in manufacture so in science- retooling is an extravagance to be reserved for the occasion that demands it. The significance of crisis is the indication they [Philosophers of science] provide an occasion for retooling has arrived" (p. 76). Kuhn also stated that a crisis, when acknowledged, provides the necessary elements for a fundamental paradigm shift. When the decision is made to reject one paradigm, the decision is made at the same time to accept a new, replacement paradigm.

Once crisis has forced a new look at an existing paradigm, many versions usually begin to appear, and, as a consequence of the crisis, the rules of normal problem-solving become more flexible in a way that allows a new paradigm to emerge (Kuhn, 1962). The flexibility that Kuhn (1962) described is sometimes just looking at the same data in a different way. Kuhn called this change a "gestalt switch," which refers to the Gestalt branch of psychology. D. Shultz and S. Shultz (2008) describe gestalt as meaning that the unified whole cannot be explained by a collection of elements or a sum of parts because "the whole is different from the sum of its parts" (p. 366). Kuhn also stated that "The resulting transition to a new paradigm is scientific revolution" (p. 90).

Kuhn's (1962) work relates to the current research because of his statement that "Political revolutions are inaugurated by a growing sense, often restricted to a segment of the political community, that existing institutions have ceased adequately to meet the problems posed by an environment that they have in part created" (p. 91). In this passage, Kuhn used social or political revolution as an analogy for scientific revolution. The parallelism created by Kuhn can also be connected to the social sciences (e.g., psychology, education, and sociology). Kuhn suggested that a crisis is necessary for there to be a paradigm shift in society as well as science.

This concept of crisis as a requirement for a paradigm shift can also be applied to education. For example, a crisis is on the horizon in the field of mathematics regarding the debate over whether to use graphing calculators as instructional tools for student understanding (Handal et al., 2011). Olson and Clough (2001) noted that the use of graphing technology is one issue that is being debated by teachers of mathematics. Kaput and Schorr (2008) stated that the graphing calculator is one of the technological advances that have made its way into almost every high school math classroom.

However, while Confrey and Maloney (2008) acknowledge that the new hand-held devices are inexpensive, durable, and are even permitted on many standardized tests, they claim that the units are, "an intellectual and pedagogical *short circuit* for a student" (p. 204). Also cited as disadvantages by Confrey and Maloney are claims that the calculator "tends to drive mathematics toward the symbolic" (p. 204), and "there is little published evidence that its designers have carefully studied student strategies, or designed for response to student strategies" (p.204). Olson and Clough (2001) stated that calculators and other technologies do save the student from having to perform mundane tasks but those mundane tasks are the foundation of student learning.

The ongoing debate supports the claim by Kuhn (1962) that a crisis must emerge before a paradigm shift will occur. The crisis that is needed in education for the appropriate use of the graphing calculator to be fully integrated into instruction has yet to occur. Kuhn stated that the scientist [teacher] "is a solver of puzzles, not a tester of paradigms" (p. 143).

Theoretical Framework

Background

With the implementation of a technological innovation, change is inevitable (Chamblee et al., 2008; Hall & Hord, 2006). The attitude of the educator is a major human factor that must be taken into account when implementing innovation in the classroom (Atkins & Vasu, 2000; Gbomita, 1997; Snider & Gershner, 1999). Assessing a teacher's attitude concerning the innovation gives an indication of understanding, along with determining a teacher's ability to adopt and integrate the innovation (technology) into instruction (Agbatogun, 2010). Since concern is a major component of attitude, the theoretical framework in this study is teachers' stages of concern (Liu & Huang, 2005).

Concerns are defined as the feelings, thoughts, and reactions individuals have about change that is introduced into their surroundings (Hall, George, & Rutherford, 1986). The work of Fuller (1969) brought the concept of developmental concerns to the attention of other educational researchers. Fuller suggested that there are three developmental stages of concern for teaching: self phase, task phase, and impact phase.

The self phase (stages 0-2) is described by Hord et al. (2006) as being a time when the change effort is in an early stage and when the teacher is likely to have self-concerns. The individual could be thinking that more information is needed about the change or how the change will affect classroom instruction. Hord et al. stated that the task phase (stage 3) is usually marked with more intense concerns, and the teacher can be observed preparing for the change. Hord et al. stated that the impact phase (stages 4-6) is where the most intense concerns can be observed. The impact phase is when the teacher reflects on how the change is affecting student learning. Hord et al. (2006) concluded with, “When teachers have used an innovation with efficiency for some time they may become concerned about finding even better ways to reach and teach students” (p. 33).

Hord et al. (2006) went further and stated that individuals usually appear to express or show growth in terms of feelings and skills. These feelings and skills change as the individual becomes more experienced. Individuals also relate change to how the change will affect themselves or their rituals and routines. Only people can bring about change, and the modification of behavior is central to successful change; furthermore, the true meaning of change is found within the human factor (Hord et al., 2006).

Concerns-Based Adoption Model

Hord et al. (2006) describe a framework for understanding change that is referred to as the CBAM (see Figure 1.1, p. 12). Using CBAM as a framework for their for study, Hord et al. reached the following conclusions: (a) Change is really a process that takes place over time and not just an event; (b) Change is accomplished by individuals; (c) Change is a highly personal event; and (d) Change involves developmental growth. Hord et al. also stated that, in most cases, individuals are not alike, and intensity of concerns is unique. They also said that change is most successful when support is available for the individual. Additionally, different interventions are required for different types of individuals.

Individuals appear to demonstrate growth in regards to their concerns. These concerns tend to shift with respect to the change as the individual becomes more exposed to the change. The individual relates the change to concerns for self, or, as Hord et al. (2006) asked, "How will the change affect my current classroom practice?" (p. 6). Hord et al. further made the point that "only people can make change by altering their behavior. The real meaning of any change lies in its human, not its material, component" (pp. 6-7).

Principles of Concern

Studying and identifying concerns of individuals can be an effective way to bring about meaningful change in a school environment. Hord et al. (2006) discussed the general principles of concerns and stated, "There is nothing inherently good or bad about a particular stage or pattern of concerns" (p. 43). Hord et al. clarified this point by stating that interactions with a person who has high concerns in the early stages of concern may be quite different from those with someone with high concerns in a later stage. However, neither person nor stage of concern is better or worse than the other.

Hord et al. (2006) stated that "concerns are not fixed" (p. 43), and "they will recycle in response to each new innovation or even to phases of an incremental innovation" (p. 43). Movement through the different stages of concern cannot be forced, but, rather with the use of professional development, movement through the stages of concern can be facilitated. The lack of some type of assistance or the incorrect approach can hinder the developmental process of change (Hord et al., 2006).

Stages of Concern

Hord et al. (2006) described concerns as "feelings, thoughts, and reactions individuals have about a new program or innovation that touches their lives" (p. 30). Moreover, George et al. (2008) stated that "Concerns are an important dimension in working with individuals involved in a change process" (p. 7). The Stages of Concern (SoC) portion of the CBAM measures the concerns of individuals who are affected by some innovation. A study conducted by Hord et al. (2006) defined the stages as: unconcerned (stage 0), informational (stage 1), personal (stage 2), management (stage 3), consequence (stage 4), collaboration (stage 5), and refocusing (stage 6). Each stage varies with intensity as the change progresses.

The point is made that individuals do not necessarily progress through the stages in a step-by-step pattern. Hord et al. (2006) stated:

> While the seven stages of concerns are distinctive, they are not mutually exclusive. An individual is likely to have some degree of concern at all stages at any given time, yet our studies have documented that the stage or stages where concerns are more (and less) intense will vary as the implementation of change progresses. These variations in intensity mark the developmental nature of individual concerns (p. 30).

Hord et al. (2006) continued by reporting the way in which the development of concerns can be grouped into three dimensions (see Appendix D, Figure 1.2). These dimensions are defined as: self (stages 0-2), task (stage 3), and impact (stage 4-6). While the intensity associated with concerns usually does progress through stages, this method is not absolute. Individuals do not necessarily begin the stages at the same time or move through the stages at the same pace.

Additionally, Hord et al. (2006) discussed the nature of concerns of individuals. They described the intensity of the concern as being "wave like" (p. 32). The self-concerns are usually the most intense, typically abating with time. When the intensity associated with the task dimension or the management stage of concern reduces, then the impact intensity can be expected to rise. The progression and intensity of concerns that individuals experience during a time of change are directly affected by the type of change, along with the amount of assistance offered to the individual.

Empirical Literature

Each of the seven studies in this section share the common premise that the innovation, technology, is not the key to learning, but, rather the teacher's attitude (concerns) towards the new innovation is crucial for the technology to be used as a tool for learning. The following studies were selected to provide a context for the research to be conducted and to stress the importance of this research. The studies do not debate the effectiveness of an innovation but, rather, discuss independent noncognitive variables that influence the effectiveness of the innovation.

Gbomita (1997) conducted quantitative research that asked questions concerning the nonuse of technology in education. Gbomita designed this study to determine if a behavior associated with educators could be predicted in relation to the adoption of the microcomputer as a medium for delivering instruction with reference to selected social system factors. Three objectives for this study were developed: First, Gbomita wanted to identify the stage of adoption of microcomputers as a medium for delivering instruction by business educators; Secondly, Gbomita wanted to identify the relationship between selected sociosystemic factors and the microcomputer adoption behavior of business educators; The third objective was to identify the predictability of the microcomputer adoption behavior of business educators from the selected factors (Gbomita, 1997).

Gbomita (1997) stated that 400 participants were randomly selected from a population of 1,796 high school business teachers. From those 400, 203 participants responded to the instrument when surveyed. The instrument used in the study was the Microcomputer Adoption Survey Instrument (MASI).

Gbomita (1997) found that 88.2% of teachers were aware that microcomputers were being used in instruction. The same percentage of educators had requested more information to assist in forming ideas about how the technology would affect their instruction. Most of the teachers (82.3%) reported either being in the planning stages or actually using the microcomputer to deliver instruction. Also, a majority of teachers (95.1%) responded that using the technology was a “good educational practice” (Gbomita, 1997, p. 95).

Also reported by Gbomita (1997) were findings about the predictability of microcomputer adoptive behavior. From the 15 selected factors, all but three had either low or no predictability. Compatibility, number of students, and school characteristics did have a statistically significant relationship (correlation) with adoptive decisions.

However, Gbomita stated that these relationships explained only an insignificant amount of adoptive change.

Two conclusions from the study were reported: First, educators in general had adopted microcomputers to deliver instruction, and, secondly the educators participating in the study had progressed through the stages of adoption Gbomita, 1997). Furthermore, Gbomita stated that the difference between this study and previous research is that the decision to implement microcomputers was mandated. Gbomita stated "generally the faster rate of adoption of innovations results from authority decisions, where the decision has been imposed" (p. 98).

Gbomita (1997) examined the adoptive behavior of educators and found that the majority had adopted microcomputer technology as an instructional tool. The study also stated that there was clear evidence that educators had adapted the technology and considered the technology described to be an effective practice. However, the research was not able to predict educator behaviors except in three factors: teacher attitude, specific characteristics of the innovation, and critical threshold. The three factors are suggested to influence adoption behavior to some extent (Gbomita, 1997). The significance this study has to the current research is that teacher attitude did appear to affect a teacher's behaviors or concerns.

Doerr and Zangor (2000) conducted a qualitative study that, in part, addressed the issue of the teacher's role, knowledge, and beliefs concerning the graphing calculator. This study is relevant because the framework of the study was focused on the psychological aspects of learning - the student's interaction with tasks, other students, and the teacher. The classroom environment was hypothesized to be either a major contributor or a major hindrance to the student using the technology as a tool for a Constructivist style of learning. The teacher's role, knowledge, and beliefs (concerns) were hypothesized to have a significant impact on the success of the tool (i.e., the graphing calculator).

The results reported by Doerr and Zangor (2000) indicated that the teacher's skill in using the technology was considered to be significant to the student using the graphing calculator as a tool for learning. Doerr and Zangor, when discussing the teacher who was being examined, stated "The teacher was familiar with the programming features and she had written a short program" (p. 149). The teacher's confidence and flexibility in the use of the technology was reported to have a positive effect on the student using the graphing calculator as a tool. Doerr and Zangor also reported a deeper, richer understanding of mathematical concepts, and, if a student made an alternate suggestion in the use of the graphing calculator, the teacher was willing to take the student's suggestion. The teacher in the study expressed the view that the calculator would be valuable for student learning. Doerr and Zangor affirmed that the beliefs and attitudes observed during the research support the use of technology during instruction which contributes directly to this study.

Atkins and Vasu (2000) examined the concerns of middle school teachers who were implementing computer technology in their classes. The CBAM was used as a framework for the study; however, a variation of the SoCQ and Martin's Stages of

Concern about Computing (SoCC, 1989) were used along with the Teaching with Technology Instrument (TTI). A demographic survey was also used to determine if a correlation existed between the instrument scores and other independent variables, such as age and gender.

The SoCC (Martin, 1989) is a 32-item instrument that groups concerns into the following eight stages: contextual, informational, personal, management, consequence on self, consequence on others, collaboration, and refocusing. The TTI was designed to assess training needs in three areas: writing and communicating, informational awareness and management, and construction and multimedia. While the main objective of the SoCC is to determine the intensity levels of individuals or groups associated with concern, the primary purpose of the TTI is to assess the types of technology training that need to be offered to educators.

Atkins and Vasu (2000) proposed four hypotheses in the study. They are as follows:

1. There will be a significant positive relationship between the SoCC and TTI.
2. There will be a statistically significant positive relationship between the SoCC and the independent variables. These variables were defined to be: age, computer confidence level, gender, home access to computers, levels of education, training, school access to technology, subject taught, and teaching experience.

3. There will be a statistically significant positive relationship between the TTI and the independent variables.
4. Teachers at schools that are deemed to be more advanced in their integration of technology and curriculum will have higher mean scores on the TTI than those schools that are not advanced in their integration of technology into student learning.

A statistically significant positive relationship was observed between the SoCC and the TTI ($r_s = 0.322$, $p = 0.0001$). The SoCC was significantly related to confidence level ($r_s = 0.332$, $p = 0.0001$) and number of hours of training ($r_s = 0.224$, $p = 0.005$). The SoCC and other independent variables did not indicate a significant relationship.

A positive significant relationship was found between TTI and the following variables: age ($r_s = .224$, $p = 0.005$), computer confidence ($r_s = .651$, $p = .001$), home access to computers ($r_s = 0.267$, $p = .001$), hours of training ($r_s = .199$, $p = .013$), and school access to computers ($r_s = .291$, $p = .001$).

A one-way Analysis of Variance (ANOVA) supported the hypothesis that the more technologically advanced schools had higher mean TTI scores than the schools that had implemented fewer technological advances. Teachers who had higher SoCC scores tended to have higher TTI scores. The Spearman coefficient was determined to be significant but not strong ($r_s = 0.322$, $p = 0.0001$).

Knowledge of the concerns of educators is essential for adequate and effective planning for teacher professional development. The SoCC and TTI are effective tools for measuring concerns of teachers and needs for teacher professional development. Atkins and Vasu's (2000) research is important to this study because the findings suggested that change is a major ramification for schools implementing an innovation.

Rakes and Casey (2002) conducted research that, in part, examined mistakes made by decision makers in education and reported that too often it is the opinion of school administrators that the successful use of technology in the classroom is viewed as simple skills acquisition rather than a change process. These changes often affect teachers' concerns in a very deep and personal way. Rakes and Casey's purpose was to identify the concerns of teachers who were using technology in their instruction. The CBAM provided the framework for the study, while the SoCQ was the instrument used to gather data associated with teacher concerns. The data was disaggregated into stages of concern and demographics. Data was collected on teaching experience, highest degree held by the teacher, amount of technology training, technology exposure outside the classroom, and length of time teaching with technology (Rakes & Casey, 2002).

The study found a high informational (stage two) aggregated data profile, which was reported as an intense concern about the self stage (stage one; Rakes & Casey, 2002). These results suggested concerns about status, reward, and the potential effects of technology. Stage two concerns must be addressed before the individual can embrace the innovation with any objectivity. Rakes and Casey (2002) suggested that intense, personal concerns of teachers have been disregarded in the pursuit of higher student achievement.

A suggestion was made that administrators should address these concerns by providing professional development in the use of the tools.

Liu and Huang (2005) conducted a quantitative study using the CBAM and the SoCQ as instruments. The study was designed to examine the trends and patterns of teacher concerns about integrating technology into kindergarten through twelfth grade classrooms. Three central issues were addressed:

1. What pattern of concern is revealed about technology integration in the classroom in teachers' responses to the instrument?
2. Are there significant differences in concern among teachers with different perceptions of their levels of implementation status?
3. Does this study support the Hall et al. (1986) hypothesized development of stages of concern for teachers with different perceptions of their levels of implementation status?

Teachers' concerns were reported to be intense at the informational, personal, and refocusing stages. These findings suggested that this level of intensity may have been due to how far along teachers were in the implementation process with the technology. Teachers have a high level of concern about the commitment necessary to integrate technology into the curriculum.

There were significant differences in the concern scores reported among teachers associated with the three levels of perception. Teachers who perceived their levels of implementation status differently displayed very different attitudes. They thought and acted differently in terms of integrating technology into teaching and learning. These reactions could account for the significant differences in concern scores.

Liu and Huang (2005) suggested that, due to the innovations associated with technology being introduced as part of the curriculum, teachers' concerns were intense at the informational, personal, and refocusing stages. This concern profile supports the Hall et al. (1986) hypothesized development of Stages of Concern for each of the three user groups: inexperienced, experienced, and renewing. The importance of Liu and Huang's findings is that their recommendations suggested that technology be integrated into the professional development curriculum for teachers. Additionally, Liu and Huang stated that teachers who effectively integrate technology into classroom instruction should be rewarded. This idea ties directly to the formal training being considered in this study.

Chamblee et al. (2008) also studied what effects professional development had on teacher Stages of Concern, specifically high school mathematics teachers' concerns associated with the implementation of graphing calculators. Participants in this study were high school mathematics teachers who received 60 pre-service and 45 in-service training hours. The theoretical framework used was the CBAM, and the instrument used was the SoCQ.

Chamblee et al. (2008) used a pretest-posttest design utilizing the SoCQ with 22 participants during their first day of in-service and at the end of a two-week summer workshop. Demographic data was also collected on the teachers' backgrounds and their history of technology use. Two analyses were performed which involved mean stage scores. Raw scores were converted to percentile ranks, and an ANOVA was conducted at the end of the project on mean stage scores to determine concerns differences.

An analysis of the initial holistic stage scores (high awareness, information, personal, and collaboration holistic stage scores respectively) collected suggested that teachers were highly aware of graphing calculators and their uses and were willing to discover more about how the calculator would impact teaching mathematics, how much time it would take to implement the technology, and how to expand their knowledge about the technology. The data also suggested that the teachers:

> Had not yet begun to develop an understanding of the best uses of graphing calculators, think about the impact of using graphing calculators in relation to their students, and reflect on the benefits of using graphing calculators in the classroom (low management, consequence, and refocusing holistic stage scores (Chamblee et al., p. 190).

The demographic data gathered confirmed the findings of the SoCQ. The teachers indicated that most had attended “How-To” workshops but that the training lacked information regarding the actual use of the calculator as a tool for learning.

The analysis of the holistic scores from the post-professional development data at the end of the project showed higher management holistic stage scores, which indicated that concerns related to the knowledge of the technology had improved. The teachers were at the higher refocusing holistic stage of the CBAM model which suggested further refinement was desired. However, higher collaboration and refocusing holistic stage scores indicate that concerns were intense about fully implementing graphing calculators in the classrooms.

Chamblee et al. (2008) reported that the ANOVA revealed no significant differences ($p < .007$) between the pretest and posttest of the SoCQ, and, as a whole, the teacher's level of concern appeared unchanged by the treatment. Chamblee et al. theorized that "as mathematics teachers learned and implemented more graphing calculators applications, they became more concerned about how to best use graphing calculators to teach mathematics" (p. 191). Also, a lack of low-level concerns being measured by the SoCQ suggested that developers of graphing technology need to provide training that extends beyond the basic operation of the unit. The connection of the work of Chamblee et al. (2008) to this research was that the researchers agreed that teachers need professional development that will show exactly how to blend technology and curriculum efficiently and effectively.

Dewey et al. (2009) conducted quantitative research that considered teacher attitudes concerning graphing calculators. Dewey et al. focused on identifying teachers' personal philosophies and views on mathematics and how those philosophies and views reflect on curriculum and instructional practices. This study also sought to determine the availability and usage of the graphing calculator in the classroom.

The study used a modified version of *Use of and Attitude Towards Graphing Calculator* (UATGC) survey. High schools and middle schools teachers were surveyed, and teachers in 40 out of 75 schools responded. Seventy-eight percent reported access to some degree of school-provided graphing calculator technology. Chi-square tests and non-directional *t*-tests were used to determine if a relationship existed between certain teacher characteristics and the graphing calculator.

The UATGC was used to determine how teachers viewed changes in curriculum, instructional practices, and the role of graphing calculators in algebra instruction. Statistically significant differences ($p < .05$) were found when testing the relationship between teaching Algebra I and Algebra II. Statistically significant differences ($p < .01$) were also found when non-directional *t*-tests were conducted between teacher age and the number of graphing calculators being used and between the number of years teaching and graphing calculator use.

These findings suggested that a reason for the extreme attitudes associated with the use of graphing calculators is that "perceptions and attitudes regarding technology are not so much aimed at the technology itself, but rather stem from teacher's personal philosophies and views of mathematics" (Dewey, 2009, p. 384). The study also suggested that teachers were uncertain how to reconcile the capabilities of the graphing calculator with the mathematics curriculum. Findings indicated that many teachers believe that students must master a particular skill before the calculator can be used in place of that skill. Dewey's (2009) study recommended further examination of teacher's perspectives of technology and assessment of teachers' attitude towards technology.

Wozney, Venkatesh, and Abrami (2006) investigated teacher attitudes and computer technology practices of 764 teachers. The researchers wanted to know how personal and school-related factors impact a teacher's decision to implement the integration of technological innovation for learning. Wozney et al. used "Expectancy-Value Theory" as a model for understanding and predicting behavior in the process of adopting innovations.

Wozney et al. (2006) developed a survey from the Expectancy-Value Theory. The Technology Implementation Questionnaire (TIQ) consisted of 33 belief items that were divided into three broad motivational categories. These categories were designated as perceived expectancy of success, perceived value of technology, and perceived cost of technology use.

Wozney et al. (2006) found that "technology implementation is a dynamic process mediated by subjective teacher characteristics and by conditions in the school" (p. 192). They also reported that teachers who prefer more student-centered approaches towards instruction also are more likely to (a) integrate technology more often; (b) report a higher level of technology proficiency; and (c) report a higher level of technology integration into the curriculum. Wozney et al. also reported that expectancy of success and perceived value were the most important issues in differentiating levels of computer use among teachers.

Wozney et al. (2006) stated that to maximize the implementation of educational innovations professional development must be focused on how the innovation can enhance a teacher's expectation of success. The professional development that is offered must highlight the success of other teachers who have implemented the innovation into their instruction. Wozney et al. stated that "Teachers also need to be convinced of the value of technology as a tool to supplement and improve classroom practice" (p. 195). Wozney et al. also stated that professional learning communities should be formed around the technological innovation to assist teachers in addressing issues and challenges that arise during the implementation of the technology.

The research of Wozney et al. (2006) connected to this study through the research that was conducted concerning teacher attitudes. The study connected the teacher's attitude and concerns towards a new innovation (technology) and how well the innovation is being integrated into teaching and learning. Wozney et al. also stated that future research is needed that focuses on additional factors like peer and administrative support. This recommendation ties to Research Question Two where administrative policies allow for a technological innovation to be used in one state for assessment and not in the other.

Summary

The review of literature reveals that there is much debate concerning the use of graphing calculators in the teaching and learning of mathematics (Acelajado, 2004; Guerrero, et al., 2004; Heller, et al., 2005). Research suggests that the attitudes and concerns of the teacher are the strongest predictors of success in integrating technology in the classroom (Atkins & Vasu, 2000; Doerr & Zangor, 2000; Wozney et al. 2006). The influence of technology can assist the teacher in a progression through the Stages of Concern and in the adoption of a new innovation (Chamblee et al., 2008; Hord et al., 2008; Liu & Huang, 2005). The literature reviewed also supports the need for further research that assesses teacher attitudes towards the graphing calculator and the teaching and learning of mathematics (Chamblee et al, 2008; Dewey et al., 2009; Liu & Huang, 2005).

Teaching mathematics with or without the graphing calculator is an educational issue much like that of the competing paradigms described by Kuhn (1962) when he said:

> Though each [scientist] may hope to convert the other to his way of seeing his science and its problems, neither may hope to prove his case. The competition between paradigms is not the sort of battle that can be resolved by proofs. (p.147)

Kuhn (1962) did offer some resolution by stating "Individual scientists embrace a new paradigm for all sorts of reasons and usually for several" (p. 151). Measuring and studying the beliefs (concerns) of teachers could lead to a paradigm shift in the use of the graphing calculator (Kuhn, 1962). Teachers can influence and assist students with the emergence of the graphing calculator as a tool for learning (Doerr & Zangor, 2000).

CHAPTER THREE: METHODOLOGY

Introduction

This chapter provides a framework for how the research was conducted. The contents of this chapter include a description of the design of the study, the participants of the study, the research questions, research and null hypotheses, the setting of the study, the instrument used for the study, the data collection procedures, the test assumptions, and a summary of chapter content.

The purpose of this study was to utilize the SoCQ to examine the concerns of teachers in reference to an innovation, the graphing calculator. Research Question 1 asked if means between peak stage scores (stages 0-6) on the SoCQ, or a linear combination of these scores, were the same or different based the relationship with the amount of teaching experience with a graphing calculator or formal training with the graphing calculator. This study utilized a two-way multivariate analysis of variance (MANOVA) to determine the effect of two independent variables, formal training and experience teaching with a graphing calculator, on seven dependent variables, teachers' Stages of Concern (stages 0-6).

Research Question 2 asked if means between stage scores (stages 0-6) on the SoCQ, or a linear combination of these scores, were the same or different based on the teacher's state of employment. A one-way MANOVA was conducted to determine if there was a statistically significant difference in means between the dependent variables (stages 0-6) and the independent variable, state, where a teacher is employed (Georgia or Tennessee).

Design of the Study

A causal-comparative design was used in this research study. A causal-comparative design was selected because it examines the relationship among variables in studies in which the independent variable has already occurred and where it was impossible to manipulate the independent variable (Best & Kahn, 2006).

The first research question asked if there was a significant difference between the mean stage score of the seven dependent variables (stages 0-6) based on formal training and teaching experience with the graphing calculator. Formal training has two levels, eight hours or less of training and more than eight hours of training, and teaching experience has three levels, novice (0-5 years), moderate (6-10 years), and experienced (11 years or more). The second research question asked if an independent variable, the state a teacher is employed (Georgia or Tennessee) had a statistically significant effect on seven dependent variables, teachers' Stages of Concern (stages 0-6). The two levels of the independent variable was known to differ in that Tennessee students are allowed to use the innovation (the graphing calculator) on state-mandated end-of-course examinations (TDOE, 2011). Georgia students are not allowed to use the innovation on similar end-of- course examinations (GDOE, 2011).

The number of high school teachers of mathematics in both study areas (Northwest Georgia and Southeast Tennessee) was estimated to be approximately 825.

Because only 10 of the potential 16 school systems in Northwest Georgia gave permission for the study, and only three of the potential 12 school systems in Southeast Tennessee gave permission for the study, the invitations numbered only 275. The final sample of math teachers invited to participate from within the Northwest Georgia Regional Educational Service Agency (RESA) was 151, and the final sample of math teachers invited to participate from within the Southeast Tennessee Field Service Center (FSC) service areas was 124.

Convenience sampling was used because of the limited numbers of cases available. The researcher made the assumption that, due to the difference in the timing of the introduction of graphing calculators in Georgia as compared to Tennessee, all subgroups did include teachers with varying years of teaching experience and formal training. The demographic data collected independent of the SoCQ was used to confirm this assumption. Data was collected from the sample directly from the SEDL website using the described instrument along with the demographic survey that contained specific questions designed to gather data concerning the predictor variables.

The participants were selected based on their teaching level and content area. Only high school teachers of mathematics, both general and special education resource teachers, were invited to participate in the study. Special education teachers (in both Georgia and Tennessee) who were assigned to self-contained or resource classrooms were required to be certified in high school mathematics. This group of teachers had fields of endorsements that included grades six through twelve (mathematics) which was the same as the requirements for high school teachers of mathematics who teach in general education classrooms.

Research Questions and Null Hypothesis

This study addressed the following research questions:

Research Question 1: Is there a statistically significant difference in a linear combination of teachers' mean stage scores (stages 0-6) based on their experience teaching with a graphing calculator and the formal level of training with a graphing calculator?

Research Hypothesis 1.1: There will be a statistically significant difference in a linear combination of teachers' mean stage scores (stages 0-6) based on teaching experience with the graphing calculator and the formal level of training with a graphing calculator. If this hypothesis is found significant, then hypotheses that examine each dependent variable individually will be tested.

Research Hypothesis 1.2: There will be a statistically significant difference in a linear combination of teachers' mean peak stage scores (stages 0-6) based on teaching experience with the graphing calculator. If this hypothesis is found significant, then hypotheses that examine each dependent variable individually will be tested.

Research Hypothesis 1.3: There will be a statistically significant difference in a linear combination of teachers' mean stage scores (stages 0-6) based on the formal level of training with a graphing calculator. If this hypothesis is found significant, then hypotheses that examine each dependent variable individually will be tested.

Null Hypothesis 1.1: There will not be a statistically significant difference in a linear combination of teachers' mean stage scores (0-6) based on teaching experience with the graphing calculator and the formal level of training with a graphing calculator.

Null Hypothesis 1.2: There will not be a statistically significant difference in a linear combination of teachers' mean stage scores (0-6) based on teaching experience with the graphing calculator.

Null Hypothesis 1.3: There will not be a statistically significant difference in a linear combination of teachers' mean stage scores (stages 0-6) based on the formal level of training with a graphing calculator.

Research Question 2: Is there a statistically significant difference in a linear combination of teachers' mean stage scores (stages 0-6) according to the teacher's state of employment?

Research Hypothesis 2.1: There will be a statistically significant difference in a linear combination of teachers' mean stage scores (0-6) based on the teacher's state of employment. If this hypothesis is found significant, hypotheses that examine each dependent variable individually will be tested.

Null Hypothesis 2.1: There will not be a statistically significant difference in a linear combinations of teachers' mean stage scores (0-6) based on the teacher's state of employment.

Participants

The population of interest included all high school mathematics teachers who were teaching in Northwest Georgia and Southeast Tennessee. The number of high school teachers of mathematics in both study areas (Northwest Georgia and Southeast Tennessee) was estimated to be approximately 825. Because only seven of the potential 16 school systems in Georgia gave permission for the study, and because only three of the potential 12 school systems in southeast Tennessee gave permission for the study, the only 275 invitations were issued.

Of the 275 invitations that were sent to teachers, 128 responded (46.55%). The participation by state was as follows: In Georgia, 124 teachers were invited to participate, and 55 responded (43.00%). In Tennessee, 151 teachers were invited to participate, and 73 responded (48.67%).

Convenience sampling was used and the assumption was made that the data was representative of the target population. The demographic data collected independent of the SoCQ was used to evaluate this assumption.

High school teachers of mathematics who were either general education teachers or special education resource teachers were invited to participate in the study. Special education teachers, who were assigned to self-contained or resource classrooms, are required to be certified in high school mathematics in both Georgia and Tennessee. This group of teachers had fields of endorsements that include sixth through twelfth grade mathematics, which is the same endorsement required of high school teachers of mathematics.

A demographic survey (attached to the SoCQ) of the seven school systems in Georgia and the three school systems in Tennessee was distributed by the researcher via the internet (the teachers' school email). The assumption was made that the teacher demographics (e.g., ethnicity, gender, age, and time in the classroom) of the Georgia sample were statistically similar to the teacher demographics of the Tennessee sample. Demographic data collected during the survey was used to evaluate the assumption that each sample was representative of the population.

The final sample did include 128 math teachers located within 10 high schools in the RESA (n = 55) and 3 high schools in the FSC service areas (n = 73). The actual demographics are reported next.

Demographics

Grade Level

The first question of the demographic section of the survey addressed grade level. All groups were represented at essentially the same level except for the ninth grade Georgia group which was approximately 8% larger than the Tennesse group. Table 3.1 presents the results of the grade level data.

Table 3.1

Paricipants by Grade Level as a Percent

	9th	%	10th	%	11th	%	12th	%
Total	43	(33.60)	26	(20.30)	41	(32.00)	18	(14.10)
Tennessee	22	(30.10)	14	(19.20)	25	(34.30)	12	(16.40)
Georgia	21	(38.20)	12	(21.80)	16	(29.10)	6	(10.90)

Note: % is used as an abbreviation for Percentage.

Teacher Experience

The next demographic examined was overall teaching experience. Teachers were asked to give their total teaching experience in complete school years, and the samples are essential equal. Table 3.2 shows that the samples were essentially equal.

Table 3.2

Teaching Experience by State

	Tennessee	Georgia	Total
Mean	15.4	15.3	15.3
Standard Deviation	11.2	12.3	11.8

Teacher Certification

Special Education teachers of mathematics who are asssigned to resource (contained) classrooms hold the same mathematics certification as general education teachers who were also invited to participate in the study. Of the 128 teachers who participated, five (3.90%) indicated that they were special education teachers. In

Georgia, three out of 55 (5.80%) teachers were special education teachers; in Tennessee, two out of 73 (2.80%) teachers were special education teachers.

Subject Areas Taught

The examination of the subjects areas being taught by participants revealed that all subject areas were almost equally represented. Tennessee was, at the time of this study, still following a standard sequence of math subjects for a student's ninth, tenth, and eleventh grades (Algebra 1, Geometry, and Algebra 2) while Georgia had adopted the integrated math series for a student's ninth, tenth, and eleventh grades (Math 1, Math 2, and Math 3). The following was the percentage of participants who were teaching at each grade level when the survey was given:

- 9th grade math 29.69%:
- 10th grade math 23.44%:
- 11th grade math 25.78%:
- 12th grade math, 17.96%:

Almost all grade levels were approximately equally represented. However, there was a significant difference (11.71%) in the number of teachers teaching ninth and tenth grade math between states. Georgia offers a math support class that is taught along with Math 1, Math 2, and Math 3 (2011-2012 school year). Students typically exit the math support series as they advance through the grade levels. These additional classes and reduction in math support class size by the 11th grade could account for the higher percentages of Georgia teachers who teach math in grades nine and ten. Table 3.3 displays the subjects taught by grade level.

Table 3.3

Curriculum Being Taught by Participants Most Often by Grade Level

Grade	Subject	TN	%	Subject	GA	%	Total	%
9th	Algebra 1	18	24.66	Math 1	20	36.37	38	29.69
10th	Geometry	15	20.54	Math 2	15	27.27	30	23.44
11th	Algebra 2	21	28.77	Math 3	12	21.82	33	25.78
11th	Pre-Cal	83	10.96	Pre-Cal	3	5.45	11	8.59
12th	Algebra 3	3	4.11	Math 4*	0	0	3	2.34
12th	Calculus	6	8.22	Calculus	2	3.64	8	6.25
12th	Statistics	1	1.37	Statistics	0	0.00	1	1.78
	Other	1	1.37	Other	3	5.45	4	3.13
Total		73	100.00		55	100.00	128	100.00

Note. TN and GA are abbreviations for Tennessee and Georgia. % is used as an abbreviation for Percentage. Pre-Cal is used for an abbreviation for Pre-Calculus. Math 4 will not be offered in Georgia until the 2011-2012 school year.

Education

Demographic data was collected according to each participant's highest educational degree obtained. Seventy-two percent of Georgia teachers hold either a masters or specialist degree, and 58% of Tennessee teachers have similar degrees. The state of Tennessee does not offer an increase in pay for the educational specialist degree which could account for the difference (30.4%) in specialist degrees earned between the two states.. Table 3.4 lists the teachers' degrees earned by state.

Table 3.4

Participant's Highest Degree Earned

Degree	Tennessee	%	Georgia	%	Total	%
Bachelors	26	35.60	13	23.60	39	30.50
Masters	42	57.50	21	38.20	63	49.20
Ed.Specialist	3	4.10	19	34.50	22	17.20
Doctorate	2	2.80	2	3.70	4	3.1
Total	73	100.00	55	100.00	128	100.00

Note: % is an abbreviation for percentage.

Ethnicity

Demographic information was collected concerning the participant's ethnicity. The two samples appear representative of the population. For the total sample, one participant self-reported (.78%) Hispanic or Latino, seven (5.47%) reported Black or African-American, and 120 participants (93.75%) indicated that they were Caucasian. The Georgia sample reported that one (1.82%) of the 55 participants was of Hispanic or Latino descent, the remainder of the Georgia sample indicated that they were Caucasian. The Tennessee sample reported seven (9.59%) of the 73 participants were black or African-American while the remainder of the Tennessee sample indicated Caucasian.

Gender

Among the Total Group category, there were 48 (37.50%) male participants and 80 (62.50%) female participants. The Georgia participants reported 19 (34.50%) males and 36 (65.50%) females. The Tennessee participants reported 29 (39.70%) males and 44 (63.30%) females.

Setting

The Northwest Georgia RESA and Southeast Tennessee FSC are both agencies that support teachers' professional development. The two service areas of the agencies' border each other, and the student demographics of both areas are similar in ethnicity, population, age, gender, and socio-economic status. The Georgia Department of Education (2010) reported that 50% of students in school districts located in the Northwest Georgia RESA service area participate in free or reduced lunch benefits that the annual teacher salary averages $45,800, and that minority enrollment is approximately 34%. The Tennessee Department of Education (2010) reported that 42% of students located in the Southeast Field Service area participate in free or reduced lunch benefits and that the annual teacher salary averages $42,600, and the minority enrollment is approximately 30%.

Northwest Georgia RESA serves the Bartow County, Bremen City, Calhoun City, Cartersville City, Catoosa County, Chattooga County, Chickamauga City, Dade County, Floyd County, Gordon County, Haralson County, Paulding County, Polk County, Rome City, Trion City, and Walker County school systems. In this service area, the graphing calculator is considered a learning tool that enhances a student's understanding of mathematics. The use of the graphing calculator is encouraged by the Georgia

Department of Education for instruction, but the technology is not allowed on state-mandated End-of-Course tests.

The Southeast Tennessee FSC serves the Bradley County, Cleveland City, Hamilton County, Marion County, Richard City, McMinn County, Athens City, Etowah City, Meigs County, Polk County, Rhea County, and Dayton City schools. The use of the graphing calculator in the state of Tennessee differs from Georgia in that the technology is introduced as early as the seventh grade and is allowed on state-mandated End-of-Course tests.

Instrumentation

The CBAM is a tool to help administrators identify the specific needs of individuals involved in a change process (George et al. 2008). CBAM is also implemented to address the needs of teachers based on data gathered through the framework's diagnostic dimensions (George et al., 2008; See Figure 1.1, p. 12). CBAM was described by Chamblee et al. (2008) as being often used to document the change process when stimuli are introduced. Hall, Wallace, and Dossett (1986) developed the CBAM using the research of Fuller (1969) to measure the change that individuals experience as they are exposed to, and become familiar with, an innovation.

George et al. (2008) described the CBAM as a framework that was developed in the 1970's as a result of numerous attempts to package and sell educational best practices as "discrete innovations or programs, developed by an external force and presented to teachers and schools as a package product" (p. 1). The idea behind the products was that the teachers only had to open and implement the product for success to be ensured. In most cases, the expected results were not the actual outcome (George, et al., 2008).

Further research and experimentation by Hall et al. (1986) led to the development of the SoCQ. The SoCQ is considered to be a component of CBAM and is used to measure concerns that develop as a result of new innovations being introduced to teachers and students. George et al. (2008) reported that definite categories of concern exist when a new innovation is introduced, and individuals generally exhibit a logical progression as teaching experience is obtained. According to George et al., the SoCQ instrument is based on seven different types of concerns an individual could express about a change: unconcerned (stage 0), informational (stage 1), personal (stage 2), management (stage 3), consequence (stage 4), collaboration (stage 5), and refocusing (stage 6). A more in-depth description is given in Appendix D, Figure 1.2. The SoCQ is a 35 item Likert-scale instrument with eight levels of responses. Responses on the instrument are ordered zero through seven on the Likert scale (zero is the lowest; seven is the highest) according to how true a statement seems to the participant at the time (George et al., 2008). The raw scores are totaled and converted to percentile scores using a conversion chart (see Appendix D, Figure 3.1) to construct profiles for individual participants and groups. However, the researchers recommended that raw scores (0-35) for stages zero through six be used for statistical analyses.

Internal Reliability

The internal reliability for the SoCQ's individual scales ranges from r = .64 to r = .83. These alpha scores were obtained through research conducted by George et al. (2008). To ensure high internal reliability, George et al. included a statement, or item, only if it had responses that correlated more highly with responses to other items measuring the same Stage of Concern than with responses to items in other stages. Table 3.5 below shows the alpha coefficients of internal consistency for each of the seven Stages of Concern scales. These coefficients reflect the degree of reliability among items on a scale in terms of overlapping variance. The formula is a generalization of the Kuder-Richardson Formula 20 for dichotomous items. The coefficients in Table 3.5 were computed by using data from a stratified sample of 830 teachers and professors, from their first exposure to the 35-item questionnaire.

Table 3.5

Coefficients of Internal Reliability for the Stages of Concern Questionnaire[a*]

Stage	0	1	2	3	4	5	6
Alpha	.64	.78	.83	.75	.76	.82	.71

Note. Reprinted with permission of SEDL.

[a]*n = 830, 35 items

After initial completion of the instrument, random samples of 171 participants were asked to complete the SoC questionnaire a second time. George et al. reported that 132 participants completed and mailed in the retest data. Table 3.6 shows the test-retest correlation (George et al., 2008). George et al. also reported that the percentile scores used were based on a group of 830 elementary, secondary, and higher education teachers.

Table 3.6

Test-Retest Correlations on the Stages of Concern Questionnaire[a*]

Stage	0	1	2	3	4	5	6
Alpha	.65	.86	.82	.81	.76	.84	.71

Note. Reprinted with permission of SEDL.
[a*] n = 132

The distribution of the highest Stages of Concern is given in Table 3.7. The diversity of the group allowed reliable estimates of alpha coefficients and other characteristics of the SoCQ (George et al., 2008).

Table 3.7

Percent of Respondents' Highest Stage of Concern, Initial Sample[a*]

Stage	0	1	2	3	4	5	6
Percent	22	12	9	13	13	20	11

Note. Reprinted with permission of SEDL.
[a*] n = 830

Validity

George et al. (2008) reported that the validity of the SoCQ was established by examining the relationship of SoC scale scores with variables related to concerns theory. Also, intercorrelation matrices, interview data, and confirmation of group differences over time were used to investigate the validity of the SoCQ scores.

The first analysis was obtained from a 195-item pilot checklist that surveyed 363 teachers (George et al. (2008). The analysis of the data (n = 363) indicated that 83% of the items correlated more with the stage in which the teachers had scored than with the total score on the instrument (George et al., 2008). It was also reported that 72% of the teachers' scores correlated more highly with the stage in which the individual teacher had scored than with any other stage's scale score.

Procedures

Approval for this study was given by local school districts (see Appendix E) and the Liberty University Institutional Review Board (see Appendix F) on April 27, 2011. Next, a letter (see Appendix G) was sent through the United States Postal Service to potential participants (n = 275) explaining the survey. This letter was designed to give participants information concerning the study to make them aware that contact would be made electronically, and ensure confidentiality. Also enclosed was a consideration of $1.00 as a monetary incentive. This incentive in no way obligated the prospective participant, and the gratuity was retained whether or not there was participation in the study.

Superintendents from several participating school districts requested that the questionnaire be released at a time when it would not interfere with state-mandated testing. For this reason, the questionnaire was released in Tennessee school districts one week ahead of school districts in Georgia. Schools districts agreeing to participate from Tennessee were Bradley, Hamilton, and Marion. School districts agreeing to participate from Georgia were Bartow, Brantley, Cartersville, Charlton, Chickamauga, Floyd, and Murray. Brantley, Charlton, and Murray county schools where added with the permission of the chairperson of the committee for this study in order to balance the two survey groups more evenly between Tennessee and Georgia.

Letters were mailed to 151 potential Tennessee participants (see Appendix G) on May 2, 2011. The questionnaire link was sent electronically via the participant's school email on May 9, 2011. First and second reminders (see Appendices H & I) were sent May 16, 2011, and May 23, 2011, respectively. The last reminder (see Appendix J) was sent on May 31, 2011.

Letters were mailed to 124 potential Georgia participants (see Appendix G) on May 9, 2011. The questionnaire link was sent electronically via the participant's school email on May 16, 2011. First and second reminders (see Appendices H & I) were sent May 23, 2011, and May 31 2011, respectively. The last reminder (see Appendix J) was sent on June 6, 2011.

Data Screening

The data was entered into SPSS 19.0 and converted on the data view page to data labels to allow for proofreading. The cases were compared to individual data reports provided by SEDL, and corrections were made to one case found to be mis-entered. Proofreading did not produce any missing data. SPSS Missing Values Analysis (MVA) was also used to confirm the proofreading results (See Appendix D, Figure 4.1)

Data Analysis

Research Question 1 asked if there was a statistically significant difference in teachers' combination of mean stage scores (stages 0-6) based on their experience teaching with a graphing calculator and graphing calculator level of training.

The corresponding hypotheses were examined using a two-way MANOVA. A two-way MANOVA was chosen because the dependent variables, teachers' concerns (stages 0-6), were known to be present over seven stages, and two effects (training and experience) were being used as independent variables. Because of multiple dependent variables and two independent variables, a different linear combination of dependent variables was formed for each main effect, or independent variable and MANOVA emphasized the mean differences and statistical significance between all linear combinations. Also, a MANOVA could have revealed differences that would not be observed by conducting multiple ANOVAs. When responses to multiple dependent variables are considered in combination, group differences can become apparent. Finally, MANOVA was chosen over a series of ANOVAs because the MANOVA protects against inflated Type I error due to multiple tests of likely correlated dependent variables.

Assumption testing was conducted for outliers, univariate and multivariate normality, multicollinearity and singularity, linearity, homoscedasticity, and homogeneity of variance across groups. The data was checked for outliers by creating boxplots using SPSS and splitting the data according to levels of the dependent variables (stages 0-6). There were no extreme outliers observed.

Univariate normality was checked by conducting Shapiro-Wilk tests and Kolmogorov-Smirnov tests. The Kolmogorov-Smirnov was used for the training variable because all cell sizes exceeded 50 cases (73, 8 hours or less; 55, more than 8 hours) and reported normality was violated for stages two, three, and four at eight hours or less (p = .004, p = .001, & p = .005). Also, the Shapiro-Wilk tests was used for the teaching experience variable due to the cell sizes being less than 50 (novice, 61; moderate, 27; & experienced, 28) and reported that normality could not be assumed for stage 0, experienced (p = .009), stage 1, experienced (p = .006), stage 2, experienced (p = .003) stage 3, moderate (p = .019) and experienced (p = .001), and Stage 6, moderate (p = .026) and experienced (p = .015). The normality assumption was tenable for all other variables. Multivariate normality was checked by assessing Mahalanobis distance for both teaching with a graphing calculator and training with a graphing calculator. The value was evaluated for each case using the Chi-Square distributions and one case for each independent variable exceeded the critical value of 24.32. A detailed discussion of this violation appears in Chapter Four.

Multicollinearity and singularity were checked by creating correlation matrices. Correlations were not observed above .735, thus, the assumptions multicollinearity and singularity were considered tenable. Linearity was checked by examining scatterplots and the presence of a curvilinear line was not detected; therefore, the assumption of linearity was tenable. The results of Levene's Test of Equality of Error provided evidence that the assumption of homogeneity of variance across groups was not satisfactory for stage 2, stage 3, or stage 6. Therefore, a more conservative alpha level of .025 was used for stages 2, 3, and 6. All others were satisfactory. Box's *M*, which is part of the MANOVA output for SPSS was used to assess the assumption of the homogeneity of variance-covariance. The assumption was tenable based on the results of Box's test. Details concerning the assumptions are further described in Chapter Four.

Tabachnick and Fidell (2007) stated "when the research design is less than ideal, then Pillai's criterion is the criterion of choice" (p. 269). Because of violations of the assumptions of normality, and of homogeneity of variance across groups, Pillai's Trace was used to assess the null hypothesis. Effect size was reported with the eta square statistic and interpreted using Cohen's conversions. The interpretation was based on thresholds of .10 for a small effect, .25 for a medium effect, and .40 for a large effect.

Pairwise comparisons were conducted to find which level of experience affected the Stage of Concern most strongly. Scheffe's procedure was used to protect against inflated Type I error due to multiple tests. Also, the Bonferroni method was used to control for Type I error across pairwise comparisons. The alpha levels were set for stages 0, 1, 4, and 5 was .007 (.05/7). A more conservative alpha level of .003 (.025/7) was used for stages 2, 3, and 6 because the assumption of homogeneity of variance across groups was not satisfactory for stage 2, stage 3, and stage 6.

Research Question 2 asked if there is a statistically significant difference in the linear combinations of mean stage scores (stages 0-6) according to the teacher's state of employment.

A one-way MANOVA was used to analyze mean differences in the dependent variables, mean stage scores (stages 0-6), against a teacher's state of employment. A one-way MANOVA was chosen because the dependent variables, teachers' concerns (stages 0-6), were known to be present over seven stages, and one effect (state) with two levels (Georgia and Tennessee) was being used as independent variables. Because of multiple dependent variables and one independent variable with two levels, different linear combinations of dependent variables were formed for each main effect, or independent variable, and MANOVA emphasized the mean differences and statistical significance between all linear combinations. A MANOVA could have revealed differences that would not be observed by conducting multiple ANOVAs. When responses to multiple dependent variables are considered in combination, group differences can become apparent. Also, the MANOVA was chosen over a series of ANOVAs because the MANOVA protects against inflated Type I errors due to multiple tests of likely correlated dependent variables.

Assumption testing was conducted for outliers, univariate and multivariate normality, multicollinearity and singularity, linearity, homoscedasticity, and homogeneity of variance across groups. The data was checked for outliers by creating boxplots using SPSS and splitting the data according to levels of the dependent variables (stages 0-6). There were no extreme outliers observed. Univariate normality was checked by conducting Kolmogorov-Smirnov tests. In respect to the state variable, cell sizes were 55 for Georgia and 73 for Tennessee. The Kolmogorov-Smirnov test reported that normality was violated for stages 1, 3, and 6 at the Tennessee level (p = .017, p = .005, & p = .030). The normality assumption was tenable for all other variables. Mahalanobis distance was used to examine multivariate normality, and the maximum distance was given to be 25.303 which exceeded the critical value of 24.32 using the Chi-Square distributions. The assumption was not assumed tenable. A detailed discussion of this violation appears in Chapter Four.

Multicollinearity and singularity were checked by creating correlation matrices. Correlations above .735 were not observed; therefore, the assumptions were considered tenable. Linearity was checked by examining scatterplots. Since a curvilinear line was not detected, the assumption was considered tenable.

The results of Levene's Test of Equality of Error provided evidence that the assumption of homogeneity of variance across groups was satisfactory, and the assumption was tenable. Box's *M* was used to test the assumption of the homogeneity of variance-covariance. The assumption was not tenable; this is discussed in Chapter Four.

The effect size was reported with the eta squared (η^2) statistic and interpreted using Cohen's conversions. The interpretation was based on thresholds of .10 for a small effect, .25 for a medium effect, and .40 for a large effect.

Summary

Technology is recommended in the teaching and learning of mathematics (NCTM, 2000). The introduction of graphing calculators into the classroom is a change process that affects instruction, and teachers naturally have concerns about that change

(Hord et al., 2008). The CBAM is a framework that was designed to provide diagnostic information to school administrators, and the SoCQ is an instrument that is designed to capture the concerns of individuals affected by the change (Hord et al., 2008).

This methodology was designed to collect and analyze information related to teacher concerns about an innovation, the graphing calculator. The study was designed to determine if means between peak stage scores (stages 0-6) on the SoCQ, or a linear combination of these scores, were the same or different based on the relationship between the amount of teaching experience with a graphing calculator or formal training with a graphing calculator. Also, the study was designed to determine if there was a difference in the linear combinations of teachers' mean stage scores (0-6) according to the teacher's state of employment.

A demographic section (Appendix B) was added to the SoCQ survey to provide data connected to the participants' teaching experiences and the amount of formal training with graphing calculators. A two-way MANOVA was conducted to determine if there was a statistically significant difference in the effect of two independent variables, formal training and experience teaching with a graphing calculator, on seven dependent variables, and teachers' Stages of Concern (stages 0 to 6). Also a one-way MANOVA was conducted to determine if there was a statistically significant difference in the linear combinations of mean stage scores according to the teacher's state of employment. This analysis was selected to create a linear combination of dependent variables to maximize mean group differences. MANOVA had a number of advantages over ANOVA for revealing the direction and size of the correlations among dependent variables so MANOVA strengthened the research findings.

CHAPTER FOUR: FINDINGS

Introduction

The primary purpose of this study was to determine if there was a statistically significant difference in the concerns of teachers in regards to the use of a graphing calculator based on their years of experience using a graphing calculator during instruction or the amount of training they have received on how to utilize a graphing calculator for instruction. This chapter presents an analysis of the data collected during the research phase of the study. The statistical results and accompanying graphical representations are organized according to the research hypotheses.

Data Analysis

Research Question 1

The following section discusses analysis concerning research question 1 and corresponding research and null hypotheses.

Research Question 1: Is there a statistically significant difference in a linear combination of teachers' mean stage scores (stages 0-6) based on their experience teaching with a graphing calculator and the formal level of training with a graphing calculator?

Research Hypothesis 1.1: There will be a statistically significant difference in a linear combination of teachers' mean stage scores (stages 0-6) based on teaching experience with the graphing calculator and the formal level of training with a graphing calculator. If this hypothesis is found significant, hypotheses that examine each dependent variable individually will be tested.

Research Hypothesis 1.2: There will be a statistically significant difference in a linear combination of teachers' mean stage scores (stages 0-6) based on teaching experience with the graphing calculator. If this hypothesis is found significant, hypotheses that examine each dependent variable individually will be tested.

Research Hypothesis 1.3: There will be statistically significant difference in a linear combination of teachers' mean stage scores (stages 0-6) based on the formal level of training with a graphing calculator. If this hypothesis is found significant, hypotheses that examine each dependent variable individually will be tested.

Null Hypothesis 1.1: There will not be a statistically significant difference in a linear combination of teachers' mean stage scores (stages 0-6) based on teaching experience with the graphing calculator and the formal level of training with a graphing calculator.

Null Hypothesis 1.2: There will not be a statistically significant difference in a linear combination of teachers' mean stage scores (stages 0-6) based on teaching experience with the graphing calculator.

Null Hypothesis 1.3: There will not be a statistically significant difference in a linear combination of teachers' mean stage scores (stages 0-6) based on the formal level of training with a graphing calculator.

A two-way multivariate analysis of variance (MANOVA) was conducted to determine the effect of two independent variables, formal training and experience teaching with a graphing calculator, on seven dependent variables, teachers' stages of concern (stages 0-6). The formal training variable had two levels: eight hours or less of training and more than eight hours of training. The teaching with a graphing calculator variable had three levels, novice (0-5 years), moderate (6-10 years), and experienced (11 or more years).

The pooled means and standard deviations for the dependent variables, stages zero through six, were: M_{s0} = 14.48 (*SD* = 6.67), M_{s1} = 13.85 (*SD* = 6.82), M_{s2} = 12.99 (*SD* =7.16), M_{s3} = 10.43 (*SD* = 5.66), M_{s4} = 16.35 (*SD* = 6.51), M_{s5} = 15.60 (*SD* = 7.04), and M_{s6} = 13.84 (*SD* = 5.82). Descriptive statistics disaggregated by training and experience are in Table 4.1.

Table 4.1

Descriptive Statistics Disaggregated by Training and Teaching

	Training				Teaching					
	Eight or less		Nine plus		Novice		Moderate		Experienced	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Stage 0	15.70	6.82	12.85	6.16	16.52	6.78	12.61	5.15	12.41	6.80
Stage 1	14.53	6.72	12.91	6.90	16.51	6.33	11.70	6.39	10.78	6.27
Stage 2	12.95	7.01	13.05	7.42	14.63	7.55	11.94	5.90	10.84	6.97
Stage 3	10.73	5.82	10.04	5.64	11.52	5.95	10.67	5.63	8.03	4.38
Stage 4	15.07	6.25	18.05	6.51	16.49	6.62	16.42	6.27	16.00	6.71
Stage 5	14.67	7.89	16.84	6.70	15.92	7.22	14.06	6.15	16.56	7.47
Stage 6	12.67	4.85	15.40	6.63	13.86	5.38	13.85	6.37	13.81	6.25

Note. $n = 128$. Training is expressed in hours and teaching in years.

Assumption testing was conducted for outliers, univariate and multivariate normality, multicollinearity and singularity, linearity, and homoscedasticity. The data was checked for extreme outliers by creating boxplots using SPSS. Boxplots were created with split data sets according to levels of the independent variable. Outliers were observed at stage three (scores of 28 and 31) and stage six (two scores of 30). However, all were determined to be less than 1.5 times the interquartile range (IRQ) above the third quartile and classified as mild (Assumption Testing, personal communication, 2012). There were no extreme outliers observed.

To examine the univariate normality of each dependent variable for each independent variable Shapiro-Wilk tests (sample sizes smaller than 50) and Kolmogorov-

Smirnov tests (sample sizes 50 or larger) were used. These tests were conducted using SPSS 19 in two groups. First, training with two levels (eight hours or less and more than eight hours) was tested against stage 0 through stage 6 and then teaching experience with three levels (novice, 0-5 years, moderate, 6-10 years, and experienced, 11 plus years) against stages 0 through stage 6. In respect to the training variable, cell sizes were 73 for eight hours or less and 55 for more than eight hours. Cell sizes for the teaching experience were: novice-61 participants, moderate-27 participants, and experienced-28 participants.

The Kolmogorov-Smirnov reported that normality was violated for stages two ($p = .004$), three ($p = .001$), and four ($p = .005$) at eight hours or less for the training variable. Also, normality could not be assumed for the teaching variable for stage 0, experienced ($p = .009$), stage 1, experienced ($p = .006$), stage 2, experienced ($p = .003$) stage 3, moderate ($p = .019$) or experienced ($p = .001$), and Stage 6, moderate ($p = .026$) or experienced ($p = .015$). The normality assumption was tenable for all other variables.

To test multivariate outliers, the Mahalanobis distance values were addressed. The value was evaluated for training with a graphing calculator and teaching with a graphing calculator. The variables were evaluated for each variable (training and teaching) by using the Chi-Square distributions. One case for each variable (training-25.303 and teaching-25.159) exceeded the critical value of 24.32, thus the assumption was not tenable. This aligns with DeCarlo (2010) "If univariate distributions are nonnormal, then the multivariate distribution will be nonnormal" (p. 1). However, DeCarlo (2010) also stated that, “In practice, many structural equations models with continuous variables will not have severe problems with nonnormality” (p. 1). According to Tabachnick and Fidell (2007) “With univariate *F*, and large samples, the central limit theorem suggests that the sampling distribution of means approach normality even when raw scores do not” (p. 251). A sample size of 128, which included a minimum of 27 participants in each cell and more than 116 degrees of freedom for error, ensured multivariate normality of the sampling distribution of means.

Multicollinearity and singularity were checked by creating correlation matrixes using SPSS and checking for high correlation. Table 4.2 displays the Pearson correlation matrix. Since correlations were not observed above .735, the assumptions of multicollinearity and singularity are tenable.

Table 4.2

Correlation Coefficients for Relations Between Stages of Concern

	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6
Stage 0	-						
Stage 1	.221*	-					
Stage 2	.153	.735**	-				
Stage 3	.223*	.611**	.527**	-			
Stage 4	-.074	.523**	.520**	.372**	-		
Stage 5	-.250**	.406**	.448**	.267**	.576**	-	
Stage 6	.072	.513**	.523**	.451**	.693**	.362**	-

Note. $^{*}p<.05$, $^{**}p<.01$

Linearity was checked by examining scatter plots (see Appendix K). The presence of a curvilinear line was not detected, which indicates that the assumption that linear relationships among all pairs of dependent variables, all pairs of covariates, and all dependent-covariate pairs are tenable.

The assumption of homoscedasticity was determined by Levene's Test of Equality of error for homogeneity of variance and Box's M for homogeneity of the variance-covariance matrices. The results of Levene's Test of Equality of Error provided evidence that the assumption of homogeneity of variance across groups was not satisfactory for stage 2, stage 3, and stage 6. Therefore a more conservative alpha level of .025 was used for stages 2, 3, and 6. All other stages were satisfactory. Box's *M* was used to test the assumption of the homogeneity of variance-covariance matrices which is part of the MANOVA output for SPSS. The assumption of the homogeneity of variance-covariance was tenable based on the results of Box's test, M = 126.26, $F(112, 10075.33)$ = .67, p = .81.

Pillai's Trace was used because it is a more robust criterion when assumptions are violated or sample sizes among groups are not equal (Tabachnick & Fidell, 2007). The interaction effect was not statically significant, Pillai's Trace = .18, $F(14, 234) = 1.60$, p = .08, partial η^2 = .09, observed power .87. The results for formal training main effect were not statistically significant, Pillai's Trace = .10, $F(7,116) = 1.92$, p = .07, partial η^2 = .10, observed power .74. The results for the MANOVA were statistically significant for the teaching experience main effect, Pillai's Trace = .26, $F(14,234) = 2.49$, p = .003, partial η^2 = .13, observed power .98. Null hypothesis 1.2, there will not be a statistically significant differences in a combination of teachers' mean stage scores (stages 0-6) based on teaching experience with the graphing calculator can be rejected.

Pairwise comparisons were conducted to find which level of experience affected the stage of concern most strongly. Scheffe's procedure was used to protect against inflated Type I error due to multiple tests (Tabachnick & Fidell, 2007). Also, the Bonferroni method was used to control for Type I error across pairwise comparisons (Tabachnick & Fidell, 2007). The alpha levels set for stages 0, 1, 4, and 5 was .007 (.05/7). A more conservative alpha level of .003 (.025/7) was used for stages 2, 3, and 6.

When the dependent variables were considered separately, there was a significant difference between the novice and moderate at stage 1 (p = .003) and between the novice and experienced at stage 1 (p = .000). The means score indicates that there was a significant difference between levels at stage 1 and that novice scored lower than moderated and experienced teachers at stage 1.

Research Question 2

The following section discusses analysis concerning Research Question 2 and the corresponding research and null hypotheses.

Research Question 2**:** Is there a statistically significant difference in a linear combination of teachers' mean stage scores (stages 0-6) according to the teacher's state of employment?

Research Hypothesis 2.1: There will be statistically significant differences in a linear combination of teachers' mean stage scores (stages 0-6) according to the teacher's state of employment. If this hypothesis is found significant, hypotheses that examine each dependent variable individually will be tested.

Null Hypothesis 2.1: There will not be a statistically significant difference in a linear combination of teachers' mean stage scores (stages 0-6) according to the teacher's state of employment.

A one-way MANOVA was conducted to determine if there was a statistical significance in means between the dependent variables, teachers' stages of concern (stages 0-6), and the independent variable, state (Georgia or Tennessee). The independent variable, state, had two levels, teaching in Georgia or teaching in Tennessee.

The pooled means and standard deviations for the dependent variables, stages zero through six are: M_{s0} = 14.48 (*SD* = 6.67), M_{s1} = 13.85 (*SD* = 6.82), M_{s2} = 12.99 (*SD* =7.16), M_{s3} = 10.43 (*SD* = 5.66), M_{s4} = 16.35 (*SD* = 6.51), M_{s5} = 15.60 (*SD* = 7.04), and M_{s6} = 13.84 (*SD* = 5.82). Descriptive statistics disaggregated by state are displayed in Table 4.3.

Table 4.3

Descriptive Statistics Disaggregated by State

	Georgia		Tennessee	
Variable	*M*	*SD*	*M*	*SD*
Stage 0	16.96	6.87	12.62	5.90
Stage 1	14.40	6.97	13.41	6.72
Stage 2	12.67	6.97	13.23	7.34
Stage 3	11.85	5.83	9.26	4.96
Stage 4	14.96	6.44	17.40	6.40
Stage 5	14.53	6.60	16.41	7.29
Stage 6	13.05	5.11	14.38	6.14

Note. n = 128

Assumption testing was conducted for outliers, univariate and multivariate normality, multicollinearity and singularity, linearity, and homoscedasticity. The data was checked for extreme outliers by creating boxplots using SPSS, and there were no extreme outliers observed.

To examine the univariate normality of each dependent variable to each level of the independent variable, Kolmogorov-Smirnov tests were used. In respect to the state variable, cell sizes were 55 for Georgia and 73 for Tennessee. The Kolmogorov-Smirnov test reported normality was violated for stage 1 (p = .017), stage 3, (p = .005), and stage 6 (p = .030) at the Tennessee level. The normality assumption was tenable for all other variables.

To examine the multivariate normality, the Mahalanobis distance was measured. The maximum distance was 25.303, which exceeded the critical value of 24.32. The assumption cannot be assumed tenable. This aligns with DeCarlo (2010) “If univariate distributions are nonnormal, then the multivariate distribution will be nonnormal” (p. 1). However DeCarlo (2010) also stated that, “In practice, many structural equations models with continuous variables will not have severe problems with nonnormality” (p. 1). According to Tabachnick and Fidell (2007), “With univariate *F* and large samples, the central limit theorem suggests that the sampling distribution of means approach normality even when raw scores do not” (p. 251). A sample size of 128, which included a minimum of 27 participants in each cell and more than 116 degrees of freedom for error, ensured multivariate normality of the sampling distribution of means.

Multicollinearity and singularity were checked by creating correlation matrix using SPSS and checking for high correlation. Table 4.2 displays the Pearson correlation matrix. Since correlations above 735 were not observed, the assumptions of multicollinearity and singularity were considered tenable.

Linearity was checked by examining scatterplots (see Appendix K). A curvilinear relationship was not observed, so the assumption of linearity was found to be tenable.

The assumption of homoscedasticity was determined by Levene's Test of Equality of error for homogeneity of variance and Box's M for homogeneity of the variance-covariance matrices. The result of Levene's Test of Equality of Error provided evidence that the assumption of homogeneity of variance across groups was satisfactory and that the assumption was tenable. Box's *M* was used to test the assumption of the homogeneity of the variance-covariance matrices which is part of the MANOVA output for SPSS. The assumption of the homogeneity of variance-covariance was not tenable based on the results of Box's test, $M = 44.844$, $F(28, 47118.155) = 1.504$, $p = .042$. Tabachnick and Fidell (2007) stated that Box's *M* is still robust if sample sizes are unequal and $p > .001$. However, a more conservative Pillai's criterion should be used to evaluate multivariate significance.

The one-way MANOVA was found to be significant for the state of employment main effect, Pillai's Trace = .22, $F(7, 120) = 4.77$, $p = .000$, partial $\eta^2 = .22$, observed power .99. Null Hypothesis 2.1, there will not be a statistically significant difference in a linear combination of teachers' mean stage scores (stages 0-6) according to the teacher's state of employment can be rejected.

Tests of between-subjects effects were next conducted to determine at which stages the main effect was significant. The Bonferroni method was used to control for Type I error due to multiple tests of between subject effects (Tabachnick & Fidell, 2007). The alpha levels set for all stages were .007 (.05/7). The test of between-subject effects was significant at stage 0, $F(1, 126) = 14.76$, $p = .000$, partial $\eta^2 = .11$, observed power .97. Stages one through six were found not to be significant: stage 1 $F(1, 126) = .66$, $p = .42$, partial $\eta^2 = .01$, observed power .13; stage 2 $F(1, 126) = .19$, $p = .66$, partial $\eta^2 = .00$, observed power 07; stage 3 $F(1, 126) = 7.40$, $p = .01$, partial $\eta^2 = .06$, observed power .77; stage 4 $F(1, 126) = 4.51$, $p = .04$, partial $\eta^2 = .04$, observed power .56; stage 5 $F(1, 126) = 2.27$, $p = .13$, partial $\eta^2 = .02$, observed power .32; stage 6 $F(1, 126) = 1.69$, $p = .01$, partial eta square $\eta^2 = .01$, observed power .25. Post Hoc tests were not performed for the state variable because there were fewer than three groups. The results of the tests of between-subjected effects suggest that the mean stage score for the Tennessee group ($M = 12.62$, $SD = 5.9$) was lower than the Georgia group ($M = 16.96$, $SD = 6.87$).

Summary

Data was collected from two states, Tennessee and Georgia. Thirteen school districts consented to the study which made the number of potential participants to be 275 (Tennessee n =151, Georgia n =124). One hunderd and twenty-eight teachers responded to the online questionnaire (Tennessee, $n = 73$, Georgia, $n = 55$) for a 47% response rate (Tennessee, 48%; Georgia 44%). Demographic information was obtained from the questionnaire, and it was determined that the sample was repersentative of the population concerning: grade level, teaching experience, curriculum, education, ethnicity, and gender.

The data was screened for: accurary, outliers, normality, linearity, homoscedasticity, multicollinearity, and singularity. Accepted research and statistical techniques were used to address any violations of assumptions. After these methods were applied the data was determined to be suitable for use with parametric statistical analyses.

Research Question 1 asked if there was a difference in teachers' mean stage scores (0-6) based on their experience teaching with a graphing calculator or the formal level of training with a graphing calculator. The results for the MANOVA were statistically significant for the teaching experience main effect. The results for the intercept and training were found not to be significant. Pairwise comparisons were conducted to find which level of experience affected the stage of concern most strongly. When the dependent variables were considered separately, there was a significant difference between the novice and moderate at stage 1 (p = .003) and between the novice and experienced at stage 1 (p = .000). The mean scores indicated that novice scored lower than experienced at stage 1. The null hypothesis that there will not be a statistically significant difference in a linear combination of teachers' mean stage scores (0-6) based on teaching experience with the graphing calculator can be rejected at stage 1.

Research Question 2 asked if there was a statistically significant difference in a linear combination of teachers' mean stage scores (stages 0-6) according to the teacher's state of employment. The results of the MANOVA were found to be significant at stage 0. The tests of between-subject effects were also significant at the alpha level of .007 at stage 0. Stages 1 through 6 were found to be not statistically significant. Null hypothesis 2.1 that there will not be a statistically significant difference in a linear combination of teachers' mean stage scores (0-6) and a teacher's state of employment can be rejected at stage 0. These findings will be discussed at length in Chapter Five.

CHAPTER FIVE: DISCUSSION

Introduction

The purpose of this chapter is to provide a review of this study and discuss the general findings in light of the relevant literature and theoretical framework. Included is a review of the research problem and questions, a summary of the methods used, and the results from the data analysis. Next is a brief discussion of the literature relating the current findings to prior research. Limitations and recommendations are also discussed, including a discussion of threats to internal and external validity. This chapter concludes with a summary of the primary findings of this study.

Summary of Findings

The graphing calculator has affected the secondary math curriculum by offering multiple representations of functions and has become a tool for constructive learning (Doerr & Zangor, 2000). Also, there is a demand for teachers to integrate technology into the teaching of mathematics (Heid & Blume, 2008). With the implementation of technology, change is inevitable (Hall & Hord, 2006). Therefore, assessing a teacher's attitude concerning technology is a direct link to understanding a teacher's willingness to adopt the technology (Agbatogum, 2010).

The purpose of this causal-comparative study was to examine the concerns of teachers as measured by the SoCQ with reference to an innovation that was introduced to the classroom, the graphing calculator. The SoCQ was developed from research conducted by Frances Fuller (1969) at the Research and Development Center for Teacher Education at the University of Texas (George et al. 2008).

The SoCQ measures seven levels (stages 0-6) of concern of individuals who have been affected by the introduction of a new innovation. The seven stages are defined as follows:

1. Stage 0: Awareness;
2. Stage 1: Informational;
3. Stage 2: Personal;
4. Stage 3: Management;
5. Stage 4: Consequence;
6. Stage 5: Collaboration;
7. Stage 6: Refocusing.

The population of interest included all high school teachers of mathematics from consenting school districts in Southeast Tennessee and Northwest Georgia (*n* = 275). The sample included teachers of mathematics in Southeast Tennessee and Northwest Georgia (*n* = 128). Demographic information was collected along with the SoCQ. The sample from Tennessee (*n* = 73) was approximately equal to the sample from Georgia (*n* = 55) in respect to teacher demographics (ethnicity, population, age, and gender,).

After permission was received from the Liberty University IRB, the SoCQ was sent to potential participants. The overall response was 128 (47%) returned questionnaires. Tennessee participants returned 73 out of 151 (48%) questionnaires, and Georgia participants returned 55 out of 142 (44%) questionnaires.

The data was first screened for accuracy, outliers, normality, linearity, homoscedasticity, multicollinearity, and singularity (Tabachnick & Fidell, 2007). Accepted research and statistical techniques as described by Tabachnick and Fidell (2007) were used to address any violations of assumptions, and, after these methods were applied, the data was determined to be suitable for use with parametric statistical analyses.

Review of Data Analysis for Research Question 1

The following section discusses analysis concerning Research Question 1 and corresponding research and null hypotheses.

Research Question 1: Is there a statistically significant difference in a linear combination of teachers' mean stage scores (stages 0-6) based on their experience teaching with a graphing calculator and the formal level of training with a graphing calculator?

Research Hypothesis 1.1: There will be a statistically significant difference in a linear combination of teachers' mean stage scores (stages 0-6) based on teaching experience with the graphing calculator and the formal level of training with a graphing calculator. If this hypothesis is found significant, then hypotheses that examine each dependent variable individually will be tested.

Research Hypothesis 1.2: There will be a statistically significant differences in a linear combination of teachers' mean stage scores (stages 0-6) based on teaching experience with the graphing calculator. If this hypothesis is found significant, then hypotheses that examine each dependent variable individually will be tested.

Research Hypothesis 1.3: There will be a statistically significant differences in a linear combination of teachers' mean stage scores (stages 0-6) based on the formal level of training with a graphing calculator. If this hypothesis is found significant, then hypotheses that examine each dependent variable individually will be tested.

Null Hypothesis 1.1: There will not be a statistically significant differences in a linear combination of teachers' mean stage scores (stages 0-6) based on teaching experience with the graphing calculator and the formal level of training with a graphing calculator.

Null Hypothesis 1.2: There will not be a statistically significant difference in a linear combination of teachers' mean stage scores (stages 0-6) based on teaching experience with the graphing calculator.

Null Hypothesis 1.3: There will not be a statistically significant differences in a linear combination of teachers' mean stage scores (stages 0-6) based on the formal level of training with a graphing calculator.

A two-way MANOVA was conducted to determine the effect of two independent variables, formal training and experience teaching with a graphing calculator, on seven dependent variables, teachers' stages of concern (stages 0-6). Formal training had two levels, eight hours or less of training and more than eight hours of training. Teaching with a graphing calculator had three levels, novice (0-5 years), moderate (6-10 years), and experienced (11 or more years).

The results for the MANOVA were statistically significant for the teaching experience main effect. The results for the intercept and training were found not to be significant. Pairwise comparisons were conducted to find which level of experience affected the stage of concern most strongly. When the dependent variables were considered separately, there was a significant difference between the novice and moderate at stage 1 ($p = .003$) and between the novice and experienced, also at stage 1 ($p = .000$). The means score indicate that novice scored lower than experienced at stage 1. The null hypothesis that there will not be a significant difference in mean stage scores (0-6) based on teaching experience with the graphing calculator was rejected at stage 1.

Review of Data Analysis for Research Question 2

The next section discusses analysis concerning Research Question 2 and corresponding research and null hypotheses.

Research Question 2**:** Is there a statistically significant difference in a linear combinations of teachers' mean stage scores (stages 0-6) according to the teacher's state of employment?

Research Hypothesis 2.1: There will be a statistically significant difference in a linear combination of teachers' mean stage scores (stages 0-6) according to a teacher's state of employment. If this hypothesis is found significant, then hypotheses that examine each dependent variable individually will be tested.

Null Hypothesis 2.1: There will not be a statistically significant difference in a linear combination of teachers' mean stage scores (stages 0-6) and a teacher's state of employment.

A one-way MANOVA was conducted to determine if there was a statistically significant difference in means between the dependent variables, stages zero through six, and the independent variable, state (Georgia or Tennessee). The state independent variable had two levels, teaching in Georgia and teaching in Tennessee.

The results of the MANOVA were found to be significant at stage 0. The tests of between-subject effects were also significant at the alpha level of .007 at stage 0. Stages one through six were found not to be statistically significant. The null hypothesis that there will not be a statistically significant difference in the linear combinations of mean stage scores (0-6) and a teacher's state of employment can be rejected at stage 0.

Implications in Light of the Literature

Hord et al. (2006) stated that the CBAM was focused on school improvement and that school improvement was a change process. The CBAM is designed to facilitate this change process, identify what defines change in the school environment, identify which individuals are affected by change, and, most importantly, suggest how the change process can be managed. The findings of this study are connected to Hord et al. (2008) in that teaching experience with the graphing calculator does appear to affect teachers' concerns at the informational (stage 1) stage.

Hord et al. (2006) also stated that change involves developmental growth by stating, "Feelings and skills tend to shift with respect to the new program or practice as individuals pass through an ever-greater degree of experience" (p. 6). The findings of this study about teachers' concerns seem to support this theory at certain stages of concern. Hord et al. continued by saying, "The real meaning of any change lies in its human, not its material, component."(p. 6-7). This research supports this statement in the fact that the MANOVA detected that there was not a statistically significant difference in stage 0 scores, but there was a statistically significant difference at Stage 1 scores between novice and moderate users and novice and experienced users. The significance at stage 1 suggests that teachers' concerns had developed or grown by progressing from stage 0 to stage 1.

Fuller (1969) stated that teachers with little or no teaching experience rarely had specific concerns with teaching itself but were usually focused on other issues such as self concerns (stages 0-2). This includes issues involving questions of "Where do I stand?" (p. 219), or "How Adequate am I?"(p. 219). This study addressed teaching experience with a graphing calculator between groups (Stages of Concern) and found that a significant difference in means did exist between teaching with a graphing calculator and Stage 1, the stage that indicates the individual is more interested in learning more details about the innovation (George et al., 2006). The statistically significant difference in means between the levels of teaching experience with a graphing calculator at stage one (novice and moderate, novice and experienced) supports Fuller's (1970) theory that "Resolution seems to occur through more cognitive experiences: acquisition of information, practice, evaluation, synthesis, and so on" (p. 11).

Dewey et al. (2009) conducted a study that examined the role of the graphing calculator in the classroom. Specifically, the study focused on availability, characteristics, and attitudes of the teacher and how use of the graphing calculator affects curriculum and teaching practices. Dewey et al. stated that teachers are generally open to using technology in instruction. However, they are unsure about how the technology properly fits into students' learning. Dewey et al. stated that participants in this study reported that the factors that need to be addressed in order to eliminate personal and teaching concerns are lack of basic skills with the technology, how and when the technology should be used in teaching, and assurances that the technology will improve student achievement. The findings of this study supports the findings of Dewey et al. (2009) in that significant differences in means for teaching experience with a graphing calculator at stage 1 were observed.

Liu and Huang (2005) conducted research that involved trends and patterns of teachers' concerns about technology integration in learning. The participants completed a demographic survey along with the SoCQ. In the demographic survey, the participants chose a use level of beginner, intermediate, or advanced. The results of the SoCQ were aggregated into the three levels of experience. The beginner level group had the highest percentile means in the self (stages 0-2) and management (stage 3) dimensions and lowest in the consequence, collaboration, and refocusing dimensions (stages 4-6). These findings reported by Liu and Hung are consistent with the findings of this study in which the Georgia group seemed to have higher or identical percentile means, at the self stage (0-2).

A second review of literature was conducted to determine if any new or additional studies had become available since the original literature review for this study. One work by Handal, et al. (2011) was published after the initial search and found to be relevant to this study. The study reported on factors that led to the adoption of graphing calculators by high school math teachers in Australia. The researchers surveyed 587 teachers of high school mathematics using a questionnaire that was a variation of the *Teachers' Attitudes Towards Information Technology Questionnaire* (TAT) that was focused on hand-held graphing technology.

Handal et al. (2011) used multiple regression analysis to predict a teacher's stage of adaption from ten predictor variables. The predictor variables included: educational region, gender, educational qualifications, teaching experience, training, professional development modes, faculty support, perceptions of self-competence, interest in using graphing calculators in teaching and learning, and the number of calculators available.

The researchers reported that self competence was the most important factor followed by training, personal interest, and faculty support, respectively. The other predictors were found to not be statistically significant. Handal et al (2011) also reported that the median stage of adaptation was determined to be “understanding and application of process” (p. 343), which was reported to be the third lowest stage of adoption on a six point scale.

The study by Handal et al. (2011) is relevant to this study in that faculty support (administrative policy and expectations) was found to be statistically significant. In Handal et al., faculty support was reported to be significant in the self-dimension. This finding reported by Handel et al. seems to correspond with the impact dimension described by George et al. (2008). The research conducted by Handal et al. and results reported in this study seem to suggest that faculty support can assist the teacher through the impact stage of concern.

The research conducted by Handal et al. (2011) is connected to this study through Research Question 2. Research Question 2 asked if there is a statistically significant difference in the linear combinations of mean stage scores according to the teacher’s state of employment. The state variable was selected, because in Tennessee, students are expected to use the innovation during state-mandated assessment. In Georgia, students are not allowed to use the graphing calculator during similar assessments. This difference between the states is a direct connection to the faculty support variable in the study conducted by Handel et al. (2011). School administration in Tennessee exhibits an expectation that the graphing calculator will be used during instruction to prepare the student for state mandated testing (TDOE, 2011). In Georgia, graphing calculators were not allowed on state-mandated end-of-course tests (GODOE, 2011). The one-way

MANOVA conducted in this study found that there is a statistically significant difference between the two states at stage 0.

The review of literature in Chapter Two revealed that there was much debate concerning the use of graphing calculators in the learning of mathematics (Acelajado 2004; Guerrero et al. 2004; Heller et al., 2005). The findings of this study can be directly linked to the findings of Hord et al. (2006), Fuller (1969 & 1970), Dewey, et al. (2009), Liu and Huang (2005) and Handal et al. (2011) which was discussed in Chapter Two.

Limitations

Design Limitations

This study used a causal-comparative research design. MANOVA makes the basic assumption that participants are randomly sampled. With this design there is not a random assignment of participants or treatments, but, rather a sample of the target population. Also, Howell (2008) stated that any relationship between variables could be attributed to coincidence, and, for a conclusion that one variable causes or affects another, a reasonable explanation must be offered. Because random selection was not used, the possibility that the findings are a coincidence cannot be ruled out (Howell, 2008).

The attitudes of the local and building administration must be considered. Data was not collected on system or building policy or attitude towards technology. A department head or curriculum director could have opinions concerning graphing calculators that influence a teacher's attitude or Stage of Concern towards the graphing calculator that could affect how a participant answered the survey.

External Validity Limitations

While this study offers some explanation of how formal training and teaching with a graphing calculator affects a teacher's stage of concern, there are some issues that must be acknowledged that could limit the ability to generalize results. Although demographic information was provided that established that the two study groups (Tennessee and Georgia) were representative of the population, the study was limited to selected regions of two states, and results may not be representative of all states or even representative of the two states from which the participants were selected. Also, individual school districts or schools may have polices unknown to the researcher that influenced pedagogy, which, in turn, may have influenced teachers' attitudes towards the use of calculators or technology use.

Another threat was detected while examining the demographic data that was collected along with results of the SoCQ. Because Tennessee does not recognize the specialist or six-year degree, there is a difference in education (highest degree earned) between Tennessee and Georgia teachers. Seventy-two percent of Georgia teachers surveyed had obtained either a masters or specialist degree, and only 58% of Tennessee teachers surveyed had similar degrees.

Reliability, Validity, and Scope of Measure

The reliability and validity of the SoCQ instrument was discussed and established in Chapter Three of this study. However, the self-reporting nature of this study could have created some degree of bias which must be considered. Teachers' perceptions of their use of the graphing calculator and assessment of their personal attitudes towards the graphing calculator may not be entirely consistent with their actual practices.

George et al. (2008) stated that the interpretations of the SoCQ are only as good as the measure [input] and that interpretations should be confirmed with the participants. Because of the confidentiality of the survey and constraints of time and cost, follow-up questions to participants to confirm individual responses to the SoCQ were not conducted.

Statistical Limitations

Issues in meeting the basic assumptions of the statistics used in this study were observed and reported in Chapter Four. The first assumption for the MANOVA stated that the dependent variable(s) be normally distributed. Screening was conducted using scatterplots and values obtained using SPSS for skewness and kurtosis, and Kolmogorov-Smirnov and Shapiro-Wilk tests were conducted on each variable. However, certain cases still fell outside of limits for the tests of normality. Green and Salkind (2008) stated that samples with a moderate or large sample size yield reasonably accurate p values even when the normality assumption is violated. Other basic assumptions for the statistics were met and are discussed in Chapter Four.

The statistical analysis used has limitations that are discussed in current literature. Tabachnick and Fidell (2007) stated that MANOVA is a more complicated analysis than ANOVA. Also, there are several important assumptions to consider, and there is often some ambiguity in interpretation of effects of independent variables on any single dependent variable.

The assumptions of normality, variances and covariances among dependent variables and independent variables were addressed and met in Chapter Three. However, other issues need to be addressed concerning MANOVA. Out of a possible 36 sets of variable matches, 28 pairs were found to be significantly correlated. Tabachnick and Fidell (2007) stated "Even moderately correlated DV's diminish the power of MANOVA" (p. 244). Also, the MANOVA conducted in this study used seven dependent variables. A. P. Rovai (personal communication, October 13, 2011) stated:

> The power of a MANOVA usually decreases with an increase in the number of dependant variables. If too many dependent variables are used without a strong rationale (either theoretical or empirical) then small or negligible differences on most of them may obscure real differences on the few important variables.

Both correlation of variables and the number of dependent variables are factors that must be considered when interpreting results from the MANOVA conducted in this study.

Recommendations

Additional research seems to be needed for studying the concerns of teachers and the graphing calculator. This section includes a discussion of two additional instruments designed to be used along with the Stages of Concern Questionnaire: Innovation Configurations and Levels of Use.

While this study provided insights into teachers' concerns about the graphing calculator in the specified region studied, there are several issues concerning the use of hand-held graphing technology and how this innovation affects teachers' concerns that were not addressed in this study. The logical next step in this study would be a qualitative research study that would allow for an in-depth study of teachers' concerns. A quantitative analysis of how teachers are using graphing calculators in instruction would be another natural continuation of this study.

An additional study with an instrument that measures how an innovation is being utilized would also contribute to the body of research concerning new innovations (i.e. the graphing calculator) in the classroom. *Innovation Configurations* is an instrument that is based on CBAM theory and represents patterns of innovation use that result when different teachers put innovations into operation in the classroom (Hord et al., 2008). Monitoring how an innovation is being used and then acting upon that information is considered to be an essential part of the successful implementation of the innovation. The instrument that accomplishes this monitoring task is named *Levels of Use* by Hord et al. (2008). The *Levels of Use* instrument is designed to define operationally how the teacher uses an innovation.

Research has also indicated that few, if any, studies have examined the change process over an extended period of time. A longitudinal study that uses all components of the CBAM model (*Stages of Concern*, *Levels of Use*, and *Innovation Configurations*) is needed to fully study the effects that graphing calculators have in high school classrooms.

Conclusion

Null Hypothesis 1.2 stated that there will not be a statistically significant difference in a linear combination of teachers' mean stage scores (stages 0-6) based on teaching experience with the graphing calculator. A two-way multivariate analysis (MANOVA) was conducted to determine the effect of two independent variables, formal training and experience teaching with a graphing calculator, on seven dependent variables, teachers' stages of concern (stages 0-6).

The results for the MANOVA were statistically significant for the teaching experience main effect. The results for the intercept and training were found not to be significant. Pairwise comparisons were conducted to find which level of experience affected the stage of concern most strongly. When the dependent variables were considered separately, there was a significant difference between the novice and moderate at stage 1 (p = .003) and between the novice and experienced also at stage 1 (p = .000). The means score indicate that novice scored lower than experienced at stage 1. The null hypothesis that there will not be a significant difference in mean stage scores (0-6) based on teaching experience with the graphing calculator was rejected at stage 1. It means that teaching experience has a statistically significant affect on a teacher's Stage of Concern during the early developmental stages of change. The more the teacher has experience using an innovation, the more the intensity of a teacher's concerns reduces. This conclusion was supported by literature (Hord et al., 2006) that stated feelings and skills tend to shift with respect to an innovation as the individual passes through a greater degree of experience (Hord et al, 2006).

Null Hypothesis 2.1 stated that there will not be a statistically significant difference in a linear combination of teachers mean stage scores (stages 0-6) based on the teacher's state of employment. The one-way MANOVA conducted in this study found that there is a statistically significant difference between the two states at stage 0. The tests of between-subject effects were also significant at the alpha level of .007 at stage 0. Null Hypothesis 2.1 stated that there will not be a statistically significant difference in mean stage scores (stages 0-6), and a teacher's state of employment can be rejected at stage 0.

The rejection of the null hypothesis suggests that administrative controls, the expectation that an innovation will be used set by state, system, or building administrators appeared to have an effect on a teacher's Stage of Concern. As discussed in Chapter Three, Tennessee teachers were expected to provide instruction that allows students' to use the innovation during state-mandated assessments, whereas Georgia teachers were left to choose whether or not to use graphing calculators during instruction. The expectation of use, or the accountability that the student will be prepared to use the innovation for assessment, seems to be a deciding factor that affects a teacher's stage of concern. This conclusion about a difference between means at stage 0 of the two groups of teachers is supported by the research conducted by Hord et al. (2006) which stated "Books and materials and equipment alone do not make change; only people can make change by altering their behavior" (p. 6). Also, Gbomita (1997) stated that the difference between this study [Gbomita, 1997] and previous research is that the decision to implement an innovation [technology] was mandated. Gbomita stated "Generally the faster rate of adoption of innovations results from authority decisions, where the decision has been imposed" (p. 98).

Every student should be provided every opportunity to learn. The research reviewed in this study supports the use of technology in the teaching and learning of mathematics. Administration at the district and building levels cannot just hope that teachers will adopt the use of technology in classroom instruction. The results of this research suggest that addressing the concerns of teachers and placing administrative controls in effect that support the use of the graphing calculator could improve mathematical instruction. Also, the student could benefit from the technology by being able to explore mathematical concepts to a deeper level and increase his or her understanding of the subject through a richer learning experience.

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Appendixes

Appendix A
Instrument

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SoCQ 075

Stages of Concern Questionnaire

Name (optional): ______________________________

The purpose of this questionnaire is to determine what people who are using or thinking about using various programs are concerned about at various times during the adoption process.

The items were developed from typical responses of school and college teachers who ranged from no knowledge at all about various programs to many years' experience using them. Therefore, **many of the items on this questionnaire may appear to be of little relevance or irrelevant to you at this time.** For the completely irrelevant items, please circle "0" on the scale. Other items will represent those concerns you do have, in varying degrees of intensity, and should be marked higher on the scale.

For example:

This statement is very true of me at this time.	0	1	2	3	4	5	6	(7)
This statement is somewhat true of me now.	0	1	2	3	(4)	5	6	7
This statement is not at all true of me at this time.	0	(1)	2	3	4	5	6	7
This statement seems irrelevant to me.	(0)	1	2	3	4	5	6	7

Please respond to the items in terms of **your present concerns,** or how you feel about your involvement with **this** innovation. We do not hold to any one definition of the innovation so please think of it in terms of your own perception of what it involves. Phrases such as "this approach" and "the new system" all refer to the same innovation. Remember to respond to each item in terms of your present concerns about your involvement or potential involvement with the innovation.

Thank you for taking time to complete this task.

0	1 2	3 4 5	6 7
Irrelevant	Not true of me now	Somewhat true of me now	Very true of me now

Circle One Number For Each Item

1. I am concerned about students' attitudes toward the innovation.	0 1 2 3 4 5 6 7
2. I now know of some other approaches that might work better.	0 1 2 3 4 5 6 7
3. I am more concerned about another innovation.	0 1 2 3 4 5 6 7
4. I am concerned about not having enough time to organize myself each day.	0 1 2 3 4 5 6 7
5. I would like to help other faculty in their use of the innovation.	0 1 2 3 4 5 6 7
6. I have a very limited knowledge of the innovation.	0 1 2 3 4 5 6 7
7. I would like to know the effect of reorganization on my professional status.	0 1 2 3 4 5 6 7
8. I am concerned about conflict between my interests and my responsibilities.	0 1 2 3 4 5 6 7
9. I am concerned about revising my use of the innovation.	0 1 2 3 4 5 6 7
10. I would like to develop working relationships with both our faculty and outside faculty using this innovation.	0 1 2 3 4 5 6 7
11. I am concerned about how the innovation affects students.	0 1 2 3 4 5 6 7
12. I am not concerned about the innovation at this time.	0 1 2 3 4 5 6 7
13. I would like to know who will make the decisions in the new system.	0 1 2 3 4 5 6 7
14. I would like to discuss the possibility of using the innovation.	0 1 2 3 4 5 6 7
15. I would like to know what resources are available if we decide to adopt the innovation	0 1 2 3 4 5 6 7
16. I am concerned about my inability to manage all that the innovation requires.	0 1 2 3 4 5 6 7
17. I would like to know how my teaching or administration is supposed to change.	0 1 2 3 4 5 6 7
18. I would like to familiarize other departments or persons with the progress of this new approach.	0 1 2 3 4 5 6 7

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0	1 2	3 4 5	6 7
Irrelevant	Not true of me now	Somewhat true of me now	Very true of me now

Circle One Number For Each Item

19. I am concerned about evaluating my impact on students.	0 1 2 3 4 5 6 7
20. I would like to revise the innovation's approach.	0 1 2 3 4 5 6 7
21. I am preoccupied with things other than the innovation.	0 1 2 3 4 5 6 7
22. I would like to modify our use of the innovation based on the experiences of our students.	0 1 2 3 4 5 6 7
23. I spend little time thinking about the innovation.	0 1 2 3 4 5 6 7
24. I would like to excite my students about their part in this approach.	0 1 2 3 4 5 6 7
25. I am concerned about time spent working with nonacademic problems related to the innovation.	0 1 2 3 4 5 6 7
26. I would like to know what the use of the innovation will require in the immediate future.	0 1 2 3 4 5 6 7
27. I would like to coordinate my efforts with others to maximize the innovation's effects.	0 1 2 3 4 5 6 7
28. I would like to have more information on time and energy commitments required by the innovation.	0 1 2 3 4 5 6 7
29. I would like to know what other faculty are doing in this area.	0 1 2 3 4 5 6 7
30. Currently, other priorities prevent me from focusing my attention on the innovation.	0 1 2 3 4 5 6 7
31. I would like to determine how to supplement, enhance, or replace the innovation.	0 1 2 3 4 5 6 7
32. I would like to use feedback from students to change the program.	0 1 2 3 4 5 6 7
33. I would like to know how my role will change when I am using the innovation.	0 1 2 3 4 5 6 7
34. Coordination of tasks and people is taking too much of my time.	0 1 2 3 4 5 6 7
35. I would like to know how the innovation is better than what we have now.	0 1 2 3 4 5 6 7

Appendix B
Demographic Questions

In which state do you teach?	Options: Tennessee; Georgia
What grade level do you teach most often?	Options: 9; 10; 11; 12; other
Years of teaching experience (Count complete school years)	Options: 1; 2; 3; 4; 5; 6; 7; 8; 9; 10; 11; 12; 13; 14; 15; 16; 17; 18; 19; 20; 21; 22; 23; 24; 25; 26; 27; 28; 29; 30; 31; 32; 33; 34; 35; 36; 37; 38; 39; 40; 41; 42; 43; 44; 45 or more
Do you teach in a regular education or a resource (contained) special education math classroom?	Options: Regular Education; Special Education
Professional Training with Graphing Calculators (This includes workshops, seminars, programs or conference, either in a classroom setting or online). Please estimate the number of hours (time, not credit) estimated to the nearest hour.	Options: 0; 1; 2; 3; 4; 5; 6; 7; 8; 9; 10; 11; 12; 13; 14; 14; 15; 16; 17; 18; 19; 20; 21; 22; 23; 24; 25; 26; 27; 28; 29; 30; 31; 32; 33; 34; 35; 36; 37; 38; 39; 40; 41; 42; 43; 44; 45; 46; 47; 48; 49; 50; 51; 52; 53; 54; 55; 56; 57; 58; 59; 60 or more
How long have you been teaching with a graphing calculator (estimate to complete years)?	Options: 0; 1; 2; 3; 4; 5; 6; 7; 8; 9; 10; 11; 12; 13; 14; 15; 16; 17; 18; 19; 20; 21; 22; 23; 24; 25 or more
Subject most frequently taught.	Options: Algebra 1; Geometry; Algebra 2; Algebra 3; Precalculus; Calculus; Statistics; Math 1; Math 2; Math3; other

Degree Level	Options: Bachelors; Masters; Educational Specialist; Doctorate
Ethnicity	Options: American Indian or Alaska Native; Asian; Black or African American; Native Hawaiian or other Pacific Islander; White; Hispanic or Latino
Gender	Options: Male; Female

Appendix C
Copyright Permission

Permission for SoCQ, page

ADVANCING RESEARCH
SEDL
IMPROVING EDUCATION

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To: Edward W. Helton (Licensee)
104 Meadowbrook Lane
LaFayette, GA 30728

From: Nancy Reynolds
Information Associate
SEDL
Information Resource Center—Copyright Permissions
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Austin, TX 78723

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Date: July 1, 2010

Thank you for your interest in using the ***Stages of Concern Questionnaire*** (SoCQ 075) published by SEDL and written by Archie A. George, Gene E. Hall, and Suzanne M. Stiegelbauer in 2006 as Appendix A, pages 79-82 in *Measuring Implementation in Schools: The Stages of Concern Questionnaire*, as a PDF document on an accompanying CD-ROM, in electronic format as SEDL's *Stages of Concern Questionnaire (SoCQ) Online* and published on pages 48-49 in the SEDL publication *Taking Charge of Change*, revised ed., published in 2006, 2nd printing, 2008, that was written by Shirley M. Hord, William L. Rutherford, Leslie Huling, and Gene E. Hall.

This instrument will be referred to as the "work" in this License Agreement. SEDL is pleased to grant permission to the Licensee who will use the *SoCQ* in his dissertation at Liberty University in Lynchburg, VA, to survey high school math teachers' concerns about using graphing calculators. The following are the terms, conditions, and limitations governing this limited permission to reproduce the work:

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SEDL License Agreement, p. 2

2. No adaptations, deletions, or changes are allowed with the exception of substituting the words "the innovation" with a word or phrase that will more appropriately reflect the implementation of a particular piece of software that participants will recognize and questions that can be added to identify demographic indicators for participants before or after the instrument, but otherwise, the wording and order of items cannot be changed. No additional derivative work based on or incorporating the work will be created without the prior written consent of SEDL.

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Thank you, again, for your interest in using the ***Stages of Concern Questionnaire (SoCQ)***. If you have any questions about this License Agreement, please contact me at 800-476-6861, ext. 6548 or 512-391-6548, or by e-mail at nancy.reynolds@sedl.org.

Sincerely,

Nancy Reynolds

Nancy Reynolds for SEDL

July 6, 2010

Date signed

Agreed and accepted:

Signature: Edward W. Melton

July 1, 2010

Date signed

Printed Name: EDWARD W. MELTON

Appendix D
Figures and Tables

IMPACT	6	Refocusing	The individual focuses on exploring ways to reap more universal benefits from the innovation, including the possibility of making major changes to it or replacing it with a more powerful alternative.
	5	Collaboration	The individual focuses on coordinating and cooperating with others regarding use of the innovation.
	4	Consequence	The individual focuses on the innovation's impact on students in his or her immediate sphere of influence. Considerations include the relevance of the innovation for students; the evaluation of student outcomes, including performance and competencies; and the changes needed to improve student outcomes.
TASK	3	Management	The individual focuses on the processes and tasks of using the innovation and the best use of information and resources. Issues related to efficiency, organizing, managing, and scheduling dominate.
SELF	2	Personal	The individual is uncertain about the demands of the innovation, his or her adequacy to meet those demands, and/or his or her role with the innovation. The individual is analyzing his or her relationship to the reward structure of the organization, determining his or her part in decision making, and considering potential conflicts with existing structures or personal commitment. Concerns also might involve the financial or status implications of the program for the individual and his or her colleagues.
	1	Informational	The individual indicates a general awareness of the innovation and interest in learning more details about it. The individual does not seem to be worried about himself or herself in relation to the innovation. Any interest is in impersonal, substantive aspects of the innovation, such as its general characteristics, effects, and requirements for use.
	0	Unconcerned	The individual indicates little concern about or involvement with the innovation.

Figure 1.2. Stages of Concern About an Innovation Reprinted with permission of SELD. Copyright © 2006 SELD.

Raw Scale Score	Percentile Scores						
	Stages						
	0	1	2	3	4	5	6
0	0	5	5	2	1	1	1
1	1	12	12	5	1	2	2
2	2	16	14	7	1	3	3
3	4	19	17	9	2	3	5
4	7	23	21	11	2	4	6
5	14	27	25	15	3	5	9
6	22	30	28	18	3	7	11
7	31	34	31	23	4	9	14
8	40	37	35	27	5	10	17
9	48	40	39	30	5	12	20
10	55	43	41	34	7	14	22
11	61	45	45	39	8	16	26
12	69	48	48	43	9	19	30
13	75	51	52	47	11	22	34
14	81	54	55	52	13	25	38
15	87	57	57	56	16	28	42
16	94	60	59	60	19	31	47
17	94	63	63	65	21	36	52
18	96	66	67	69	24	40	57
19	97	69	70	73	27	44	60
20	98	72	72	77	30	48	65
21	99	75	76	80	33	52	69
22	99	80	78	83	38	55	73
23	99	84	80	85	43	59	77
24	99	88	83	88	48	64	81
25	99	90	85	90	54	68	84
26	99	91	87	92	59	72	87
27	99	93	89	94	63	76	90
28	99	95	91	95	66	80	92
29	99	96	92	97	71	84	94
30	99	97	94	97	76	88	96
31	99	98	95	98	82	91	97
32	99	99	96	98	86	93	98
33	99	99	96	99	90	95	99
34	99	99	97	99	92	97	99
35	99	99	99	99	96	98	99

Figure 3.1. Percentile Conversion Chart for the SoCQ. Reprinted with permission of SELD.

Univariate Statistics

	N	Mean	Std. Deviation	Missing		No. of Extremes[a]	
				Count	Percent	Low	High
Score	128	80.77	19.867	0	.0	1	0
YearsT	128	15.31	11.783	0	.0	0	0
Training	128	14.37	18.153	0	.0	0	15
TeachGC	126	6.91	5.715	2	1.6	0	0
Stage0	128	14.48	6.671	0	.0	0	0
Stage1	128	13.84	6.819	0	.0	0	0
Stage2	128	12.99	7.160	0	.0	0	0
Stage3	128	10.38	5.482	0	.0	0	2
Stage4	128	16.35	6.506	0	.0	0	0
Stage5	128	15.60	7.037	0	.0	0	1
Stage6	128	13.81	5.735	0	.0	0	0
State	128			0	.0		
Stage	128			0	.0		
Grade	128			0	.0		
Subject	128			0	.0		
Degree	128			0	.0		
Ethnicity	128			0	.0		
Gender	128			0	.0		

a. Number of cases outside the range (Q1 - 1.5*IQR, Q3 + 1.5*IQR).

Figure 4.1. Output generated by SPSS Missing Value Analysis.

Appendix E:
Permission Letter From School Districts

School 1, Georgia

January 17, 2011

Dear Mr.

I am currently a Doctorial Candidate at Liberty University in Lynchburg, Virginia, and preparing to conduct research for a study titled Teachers and hand-held graphing technology: An examination of relationships, predictions, and comparisons of concerns. The reason for letter is to obtain consent to survey teachers in your school district.

The purpose of this research is to:

1. Predict a teacher's stage of concern using formal training and teaching experience.
2. Determine differences in stages of concern, formal training, and teaching experience according to a teacher's state of employment (Tennessee or Georgia).

Also, I am requesting consent to collect specific demographic teacher data (ethnicity, gender, age, sex, & experience teaching math) for the purpose of determining homogeneity of groups. The research data will pertain only to the attitudes and concerns of teachers. No student data will be collected.

Due to the nature of the study being voluntary, and participants being adults, this study is considered to be of a minimal risk. Also, the benefit of this study is that it will provide school administration with pertinent data concerning teachers' concerns regarding technology for and during instruction.

The Stages of Concern Questionnaire will be used to gather information regarding teachers' concerns about using a graphing calculator to aid math instruction. A copy of the questionnaire and license agreement to use the instrument is included for your inspection.

If consent is granted, the teacher will first receive a letter through the United States Postal Service explaining the study. Next the teacher will receiving an electronic message through school emails that will be an invitation to participate in the study along with a hyperlink to the survey site and a unique password. The teacher may simply ignore the message if he or she chooses not to participate.

If you have questions about this study, I can be contacted by phone or electronically. Please note the contact information made available at the end of this letter if further information is required. If consent is granted for this study please sign, date and return this letter. A second letter has been included for your records and a postage paid return envelope is also enclosed.

Statement of Consent
Consent is given for the survey of teachers as described in this letter and employed by this school system.

Signature: John F. Harper Date: 1/25/11
Mr.JohnHarper

Sincerely,

Ed Helton

Ed Helton
104 Meadowbrook Lane
LaFayette, Georgia 30728
Phone (423) 544-4176
email: edd_helton07@comcast.net

School 2, Tennessee

January 17, 2011

Dear Mr.

I am currently a Doctorial Candidate at Liberty University in Lynchburg, Virginia, and preparing to conduct research for a study titled Teachers and hand-held graphing technology: An examination of relationships, predictions, and comparisons of concerns. The reason for letter is to obtain consent to survey teachers in your school district.

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If you have questions about this study, I can be contacted by phone or electronically. Please note the contact information made available at the end of this letter if further information is required. If consent is granted for this study please sign, date and return this letter. A second letter has been included for your records and a postage paid return envelope is also enclosed.

Statement of Consent
Consent is given for the survey of teachers as described in this letter and employed by this school system.

Signature: ____ Date: 1-21-11

Mr.JohnnyMcDaniels

Sincerely,

Ed Helton
104 Meadowbrook Lane
LaFayette, Georgia 30728
Phone (423) 544-4176
email: edd_helton07@comcast.net

School 3, Georgia

May 2,, 2011

Dear Dr.

I am currently a Doctorial Candidate at Liberty University in Lynchburg, Virginia and currently preparing to conduct research for a study titled: Teachers and hand-held graphing technology: An examination of relationships, predictions, and comparisons of concerns. This letter is to obtain consent to survey teachers in your school district

The purpose of this research is to:

1. Predict a teacher's stage of concern using formal training and teaching experience
2. Determine differences in stages of concern, formal training, and teaching experience according to a teacher's state of employment (Tennessee or Georgia).

Also, I am requesting consent to collect specific demographic teacher data for use in this study (ethnicity, gender, age, sex, & experience teaching math) for the purpose of determining homogeneity of groups. The research data collected in this study will pertain only to the attitudes and concerns of teachers. No student data will be collected.

Due to the nature of the study being voluntary and participants being adults, this study is considered to be of a minimal risk. Also, the benefit of this study is that it will provide school administration with pertinent data concerning teachers' concerns regarding technology for and during instruction.

The Stages of Concern Questionnaire will be used to gather information regarding a teachers attitudes toward a using a graphing calculator for and during instruction. .I have attached a copy of the questionnaire and license agreement to use the instrument for your inspection.

If consent is granted, the teacher will first receive a letter through the United States Postal Service explaining the study and contact information if questions arise. Next the teacher will receiving an electronic message through school emails that will be an invitation to participate in the study along with a hyperlink to the survey site and a unique password. The teacher may simply ignore the message if he or she chooses not to participate.

If you have questions about this study, I can be contacted by phone or electronically. If consent is granted for this study please sign, date and return this letter. A second letter has been included for your records Please note the contact information made available at the end of this letter.

Statement of Consent
Consent is given for the survey of teachers, as described in this letter and employed by this school system.

Signature: Drew Sand Date: 5-3-11

Sincerely,

Ed Helton
104 Meadowbrook Lane
LaFayette, Georgia 30728
Phone (423) 544-4176
edd_helton07@comcast.net

School 4, Georgia

RECEIVED 01/24/11

January 17, 2011

Dear Dr.

I am currently a Doctorial Candidate at Liberty University in Lynchburg, Virginia, and preparing to conduct research for a study titled Teachers and hand-held graphing technology: An examination of relationships, predictions, and comparisons of concerns. The reason for letter is to obtain consent to survey teachers in your school district.

The purpose of this research is to:

1. Predict a teacher's stage of concern using formal training and teaching experience.
2. Determine differences in stages of concern, formal training, and teaching experience according to a teacher's state of employment (Tennessee or Georgia).

Also, I am requesting consent to collect specific demographic teacher data (ethnicity, gender, age, sex, & experience teaching math) for the purpose of determining homogeneity of groups. The research data will pertain only to the attitudes and concerns of teachers. No student data will be collected.

Due to the nature of the study being voluntary, and participants being adults, this study is considered to be of a minimal risk. Also, the benefit of this study is that it will provide school administration with pertinent data concerning teachers' concerns regarding technology for and during instruction.

The Stages of Concern Questionnaire will be used to gather information regarding teachers' concerns about using a graphing calculator to aid math instruction. A copy of the questionnaire and license agreement to use the instrument is included for your inspection.

If consent is granted, the teacher will first receive a letter through the United States Postal Service explaining the study. Next the teacher will receiving an electronic message through school emails that will be an invitation to participate in the study along with a hyperlink to the survey site and a unique password. The teacher may simply ignore the message if he or she chooses not to participate.

If you have questions about this study, I can be contacted by phone or electronically. Please note the contact information made available at the end of this letter if further information is required. If consent is granted for this study please sign, date and return this letter. A second letter has been included for your records and a postage paid return envelope is also enclosed.

Statement of Consent
Consent is given for the survey of teachers as described in this letter and employed by this school system.

Signature: Ken Clouse Date: 1/24/11

~~Dr. Howard~~Hinesley

Ken Clouse
Assistant Superintendent
Cartersville City Schools

Sincerely,

Ed Helton
104 Meadowbrook Lane
LaFayette, Georgia 30728
Phone (423) 544-4176
email: edd_helton07@comcast.net

Schools 5 Georgia

May 2,, 2011

Dear Mr.

I am currently a Doctorial Candidate at Liberty University in Lynchburg, Virginia and currently preparing to conduct research for a study titled: Teachers and hand-held graphing technology: An examination of relationships, predictions, and comparisons of concerns. This letter is to obtain consent to survey teachers in your school district

The purpose of this research is to:

1. Predict a teacher's stage of concern using formal training and teaching experience
2. Determine differences in stages of concern, formal training, and teaching experience according to a teacher's state of employment (Tennessee or Georgia).

Also, I am requesting consent to collect specific demographic teacher data for use in this study (ethnicity, gender, age, sex, & experience teaching math) for the purpose of determining homogeneity of groups. The research data collected in this study will pertain only to the attitudes and concerns of teachers. No student data will be collected.

Due to the nature of the study being voluntary and participants being adults, this study is considered to be of a minimal risk. Also, the benefit of this study is that it will provide school administration with pertinent data concerning teachers' concerns regarding technology for and during instruction.

The Stages of Concern Questionnaire will be used to gather information regarding a teachers attitudes toward a using a graphing calculator for and during instruction. .I have attached a copy of the questionnaire and license agreement to use the instrument for your inspection.

If consent is granted, the teacher will first receive a letter through the United States Postal Service explaining the study and contact information if questions arise. Next the teacher will receiving an electronic message through school emails that will be an invitation to participate in the study along with a hyperlink to the survey site and a unique password. The teacher may simply ignore the message if he or she chooses not to participate.

If you have questions about this study, I can be contacted by phone or electronically. If consent is granted for this study please sign, date and return this letter. A second letter has been included for your records Please note the contact information made available at the end of this letter.

Statement of Consent
Consent is given for the survey of teachers, as described in this letter and employed by this school system.

Signature:
Date: 5/2/11

Sincerely,
Ed Helton

LaFayette, Georgia 30728
Phone

Schools 6 Georgia

January 17, 2011

Dear Mrs.

I am currently a Doctorial Candidate at Liberty University in Lynchburg, Virginia, and preparing to conduct research for a study titled Teachers and hand-held graphing technology: An examination of relationships, predictions, and comparisons of concerns. The reason for letter is to obtain consent to survey teachers in your school district.

The purpose of this research is to:

1. Predict a teacher's stage of concern using formal training and teaching experience.
2. Determine differences in stages of concern, formal training, and teaching experience according to a teacher's state of employment (Tennessee or Georgia).

Also, I am requesting consent to collect specific demographic teacher data (ethnicity, gender, age, sex, & experience teaching math) for the purpose of determining homogeneity of groups. The research data will pertain only to the attitudes and concerns of teachers. No student data will be collected.

Due to the nature of the study being voluntary, and participants being adults, this study is considered to be of a minimal risk. Also, the benefit of this study is that it will provide school administration with pertinent data concerning teachers' concerns regarding technology for and during instruction.

The Stages of Concern Questionnaire will be used to gather information regarding teachers' concerns about using a graphing calculator to aid math instruction. A copy of the questionnaire and license agreement to use the instrument is included for your inspection.

If consent is granted, the teacher will first receive a letter through the United States Postal Service explaining the study. Next the teacher will receiving an electronic message through school emails that will be an invitation to participate in the study along with a hyperlink to the survey site and a unique password. The teacher may simply ignore the message if he or she chooses not to participate.

If you have questions about this study, I can be contacted by phone or electronically. Please note the contact information made available at the end of this letter if further information is required. If consent is granted for this study please sign, date and return this letter. A second letter has been included for your records and a postage paid return envelope is also enclosed.

Statement of Consent

Consent is given for the survey of teachers as described in this letter and employed by this school system.

Signature: ______________________ Date: 2-15-11

Mrs.MelodyDay

Sincerely,

Ed Helton
104 Meadowbrook Lane
LaFayette, Georgia 30728
Phone (423) 544-4176
email: edd_helton07@comcast.net

School 7 Georgia

APPLICATION TO CONDUCT RESEARCH IN SCHOOLS

County Schools

Researcher: Edward W. helton

Location / Address: 104 Meadowbrook Lane, Lafayette, Georgia 30728

Phone Number: (423) 544-4176

Title of Proposed Research Study:

TEACHERS AND HAND-HELD GRAPHING TECHNOLOGY: AN EXAMINATION OF RELATIONSHIPS, PREDICTIONS, AND COMPARISONS OF CONCERNS

Proposed Project Starting Date: April 1, 2011

Proposed Project Ending Date: February 1, 2012

Purpose of the Study:

The purpose of this nonexperimental correlational study is to examine the concerns of teachers, using an instrument, the Stages of Concern Questionnaire (SoCQ), with reference to the graphing calculator. The study will ask if scores on the SoCQ (the criterion variable) regarding graphing calculators can be reliably predicated from teaching experience and the amount of formal training (predictor variables). Multiple linear regression analysis will be conducted to determine if teachers stages of concern can be predicted based on formal training and teaching experience with the graphing calculator. This study is also designed to determine if differences in stages of concern, formal training, and teaching experience with a graphing calculator can be determined by the teacher's state of employment (Georgia or Tennessee) using multivariate analysis of variance (MANOVA).

Action Research ☐ Dissertation ☒ Thesis ☐ If other explain: ______

Rationale for the Study (How will the study contribute to this field of research?)

This study will contribute to the body of research that measures how the concerns of teachers are affected by the graphing calculator along with certain variables (formal training, teaching experience, and the state where the teaching is taking place) that are hypothesized to affect teachers' concerns.

Research Questions or Hypotheses

This study will address the following research questions:

Question 1. Can a teacher's stages of concern be predicted based on formal training and teaching experience with the graphing calculator?

Null Hypothesis 1. There will not be a predictable relationship between formal training and teacher experience with the stages of concern of a teacher of mathematics.

Question 2. Are there differences in stages of concern, formal training, and teaching experience with the graphing calculator according to the teacher's state of employment (Georgia or Tennessee)?

Null Hypothesis 2. There will not be statistically significant differences in stages of concern, formal training, and teaching experience with the graphing calculator according to the teacher's state of employment (Georgia or Tennessee).

Methodology

A. Participants

Students:	Number: N/A	Grade(s): N/A
Teachers:	Number: 31 (approximately)Math	Grade(s): 9-12
Administrators:	Number: 0	
Support Staff:	Number: 0	
Parents:	Number: 0	

How were participants selected for the research project?

Teachers of High School Mathematics located in the Northwest Georgia RESA District

How much time will be required for individuals participating in the study?

30 Minutes

What will participants be asked to do?

Complete an online survey

Proposed schools to be included in the research project

Armuchee High School, Coosa High School, Model High School, and Pepperell High School

Have the principals, if applicable, been contacted, given approval to conduct research in their school, and signed the Applicant Agreement Form? YES ☐ NO ☒

How will consent be obtained from all research participants, and if necessary, from parents/guardians? See the sample Parental Permission Form in Attachment C.

Participation is voluntary and will be offered to adults only. Students are in no way involved in the research and data will not be collect concerning students. Teachers will be offered the opportunity to participate via letter (US Mail) and school email. If a teacher chooses not to participate he or she can simply ignore the correspondence. The teacher logging into the survey site is considered implied consent for participation.

Identify any potential benefits or risks for participants that might result from the research.

Potential Benefits	Potential Risks
This work will contribute to the body of research involving technology and teacher concerns.	The study is designed to collect data involving teacher levels of concern about a new innovation, the graphing calculator, and the new Georgia Performance Standards for mathematics. The risks are considered to be minimal and all data collected is confidential.

B. Research Design Information

☒ Quantitative ☐ Qualitative ☐ Mixed Methods

Briefly describe your design:

Nonexperimental correlational research is the design the study. The study is designed to determine if the teacher's stage of concern about the introduction of the graphing calculator in the classroom can be predicted based on teaching experience, formal training, and the state in which the instruction is given (Georgia or Tennessee).

C. Data Collection and Analysis

List data that will be collected for this study. Include a copy of all surveys, interview protocols, tests, checklists or other data collection instruments.

Data to be Collected	Data Collection Instruments	Data Source	Anticipated Date of Data Collection
Teacher levels of Concern towards the Graphing Calculator.	Stages of Concern Questionnaire	High School Teachers of Mathematics in defined areas of Georgia and Tennessee	April-October 2011

Describe your data analysis procedures. Identify statistical measures that will be used to test the hypotheses. If qualitative designs are used, identify coding scheme and data validation procedures.

Research question 1 asks if a prediction can be made between the criterion variable teacher stages of concern, with both of the predictor variables, teaching experience and formal training. Multiple regression analysis is used to determine the correlation of the best possible weighted combination of the two predictor variables (Ary et al. (2006). Because two predictor variables are being considered with no covariates, sequential multiple regression analysis will be used to test the hypothesis measuring the degree of teacher Stages of Concern related to teaching experience and formal training (Tabachnick & Fidell, 2007).

Question 2 asks if a difference exists between the mean peak score in two groups (Tennessee and Georgia). This question will be addressed in two parts. First, statement items on the SoCQ will be first totaled and converted into percentile scores. A conversion chart, (See Appendix C, Table 4) was provided by the developers of the SoCQ (George et al., 2008). The percentiles were based on the responses of 830 participants who completed the 35-item questionnaire in the fall of 1974. Participants were a carefully selected stratified sample, from both elementary schools and higher-education with the innovation of teaming or modules. The percentiles in this table have proved to be representative of other innovations.

To develop understanding into the concerns of the teachers, peak stage scores will be analyzed. George et al. (2008) state that interpretation of the peak score is based directly on the Stages of Concern About an Innovation chart (see Appendix C, Figure 1.2). And, the higher the peak score, the greater the relative intensity of concern at that stage and the lower the score , the less intense the concerns are at that stage.

The last part to question 2 will be to conduct a MANOVA. Mean peak scale SoCQ scores, teaching experience, and formal training of the Georgia teachers will be compared to the mean peak scale SoCQ scores, teaching experience, and formal training of the Tennessee teachers using MANOVA to determine if a combination of dependant variables (formal training, teacher experience, and peak scale SOCQ scores) are a function of the independent variables (teaching in Georgia or Tennessee). This analysis will test whether mean differences among groups, mean peak scale score, format training, and teacher experience, are likely to have occurred by chance.

Will anyone other than the researcher be involved in the data analysis process? ☐ YES ☒ NO
If yes, who will assist with data analysis procedures?

N/A

D. Applicant Agreement

FLOYD COUNTY SCHOOLS
Access to Confidential Data
Applicant Agreement

Research Applicant:	Edward W. Helton
Research Title:	TEACHERS AND HAND-HELD GRAPHING TECHNOLOGY: AN EXAMINATION OF RELATIONSHIPS, PREDICTIONS, AND COMPARISONS OF CONCERNS
Home Address:	104 Meadowbrook Lane
City/State/Zip:	Lafayette, Georgia 30728
Employer:	Catoosa County Schools
Telephone:	**Work:** (706) 866-0342 **Home:** (423)544-4176
	Fax: N/A **E-mail:** edd_helton07@comcast.net

I understand that any unauthorized disclosure of confidential information is illegal as provided in the Family Educational Rights and Privacy Act of 1973 (FERPA) and in the implementing federal regulations found in 34 CFR Part 99. I understand that participation in a research study by students, parents, and school staff is strictly voluntary. I further understand and agree that Floyd County Schools may, in its sole discretion, terminate any research or project and may revoke its consent and permission for Research Applicant to continue research within the School District.

In addition, I understand that any data, datasets or outputs that I, or any authorized representative, may generate from data collection efforts throughout the duration of the research study are confidential and the data are to be protected. I will not distribute to any unauthorized person any data or reports that I have access to or may generate using confidential data. I also understand that students, schools, or the district may not be identified in the research report. Data with names or other identifiers (such as student numbers) will be made indecipherable and disposed of when their use is complete.

I understand that acceptance of this request for approval of a research project in no way obligates the Floyd County Schools to participate in the research. I also understand that approval does not constitute commitment of resources or endorsement of the study or its findings by the school system or by the Board of Education. I further agree to immediately terminate said research project immediately if the School District revokes its permission for me to conduct the research study.

If the research project is approved, I agree to abide by standards of professional conduct while working in the schools. I understand that failure to do so could result in termination of the research study.

I agree to send a complete copy of the study results to the Department of Academics, Director of School Improvement after completion of the study for any future use to the Floyd County Schools. I understand that the study is not complete until this report has been provided to Floyd County Schools.

Edward W. Helton — 3/14/11
Research Applicant Signature — Date

Terri Vandiver — 3/15/11
Signature of Your Administrator Sponsor (i.e., Your Principal) — Date

Andrew Izaan — 3-21-11
Signature of Sponsoring Agency (i.e., College Professor) — Date

3-30-11
Signature of Floyd County Schools Department of Academics — Date

Granting Approval of the Attached Research Proposal.
Once Signed, Applicant May Proceed with Research.

4 of 5

School 8, Tennessee

April 8, 2011

Dear Doctor ,
I am currently a Doctorial Candidate at Liberty University in Lynchburg, Virginia and currently preparing to conduct research for a study titled: Teachers and hand-held graphing technology: An examination of relationships, predictions, and comparisons of concerns. This letter is to obtain consent to survey teachers in your school district

The purpose of this research is to:

1. Predict a teacher's stage of concern using formal training and teaching experience
2. Determine differences in stages of concern, formal training, and teaching experience according to a teacher's state of employment (Tennessee or Georgia).

Also, I am requesting consent to collect specific demographic teacher data for use in this study (ethnicity, gender, age, sex, & experience teaching math) for the purpose of determining homogeneity of groups. The research data collected in this study will pertain only to the attitudes and concerns of teachers. No student data will be collected.

Due to the nature of the study being voluntary and participants being adults, this study is considered to be of a minimal risk. Also, the benefit of this study is that it will provide school administration with pertinent data concerning teachers' concerns regarding technology for and during instruction.

The Stages of Concern Questionnaire will be used to gather information regarding a teachers attitudes toward a using a graphing calculator for and during instruction. I have attached a copy of the questionnaire and license agreement to use the instrument for your inspection.

If consent is granted, the teacher will first receive a letter through the United States Postal Service explaining the study and contact information if questions arise. Next the teacher will receiving an electronic message through school emails that will be an invitation to participate in the study along with a hyperlink to the survey site and a unique password. The teacher may simply ignore the message if he or she chooses not to participate.

If you have questions about this study, I can be contacted by phone or electronically. If consent is granted for this study please sign, date and return this letter. A second letter has been included for your records Please note the contact information made available at the end of this letter.

Statement of Consent
Consent is given for the survey of teachers, as described in this letter and employed by this school system.

Signature: ____________________ Date: 4/14/11

Sincerely,

Ed Helton
104 Meadowbrook Lane
LaFayette, Georgia 30728
Phone (423) 544-4176
edd_helton07@comcast.net

School 9, Tennessee

January 17, 2011

Dear Mr.
I am currently a Doctorial Candidate at Liberty University in Lynchburg, Virginia and currently preparing to conduct research for a study titled: Teachers and hand-held graphing technology: An examination of relationships, predictions, and comparisons of concerns. This letter is to obtain consent to survey teachers in your school district

The purpose of this research is to:

1. Predict a teacher's stage of concern using formal training and teaching experience
2. Determine differences in stages of concern, formal training, and teaching experience according to a teacher's state of employment (Tennessee or Georgia).

Also, I am requesting consent to collect specific demographic teacher data for use in this study (ethnicity, gender, age, sex, & experience teaching math) for the purpose of determining homogeneity of groups. The research data collected in this study will pertain only to the attitudes and concerns of teachers. No student data will be collected.

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The Stages of Concern Questionnaire will be used to gather information regarding a teachers attitudes toward a using a graphing calculator for and during instruction. .I have attached a copy of the questionnaire and license agreement to use the instrument for your inspection.

If consent is granted, the teacher will first receive a letter through the United States Postal Service explaining the study and contact information if questions arise. Next the teacher will receiving an electronic message through school emails that will be an invitation to participate in the study along with a hyperlink to the survey site and a unique password. The teacher may simply ignore the message if he or she chooses not to participate.

If you have questions about this study, I can be contacted by phone or electronically. If consent is granted for this study please sign, date and return this letter. A second letter has been included for your records Please note the contact information made available at the end of this letter.

Statement of Consent
Consent is given for the survey of teachers, as described in this letter and employed by this school system.

Signature: Date: 03-15-2011

Sincerely,

Ed Helton
104 Meadowbrook Lane
LaFayette, Georgia 30728
Phone (423) 544-4176
edd_helton07@comcast.net

School 10, Georgia

May 6, 2011

Dear Dr.

I am currently a Doctorial Candidate at Liberty University in Lynchburg, Virginia and currently preparing to conduct research for a study titled: Teachers and hand-held graphing technology: An examination of relationships, predictions, and comparisons of concerns. This letter is to obtain consent to survey teachers in your school district

The purpose of this research is to:

1. Predict a teacher's stage of concern using formal training and teaching experience
2. Determine differences in stages of concern, formal training, and teaching experience according to a teacher's state of employment (Tennessee or Georgia).

Also, I am requesting consent to collect specific demographic teacher data for use in this study (ethnicity, gender, age, sex, & experience teaching math) for the purpose of determining homogeneity of groups. The research data collected in this study will pertain only to the attitudes and concerns of teachers. No student data will be collected.

Due to the nature of the study being voluntary and participants being adults, this study is considered to be of a minimal risk. Also, the benefit of this study is that it will provide school administration with pertinent data concerning teachers' concerns regarding technology for and during instruction.

The Stages of Concern Questionnaire will be used to gather information regarding a teachers attitudes toward a using a graphing calculator for and during instruction. I have attached a copy of the questionnaire and license agreement to use the instrument for your inspection.

If consent is granted, the teacher will first receive a letter through the United States Postal Service explaining the study and contact information if questions arise. Next the teacher will receiving an electronic message through school emails that will be an invitation to participate in the study along with a hyperlink to the survey site and a unique password. The teacher may simply ignore the message if he or she chooses not to participate.

If you have questions about this study, I can be contacted by phone or electronically. If consent is granted for this study please sign, date and return this letter. A second letter has been included for your records Please note the contact information made available at the end of this letter.

Statement of Consent
Consent is given for the survey of teachers, as described in this letter and employed by this school system.

Signature: ______________________ Date: 5-9-11

Sincerely,

Ed Helton
104 Meadowbrook Lane
LaFayette, Georgia 30728
Phone (423) 544-4176
edd_helton07@comcast.net

Appendix F

IRB Approval

IRB Approval 1092.042711: Teachers and Hand-held Graphing Technology: An Examination of Relationships, Predictions, and Comparisons of Concerns

IRB, IRB

Sent: Wednesday, April 27, 2011 4:35 PM

To: Helton, Edward

Cc: Beam, Andrea; IRB, IRB; Garzon, Fernando

Attachments: Annual Review Form.doc (31 KB) ; Change in Protocol.doc (29 KB)

Good Afternoon Edward,

We are pleased to inform you that your above study has been approved by the Liberty IRB. This approval is extended to you for one year. If data collection proceeds past one year, or if you make changes in the methodology as it pertains to human subjects, you must submit an appropriate update form to the IRB. Attached you'll find the forms for those cases.

Thank you for your cooperation with the IRB and we wish you well with your research project. We will be glad to send you a written memo from the Liberty IRB, as needed, upon request.

Sincerely,

Fernando Garzon, Psy.D.
IRB Chair, Associate Professor
Center for Counseling & Family Studies

(434) 592-5054

LIBERTY
UNIVERSITY.

40 Years of Training Champions for Christ: 1971-2011

Appendix G
Letter to Teachers

May 11, 2011

Joe Teacher
123 School Drive
School Town, State, 30303

Dear Teacher,

I am currently a Doctorial Candidate at Liberty University in Lynchburg, Virginia. The questionnaire that you are being asked to complete is for the partial fulfillment of my studies. The Stages of Concern Questionnaire will be used to gather information regarding your attitudes toward a specific innovation and instruction. Also you will be asked to provide certain demographic data for use in this study. While your superintendent has authorized this study, *your participation is entirely voluntary and there will be no consequences for non-participation*. I believe that the entire process will require no more than 15 minutes of your time

My research is designed to determine what teachers of mathematics are concerned about at various times during the use of graphing calculators for teaching and learning. In the next few days, you will be receiving an electronic message through your school email. The communication will appear as:

> Dear Colleague,
>
> You are invited to participate in a questionnaire related to teacher concerns and the graphing calculator. The purpose of the questionnaire is to determine what people are concerned about at various times during the process of adopting an innovation. The survey is called the Stages of Concern Questionnaire, and it will take approximately 5-10 minutes to complete. The survey is online at:
>
> http://www.sedl.org/concerns/index.cgi?sc=wrahp7

The study is designed for the participant to remain anonymous. You may be assured that your responses will remain completely confidential, and, for your assistance in completing this survey, a small ($1.00) gift has been placed in this letter. This gift in no way obligates you in any way to participate in this study. You may keep the gift whether or not you decide to participate in the study. I also teach mathematics fulltime at a high school in this area and do appreciate the time that you give this matter. If you have questions about this study, I can be contacted by phone or electronically. Please note the contact information made available at the end of this letter. Once again, *your participation in this survey is voluntary and the completing of the questionnaire is considered to be an implied consent for your participation in this study.*

The researcher conducting this study is Edward W. Helton. If you have questions, **you are encouraged** to contact him at: 104 Meadowbrook Lane, Lafayette, Georgia 30728, (423)544-4176 or email at edd_helton07@comcast.net.

Mr. Helton is a student and is working under the direction of Dr. Andrea Beam, Assistant Professor, School of Education. If you have questions, **you are encouraged** to contact her at Liberty University 1971 University Drive, Lynchburg, Virginia 24502, (434)582-244 or email at abeam@liberty.edu

If you have questions or concerns regarding this study and would like to talk to someone other than the researcher, **you are encouraged** to contact the Institutional Review Board, Dr. Fernanda Garzon, Chair, 1971 University Boulevard, Lynchburg, Virginia 24502, or email at irb@liberty.edu

Sincerely,

Ed Helton

Appendix H
First Reminder

Dear Colleagues,

You are invited to participate in a questionnaire related to the graphing calculator.

The purpose of the questionnaire is to determine what people are concerned about at various times during the process of adopting an innovation (the graphing calculator). The survey is called the Stages of Concern Questionnaire, and it will take approximately 5-10 minutes to complete.

The survey is available online at:

http://www.sedl.org/concerns/index.cgi?sc=wrahp7

This link will automatically log on to the SoCQ for this cohort:

Thanks again for helping with this study.

Ed Helton

Appendix I
Second Reminder

Dear Colleagues,

For those who have already participated in the survey I would like to say thank you. If you have not participated the questionnaire is still available.

The purpose of the questionnaire is to determine what people are concerned about at various times during the process of adopting an innovation (the graphing calculator). The survey is called the Stages of Concern Questionnaire, and it will take approximately 5-10 minutes to complete.

The survey is available online at:

http://www.sedl.org/concerns/index.cgi?sc=wrahp7

This link will automatically log on to the SoCQ for this cohort:

Thanks again for helping with this study.

Ed Helton

Appendix J
Third Reminder and Thank You

Dear Colleagues,

Thanks for helping with my research! The time you invested will be remembered. If any of you need help with research for an advanced degree please feel free to contact me. I will be glad to return the favor.

Also, if you would like a copy of my work after it has been defended and accepted, please reply to this email. I will forward an electronic copy to you. I am projecting to be completed by late fall or early winter of this year.

One more thing, if you have not yet had the time to complete the questionnaire, it is still availible and it will take approximately 5-10 minutes for you to complete.

The survey is available online at:

http://www.sedl.org/concerns/index.cgi?sc=wrahp7

This link will automatically log on to the SoCQ for this cohort:

Thanks again for helping with this study.

Ed Helton

Appendix K

Linearity and Homoscedasticity

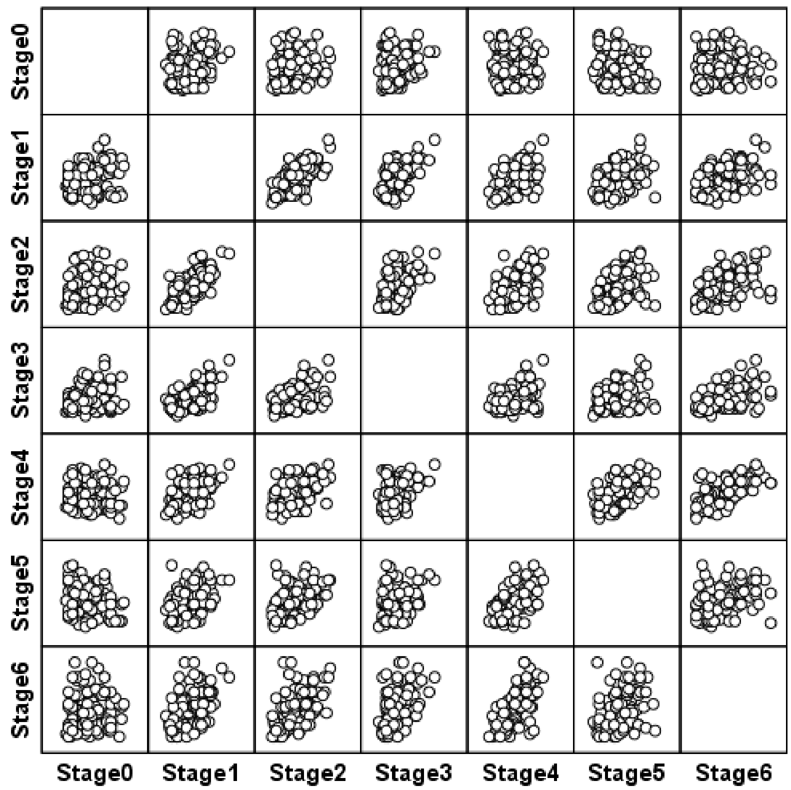

Figure 4.2. Scatterplots