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Graphics Calculators In Developmental Mathematics—Policies And Practice: An Investigation Of Factors Affecting Instructors' Classroom Usage In Tennessee Community Colleges

Joyce Petty Smith
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To the Graduate Council:

I am submitting herewith a dissertation written by Joyce Petty Smith entitled "Graphics Calculators In Developmental Mathematics—Policies And Practice: An Investigation Of Factors Affecting Instructors' Classroom Usage In Tennessee Community Colleges." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Education, with a major in Instructional Technology and Educational Studies.

P. Mark Taylor, Major Professor

We have read this dissertation and recommend its acceptance:

Mary Jane Connelly, Donald J. Dessart, Sharon Husch

Accepted for the Council:
Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Sharon Husch__________________________

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Anne Mayhew______________
Vice Chancellor and Dean of
Graduate Studies

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GRAPHICS CALCULATORS IN DEVELOPMENTAL MATHEMATICS—POLICIES AND PRACTICE: AN INVESTIGATION OF FACTORS AFFECTING INSTRUCTORS' CLASSROOM USAGE IN TENNESSEE COMMUNITY COLLEGES

A Dissertation

Presented for the

Doctor of Education

Degree

The University of Tennessee

Joyce Ann Petty Smith

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DEDICATION

This work is dedicated to my parents, Mattie Belle Quirk Petty and John Thomas (J. T.) Petty, Jr., who were always supportive of my endeavors and whose example of a loving couple was one to emulate. To Mom, who educated herself far beyond her eighth grade formal education and whose example of strength showed me that all situations, even the worst, can be handled with prayer and humor. To Dad for never indicating there were things that women could not do and for giving me an example of a person whose handshake agreement was a contract more binding than any signature.

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ABSTRACT

The purpose of this study was to investigate the frequency of Tennessee community college full-time developmental mathematics instructors' classroom graphics calculator usage (percent of class time) and various personal and professional descriptors of those instructors and the graphics calculator policies at each college: number of years of full-time teaching at community college level, number of years teaching mathematics, level of education, amount of formal (workshop or class participant) professional development with graphics calculators, brand of graphics calculator used by their college, percentage of time a graphics calculator is used in the classroom for calculations, percentage of time a graphics calculator is used in the classroom to depict algebra graphically or numerically (table), percentage of time the graphics calculator is used in each developmental mathematics course (Basic Mathematics, Elementary Algebra, Intermediate Algebra), gender, academic rank, number of years their college has used graphics calculators for developmental mathematics, and the graphics calculator policy (not allowed, no policy, recommended, required) at each college for each of the developmental mathematics courses (Basic Mathematics, Elementary Algebra, Intermediate Algebra). Data was collected from Tennessee community college mathematics department heads and full-time mathematics faculty members who taught at least one developmental mathematics course each semester (fall and spring) during 2002. The two data collecting instruments were a forced-choice, web-based survey of developmental mathematics instructors and an email-based department head questionnaire.

Descriptive statistics and a Spearman correlation coefficient matrix were used for statistical analyses of the data to answer the six (6) research questions in relation to the thirteen (13) instructor survey questions with included comments and the four (4) department head questionnaire questions. If an instructor were depicted as having all the traits of the majority of the participants' responses, the following would be "the" Tennessee community college developmental mathematics instructor. This instructor would be a female Associate Professor (fully promoted) with a Masters Degree. She would have been a full-time college faculty member for 15 years or less and would have been teaching mathematics 16 or more years. She would have had 20 or less contact hours of professional development with graphics calculators, and she would used a Texas Instruments graphics calculator in the classroom 0% – 20% of the time.

The correlation matrix indicated the following significant relationships: instructors' brand of graphics calculator used and instructors' frequency of graphics calculator usage for all categories (calculations, depicting algebra graphically and numerically (table), and calculator use in Basic Mathematics, Elementary Algebra, and Intermediate Algebra), and instructors' amount of formal professional development correlated with all frequency of use categories.

Analysis of data from the correlation matrix indicated some significant relationships. Significant correlations emerged from the correlation matrix: among all frequency of use categories, between instructors' years teaching mathematics and years as a full-time community college faculty member, instructors' years teaching mathematics and academic rank, instructors' years as a full-time community college faculty member and academic rank, instructors' highest degree earned and academic rank, instructors' highest degree earned and contact hours of formal (workshop or class participant) professional development, instructors' contact hours of formal workshop professional development and brand of graphics calculator used, instructors' contact hours of formal workshop professional development and gender, instructors' contact hours of formal workshop professional development and academic rank, and instructors' brand of graphics calculator used and academic rank.

Calculator usage policies were derived from the department head responses. Five colleges indicated they have never used graphics calculators in developmental mathematics and six colleges indicated they have used graphics calculators in developmental mathematics for nine or more years.

Like results from analysis of department head questionnaire responses, the comments painted a mural of diversity in choices and thoughts on the use or non-use of graphics calculators in developmental mathematics. The six trends that emerged from participant comments included the following categories: algebra prior to calculator; Basic Mathematics, Elementary Algebra, and Intermediate Algebra; caution; clarification; explanation of use; negative, no use, or limited use; and other questions, topics, and uses. The category, explanation of use, with participants providing an explanation of how they and/or their colleagues use calculators at their colleges was the trend most (10) mentioned; and the category, negative, no use, or limited use, with participants indicating personal, professional, or departmental choices of not using or limiting the use of graphics calculators was next, with eight comments.

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CHAPTER I

INTRODUCTION

Developmental mathematics courses provide the bridge for the mathematical gap between high school or GED graduation and entrance into college level mathematics courses for many college students. The offering of developmental courses has been labeled as a secondary school within the college (Casazza, 1999). Students who are required to take developmental mathematics are often poorly educated mathematically, forgetful of what they did learn, emotionally stressed, frightened, angry, learning challenged, physically challenged, or any combination of these. Developmental mathematics courses provide an opportunity to remedy the mathematical problems of these students without exacerbating any non-mathematical problems that may exist. Developmental mathematics instructors should provide students with instruction that is rich with research-based techniques and strategies, including the appropriate use of technological tools, thus, offering the student a better opportunity to gain or enhance mathematical knowledge and understanding (Laughbaum, 2003; Smith, 1998).

With so many students taking developmental mathematics courses it is imperative that instructors seek the most effective procedure for presenting the material. Though they know the mathematics information and wish to explain it to their students, some college instructors have training in neither teaching techniques nor in any form of technology. Even the "the same old material" must be analyzed for its effectiveness or usefulness in today's world (Howe, 1998).

New methods to effectively present material must be utilized and, often, created. Using graphing calculators in the presentation of material can be supportive of initiating and processing curriculum changes as educators rethink the teaching and learning of mathematics (Gomez, 1996; Heid, 1997). Technology has been a driving force for change in standards and in instruction techniques as teachers strive to enact new standards (Howe, 1998; Peressini & Knuth, 2005). The use of technology has spurred change in the very nature of mathematics teaching and learning (Dildine, 1999; Shore, 1999).

The *Curriculum and Evaluation Standards* (National Council of Teachers of Mathematics [NCTM], 1989), *Heeding The Call For Change: Suggestions For Curricular Action* (Mathematical Association of America [MAA], 1992), and *Crossroads in Mathematics* (American Mathematical Association of Two-Year Colleges [AMATYC], 1995) called for reform in curriculum and pedagogy of mathematics classes and promoted the use of technology in kindergarten through twelfth grade and collegiate classes. Mathematics interests in Tennessee community colleges were represented in the writing and endorsement of elements of the reform standards. Four of the 27 members of the task force for AMATYC's *Crossroads in Mathematics* were from Tennessee, with three of the four representing community colleges (AMATYC, 1995). The standards in *Crossroads in Mathematics* were endorsed by many national and state organizations including National Association for Developmental Education (NADE), NCTM, and Tennessee Mathematical Association of Two-Year Colleges (TMATYC).

The teaching of developmental mathematics in community colleges in Tennessee as well as the rest of the nation should meet standards of kindergarten through twelfth grade mathematics nationwide (NCTM, 1989) in preparing students for college-level mathematics. This effort includes helping students to learn mathematics, to learn to think mathematically, and to learn how to use technology that can enhance understanding of mathematical concepts as outlined in *Crossroads in Mathematics* (AMATYC, 1995; Gomez, 1996; Waits & Demana, 2001). One way that developmental mathematics teachers can teach these concepts is with the graphics calculator. Teaching and learning with the graphics calculator provides a visualization tool that allows some students to "get it" for the first time (Dildine, 1999; Doerr & Zangor 2000; Shore, 1999; Vonder Embse, 1997). This achievement can be very rewarding for students and for teachers who work to make this happen. Some instructors, however, are dinosaur-like, unaware of extinction. No longer can teachers stand in front of the classroom with chalk or marker in hand and expect that to be enough. Technology is here; it is an integral part of society and very few are untouched by it. Helping students learn the use of technology while they learn mathematics must be an essential, integrated part of every mathematics instructor's daily plans (New Jersey Mathematics Coalition, 1996). Dessart, DeRidder, and Ellington (1999) called for calculator integration in mathematics instruction, not only for computation, but for concept development as well. They referred to the obligation of schools to provide calculator education.

As paradigms shift, new pedagogy must be considered to improve knowledge and understanding of mathematical concepts and the way these concepts interact with life (Dildine, 1999; McGraw, Meyer, & Tompkins, 1995). Integration of technology into the mathematics curriculum must be just that: integration into the curriculum, the process for teaching and learning (Dessart, DeRidder, and Ellington, 1999; Thorpe, 2002). The use of technology must not be an add-on or an afterthought, something instructors do if they have time or think of it. The use of technology in the curriculum must be as much a part of everyday classroom practice as the textbook, as instructions, as questions, as practice and thinking; that is: total integration (AMATYC, 1995; Waits & Demana, 2001). As with other useful components of the mathematics curriculum, students and teachers can use the available technology to further explore mathematics and its applications (Boyd & Carson, 1991; Dildine, 1999; Doerr & Zangor 2000; Heid, 1997; Knuth & Peterson, 2003; Shore 1999; Tharp, Fitzsimmons, & Ayers, 1997; Vonder Embse, 1997).

Background of the Problem

The State of Tennessee requires mathematically under-prepared students, as diagnosed by placement tests, to take developmental mathematics courses. Jenkins (2002) indicated that Tennessee reported the highest percentage (70.9%) of entering college students who required remediation. Nationwide there has been a call for improvement of preparatory courses to meet the needs of students before they entered college-level mathematics (Sackett, 1994). The need for departments and instructors dedicated to the needs of developmentally disadvantaged mathematics students became apparent (AMATYC, 1995). As developmental mathematics departments and mathematics departments were organized or reorganized, curricula, materials, and books were chosen and altered to meet the mathematical needs of students. Nationwide, as technology evolved, so did mathematics curricula (Fey, 1992).

Most students in developmental mathematics courses have had some experience with mathematics in high school with varying degrees of success and failure. For those students who are required to take developmental mathematics courses, whether they have never had it, had it and did not learn it, or had it, learned it, and cannot remember it, assistance beyond reading the textbook is essential (Gal & Stout, 1997/98; Seese, 1994). With a graphics calculator a student can experience and visualize expressions, functions, equations, and the solution(s) of equations by graphing (AMATYC, 1995; Caldwell, 1995; Doerr & Zangor, 2000; Shore, 1999; Vonder Embse, 1997). If the arduous task of graphing and/or checking by hand is quickened by a graphics calculator, the student is much more likely to use this method and learn more about mathematics (Glazer, 1993; Shore, 1999) and to have confidence in the accuracy of the answer (Ruthven, 1990). When students are relieved of the tedium of hand calculations, they can focus more on the understanding of the exercise through exploration and discovery (Caldwell, 1995; Doerr & Zangor 2000; Shore, 1999; Vonder Embse, 1997; Waits & Demana, 2001; Wolff, 1993).

The philosophy during the last two decades among professional mathematics organizations is to address the needs of the student, not just to get the student to the next course level (AMATYC, 1995; NCTM, 1989). In the information age with many jobs requiring the use of technology in normal business activities, students need to become familiar with the use of technology (NCTM, 1989; NCTM, 2005). One way of doing this is for instructors and students to use technology in the classroom (Fromboluti, 1992; Gilchrist, 1993; Heid, Choate, Sheets, & Zbiek, 1995). Instructors must determine how technology is to be integrated into the curriculum and how successful this use of technology is in the teaching of the developmental mathematics student. Cuoco and Goldenberg (1996) expressed the need for restructuring the mathematics curriculum to include methodology that uses technology to assist the student in experiencing the excitement of exploration. Though many colleges and high schools allow the use of graphics calculators in the classroom, not all instructors are using these calculators as a part of their instructional activities. Laughbaum (1998) reported that only 24.4% of teachers were using a graphing calculator to teach developmental mathematics.

Graphics calculators have been available at a reasonable price (under $100) for approximately ten years. There are clear advantages of the graphics calculator over the scientific calculator. These include:

- the graphing capability;
- the large screen that allows students and teachers to see not only the answer, but the exercise or expression as well;
- the table feature;
- the link capability for sharing information and programs calculator to

calculator, computer to calculator, and calculator to computer;

- the programming capability and the availability of program downloads on the Internet;
- the numerous other functions of the graphics calculator;
- the overhead view panel that may be placed directly on an overhead projector to show the students what is on the instructor's calculator screen, providing the advantage of real-time explanations and representations of concepts;
- the assistance programs from graphics calculator companies that offer free calculators and overhead view panels for schools that require their calculators.

Studies have shown that using graphics calculators in the mathematics classroom improves students' attitudes toward mathematics and their enjoyment of mathematics, while improving their mathematical self-concept and opinion of mathematics teachers (O'Callaghan, 1997); allows an alternative way of viewing mathematical concepts by offering visual (graphical and numerical), multiple representations of abstract, complex algebraic concepts (Alagic, 2003; Kissane, Bradley, & Kemp, 1994; Knuth & Peterson, 2003; Peressini & Knuth, 2005; Shore, 1999; Vonder Embse, 1997); supports instructors' and students' critical questioning and critical thinking (Doerr & Zangor, 2000; Simonsen & Dick, 1997); and produces a gain in levels of mathematical understanding and spatial relationship skills (Peressini & Knuth, 2005; Shoaf-Grubbs, 1993). Even though research evidence exists, some instructors still resist using this motivational tool in their classrooms.

The Problem

The problem, then, was a lack of graphics calculator usage in developmental mathematics courses in Tennessee community college classrooms. This research investigated factors affecting Tennessee community college developmental mathematics instructors' classroom usage of graphics calculators. In Tennessee, there are 13 public community colleges governed by the Tennessee Board of Regents (TBR). Table 1.1 lists the TBR community colleges (Tennessee Board of Regents, 2003).

The Purpose

Through a better understanding of the factors affecting instructors, hopefully, mathematics departments in Tennessee community colleges may use this knowledge to provide improvements in developmental mathematics programs. Specifically stated, the purpose of this study was to investigate:

1. frequency of Tennessee community college full-time developmental mathematics instructors' classroom graphics calculator usage (as percent of class time),
2. graphics calculator policies at each college, and
3. various personal and professional descriptors of those instructors.

The investigation included surveying the mathematics instructors and department heads to determine:

- number of years of full-time teaching at community college level,
- number of years teaching mathematics,

Table 1.1 Tennessee Board of Regents Community Colleges	
TBR Community Colleges	**Location**
Chattanooga State Technical Community College	Chattanooga
Cleveland State Community College	Cleveland
Columbia State Community College	Columbia
Dyersburg State Community College	Dyersburg
Jackson State Community College	Jackson
Motlow State Community College	Lynchburg
Nashville State Technical Institute	Nashville
Northeast State Technical Community College	Blountville
Pellissippi State Technical Community College	Knoxville
Roane State Community College	Harriman
Southwest Tennessee Community College	Memphis
Volunteer State Community College	Gallatin
Walters State Community College	Morristown

- level of education,
- number of years teaching,
- amount of formal (workshop or class participant) professional development with graphics calculators,
- brand of graphics calculator used by their college,
- percentage of time a graphics calculator was used in the classroom for calculations,
- percentage of time a graphics calculator was used in the classroom to depict algebra graphically or numerically (table),
- percentage of time the graphics calculator was used in each developmental mathematics course (Basic Mathematics, Elementary Algebra, Intermediate Algebra),
- gender,
- academic rank,

- number of years each college has used graphics calculators for developmental mathematics,
- the graphics calculator policy (not allowed, no policy, recommended, required) at each college for each of the developmental mathematics courses (Basic Mathematics, Elementary Algebra, Intermediate Algebra).

The findings of this study also may be useful to other colleges, universities, high schools, and middle schools that wish to improve technology usage in their developmental and other mathematics programs.

Assumptions

For use in this study, assumptions were:

1. Instructors were allowed and encouraged to participate in the study.
2. Participants provided honest answers.
3. The survey accurately measured factors for analysis.
4. Participants had freedom of choice in designing classroom activities.
5. The intent or goal of developmental mathematics courses was to prepare students for college-level mathematics and the world of work, to use the knowledge successfully in college-level mathematics and beyond.

Limitations

The limitations of the study included:

1. Some schools and some instructors refused to participate in the study, preventing the study from being generalizable to all TBR community colleges.
2. The study was limited to those instructors with Internet access for completing the survey.
3. The study was limited to instructors who returned their survey with responses that were usable.
4. The study was limited to the honesty and perceptions of the instructors who completed the survey.

Delimitations

The delimitations of the study included:

1. The study was purposely delimited to developmental mathematics instructors in community colleges in Tennessee.
2. The colleges, as related to the responses, were not identified in the study.

Definition of Terms

The definitions for terms used in this study were:

1. **Developmental mathematics**—pre-college-level mathematics (Basic Mathematics, Elementary Algebra, and Intermediate algebra) recommended or required as a prerequisite to taking college-level mathematics courses at community colleges in Tennessee.

2. **Basic Mathematics**—title for the developmental mathematics course that repeats basic arithmetic at community colleges in Tennessee.
3. **Elementary Algebra**—title for the developmental mathematics course that is comparable to the first year of high school algebra at community colleges in Tennessee.
4. **Intermediate Algebra**—title for the developmental mathematics course that is comparable to the second year of high school algebra at community colleges in Tennessee.
5. **Graphics calculator**—a handheld calculator, which is actually a programmable computer, that has the capability of producing a graph, table of algebraic equations, and a graph and equation of data entered into a list, as well has having computation, conversion, and trigonometric capabilities. Graphics calculator and graphing calculator are used synonymously in the literature as well as the mathematics community.
6. **Instructors—**full-time teachers (including lecturer, instructor, assistant professor, associate professor, or professor) at community colleges in Tennessee who taught at least one developmental mathematics course per semester (spring and fall of 2002).
7. **Personal descriptor**—gender.
8. **Professional descriptors**—academic rank, level of education, number of years of mathematics teaching, number of years of full-time teaching at community college level, amount of formal (workshop or

class participant) professional development with graphics calculators, brand of graphics calculator used by instructors' college, calculator requirements (not allowed, no policy, recommended, required) of Tennessee community colleges for each developmental mathematics course (Basic Mathematics, Elementary Algebra, Intermediate Algebra), number of years each Tennessee community colleges has used graphics calculators for developmental mathematics.

9. **Students**—mathematics students.
10. **Remediation**—the process whereby college students scoring below college level are prepared for becoming college-level-ready.

Research Questions

The following research questions were addressed:

1. How frequently, as measured by percentage of class time (0% – 20%, 21% – 40%, 41% – 60%, 61% – 80%, 81% – 100%), are full-time developmental mathematics instructors in Tennessee community colleges using graphics calculators in their classroom for calculations?
2. How frequently, as measured by percentage of class time (0% – 20%, 21% – 40%, 41% – 60%, 61% – 80%, 81% – 100%), are full-time developmental mathematics instructors in Tennessee community colleges using graphics calculators in their classroom for depicting algebra graphically and numerically (table)?
3. How frequently, as measured by percentage of class time (0% – 20%, 21% – 40%, 41% – 60%, 61% – 80%, 81% – 100%), are full-time

developmental mathematics instructors in Tennessee community colleges using graphics calculators in their classroom in each developmental mathematics course (Basic Mathematics, Elementary Algebra, Intermediate Algebra)?

4. Is there a relationship among the frequency of classroom calculator usage by full-time developmental mathematics instructors in Tennessee community colleges and:
    a. Instructors' number of years (0 – 5, 6 – 10, 11 – 15, 16 – 20, 21 – 25, 26 or more) of full-time teaching at community college level?
    b. Instructors' number of years (0 – 5, 6 – 10, 11 – 15, 16 – 20, 21 – 25, 26 or more) teaching mathematics?
    c. Instructors' level of education (Bachelors, Masters, Specialists, Doctorate)?
    d. Instructors' number of contact hours (0 – 10, 11 – 20, 21 – 30, 31 – 40, 41 – 50, 51 or more) of formal (workshop or class participant) professional development with graphics calculators?
    e. Instructors' brand of graphics calculator used by their college (Not specific, Casio, Hewlett-Packard, Sharp, Texas Instruments)?
    f. Instructors' gender (female, male)?
    g. Instructors' academic rank (lecturer, instructor, assistant professor, associate professor—fully promoted, associate professor—promotable, professor)?

5. What are the classroom graphics calculator usage policies (not allowed, no policy, recommended, required) at Tennessee community colleges for each developmental mathematics course (Basic Mathematics, Elementary Algebra, Intermediate Algebra)?
6. How many years (0, 1 – 2, 3 – 4, 5 – 6, 7 – 8, 9 or more) have Tennessee community colleges used graphics calculators for developmental mathematics courses?

CHAPTER II

REVIEW OF THE LITERATURE

Students with academic deficiencies primarily in mathematics are entering colleges and universities with the requirement of remediation and development of mathematics skills and problem solving ability. While many efforts are being made to remedy this situation, one of the most effective tools, the graphics calculator, is being underutilized.

The review of literature regarding the use of calculators and computers in the mathematics classroom addresses three areas of interest: (a) the need for integration of graphics calculators and other forms of technology into the kindergarten-college mathematics curriculum, (b) investigations into classroom use of graphics calculators and computers, including student perceptions, (c) teachers' and administrators' attitudes and beliefs regarding the use of graphics calculators and computers in mathematics classrooms.

Need for Integration of Graphics Calculators

The *Curriculum and Evaluation Standards* (NCTM, 1989), *Heeding The Call For Change: Suggestions For Curricular Action* (MAA, 1992), and *Crossroads in Mathematics* (AMATYC, 1995) called for reform in curriculum and pedagogy of mathematics classes and promoted the use of technology in kindergarten through twelfth grade and collegiate classes.

Since the primary purpose of secondary school mathematics has been to prepare students for everyday life, occupations, and potentially college, NCTM advocated the use of calculators and computers in the mathematics classroom as a teaching, learning, and computational tool (NCTM, 1989: NCTM, 2005). Demana and Waits (1992) advocated the use of graphing calculators in all secondary mathematics classes. The classroom use of calculators and computers has the potential to transform kindergarten through twelfth grade and college classrooms into laboratories, thus further altering both teaching and learning by allowing both students and teachers to explore, investigate, and become actively involved in mathematics (Dildine, 1999; Doerr & Zangor, 2000; Heid, 1997; NCTM, 1989; NCTM, 2005; Shore, 1999; Tharp et al., 1997; Vonder Embse, 1997).

Technology is a tool which allows students to view complex applications, use mathematical modeling and avoid long, tedious pencil-and-paper calculations, as well as offering an alternative to traditional teaching/learning, which has not always been successful for students (AMATYC, 1995; Ralston, 1999; Seese, 1994; Vonder Embse, 1997). Casazza (1998) emphasized thinking and patterning as well as the need for developmental mathematics students to be active in the process of learning in order to practice these skills. Technology promotes active student involvement and interaction with other students, allowing for the sharing of ideas and prompting inquiry and discussion in the process of constructing knowledge (Heid, 1997; Simonsen & Dick, 1997; Vasquez, 2003). Using calculators and computers requires that students evaluate, interpret, and judge the reasonableness of the display (NCTM, 1989). Garet (1995) reported a significant growth in use of calculators between 1986 and 1995 and a shift toward the implementation of professional standards, but some teachers are still not progressing toward use of standards or technology.

Boyd and Carson (1991), Dildine (1999), Doerr and Zangor (2000), Shore (1999), Smith (1998), and Vonder Embse (1997) indicated that utilizing calculators as catalysts to explore and develop algebraic concepts provides students with a substantial foundation for the further study of mathematics. Boyd and Carson also found that curriculum changes influenced by the use of technology could create enthusiasm and reconfigure the formal classroom into an active laboratory. Heid (1997) and Shore (1999) reported that a graphing calculator environment prompts students to be active participants in the classroom as they are encouraged to investigate and explore mathematics along with the instructor (Garofalo, Drier, Harper, Timmerman, & Shockey, 2000; Tharp et al., 1997). Goldenberg (2000) cautioned educators to think carefully about when and how technology is used, pointing to the lack of any accepted, universally held view of the best way to utilize technology in the teaching and learning of mathematics. Educators interested in curriculum reform, integration of technology, and the combination of both raised concerns regarding the need to make school mathematics programs meaningful and interesting as curricular changes are considered (McGraw, Meyer, & Tompkins, 1995; Peressini & Knuth, 2005). Heid (2005) pointed to technology as a key that has unlocked the path to new ways of thinking about teaching and learning in mathematics.

In a publication from the National Council of Teachers of Mathematics, *Algebra in a Technological World*, Heid, Choate, Sheets, and Zbiek, (1995), Heid

(1997), and Shore (1999) provided a look at how graphing calculators strengthen evolving images of algebra, allowing students and instructors to investigate, describe, and interpret quantitative connections in their world. The use of technology gives students the chance to use "hands-on," as well as “mind-on” procedures in problem solving (Heid, 1997). Technology helps students develop an understanding of the processes and logic upon which mathematical problem solving is based, allows students to use real-world applications, and enhances usefulness and student interest in mathematics (Alagic, 2003; Caldwell, 1995; Fromboluti, 1992; Heid, 1997; Peressini & Knuth, 2005). Dildine (1999), Doerr and Zangor (2000), Peressini and Knuth (2005), Shore (1999), and Vonder Embse (1997) viewed the graphing calculator as a catalyst, a tool, for exploring and discovering relationships and making connections in mathematics. Shore (1999) reported that developmental mathematics students who participated in the study remembered virtually nothing of their high school algebra where no graphing calculators were used.

The routine of requiring paper-and-pencil calculations, even for multi-step problem solving, contributes to the depreciation of students' opinions about mathematics as they progress from kindergarten through grade twelve (Cangelosi, 1992). Years of research provided evidence that intense use of calculators in early grades as part of classroom instruction and assessment does not impair computational proficiency and frequently strengthens problem solving and conceptualization skills (Kaput, 1992). Smith and Shotsburger (1997) suggested that graphics calculator use did not interfere with the understanding of concepts in College Algebra courses. Ralston (1999) called for abolishing pencil-and-paper arithmetic and developing number sense with creative explorations using calculators, which assist students in developing mental arithmetic skills based on these calculator explorations in mathematics.

Gilchrist (1993) expressed the opinion that even if computational skills are never mastered, students should use calculators to remove the drudgery of attempting such computations by hand, allowing them to at least be able to learn the problem solving process. Calculators bring the concept of estimating to determine if the answer is reasonable into normal, everyday use in the mathematics classroom. Students must also learn to assess when it is appropriate to use the calculator and when it is not (NCTM, 2005). Dossey (1994) asserted that calculators free students to focus on higher-order mathematical problem solving techniques. *Principles and Standards for School Mathematics* included visual representation, which can be accomplished quickly with graphics calculators, as a useful means of assisting students in the understanding of content knowledge (NCTM, 2000).

Computers and calculators are powerful tools for performing operations, promoting understanding of problem solving processes, and quickly providing graphical representations to assist students in forming connections that are the essence of algebra courses (Dildine, 1999; Doerr & Zangor, 2000; Fey, 1992; Peressini & Knuth, 2005; Shore 1999). Shore (1999) reported significant increase in students' procedural proficiency and conceptual meaning in graphing calculator sections of courses.

Much of this research is in the kindergarten through twelfth grade context. Developmental mathematics courses focus on kindergarten through twelfth grade mathematics topics and have students operating at all levels, but primarily at the middle school and high school level (Kull, 1999). In two-year colleges in 1995, 56% of the students enrolled in mathematics courses were studying at the developmental level compared to 15% at the four-year institutions (AMATYC, 1995). With over one million students needing remediation (AMATYC, 1995), the need for change in introductory college mathematics became apparent. Teachers of developmental mathematics have been called upon to expand the educational and career options for under-prepared students, not simply to repeat high school courses (AMATYC, 1995).

Thus, the literature since 1989 has established a need to integrate technology into the mathematics curriculum to promote interest in mathematics, to offer the opportunity to explore and experiment with mathematics, to improve student understanding of problem solving, to reduce drudgery, and to prepare students for the job market.

Investigations

Curriculum and Evaluation Standards (NCTM, 1989), indicated that students now have an enhanced ability to perform calculations due to the availability of calculators. There is lack of evidence that using calculators makes students dependent on them for rudimentary calculations (NCTM, 1989). However, an Arizona survey of teachers of kindergarten through eighth grade classes pointed to the inconsistency between the perceived value of using calculators and their actual classroom use (Zambo, 1994). Even though many teachers in 1993 viewed calculators as a means of reducing pencil-and-paper calculations, as much as 90% of classroom time was spent performing computational activities by hand (Gilchrist, 1993). Dion et al. (2000) reported that high school students were allowed to use calculators for work and for tests, but teachers were limited in their proficiency with graphing calculators.

In a study of elementary school teachers from 14 rural Missouri school districts who were given training in calculator usages and instructional approaches, results indicated that teachers themselves perceived no significant differences in teaching approaches, but that their students perceived a more positive attitude toward calculator usage and their overall perception of mathematics (Struyk, 1993). By 1992, NCTM's suggestions regarding use of technology had not been executed in many kindergarten through twelfth grade mathematics classrooms, and where recommendations were being heeded, higher achieving students were given preference in access to technology (Fromboluti, 1992). In 2005, NCTM issued a position statement calling for the effective, appropriate, and balanced use of calculators in mathematics education to expand students' mathematical understanding (NCTM, 2005).

In a two-year, kindergarten through twelfth grade, National Assessment of Educational Progress (NAEP) study, students and teachers reported more access to and use of computers and calculators and students with no restrictions on calculator usage had significantly higher proficiency than students whose use of calculators was restricted (Dossey, 1994). Another NAEP study, which included 4th, 8th, and 12th grade students, reported that the most effective schools had students who used calculators more frequently (Mullis, 1994). A 2000 NAEP study with 4th, 8th, and 12th grade students indicated that the 8th and 12th grade students who reported that they used calculators more often tended to have higher scores, but for 4th graders the results were the opposite (National Center for Education Statistics [NCES], 2003). In a study of pre-college use of calculators, Hembree and Dessart (1992) found that there were significant positive effects for attitude toward mathematics and self-efficacy in mathematics when students were given instruction with calculators and when students used calculators in class. Hembree and Dessart also found that average students who used calculators improved their basic skills and problem solving abilities beyond those students who were taught without calculators. Smith (1997), extending the work of Hembree and Dessart, showed positive effect for improving conceptual knowledge, apparent in all grades when students used calculators. Smith and Shotsberger (1997) reported that more than 70% of the participants in a study of graphics use calculators in college algebra classes indicated a better understanding when using a graphics calculator in the required course. Caldwell (1995) found that using graphics calculators had a significant effect on performance with functions and graphs for college algebra students. Dildine (1999) reported that middle school students exhibited positive attitudes when learning mathematics using technology, while Shore (1999) reported an increase in mathematical confidence in graphing calculator groups of developmental mathematics students. Ellington's meta-analysis (2003) revealed improvement in students’ problem-solving and operational skills as well as attitude when the use of calculators was integrated into instruction and assessment in mathematics classes.

Similarly, college students who were taught precalculus using a graphics calculator had significantly higher scores on a comprehensive final exam than students using the traditional approach (Quesada & Maxwell, 1994). Of two groups of students enrolled in a college mathematics of finance course using the same textbook and instructor, significant increases were found both in students' attitudes toward mathematics and in achievement for the group that used menu-driven symbolic calculators over the group that used standard scientific calculators (Stiff, 1992). Brasell and Rowe (1993) expressed concern about the lack of student understanding of functions and accompanying graphical relationships. Lauten (1994) related the experiences of five college and two high school students whose understandings of function and limit were affected in a graphics calculator-based environment. Lauten further related examples where students' understanding seems to have been stimulated by the use of graphics calculators.

Preparation for standards suggested by AMATYC included the guiding principle of the importance of teachers leading students toward critical thinking and revitalizing mathematics to engage students as active participants in the learning process (AMATYC, 1995). Hollar and Norwood (1999) and Caldwell (1995) indicated that teaching intermediate algebra and college algebra with graphing calculators presents the opportunity for better understanding of functions via graphing and promotes critical thinking. Boylan (1999) pointed to the importance of students being able to think critically for success in college as well as the inability of many developmental education students to achieve and exhibit this skill.

Teacher and Administrator Attitudes and Beliefs

In the past, the use of calculators was prohibited on some standardized tests. In a 1992 Statistical Aptitude Test (SAT) field trial, calculator use positively affected all student groups (College Board, 1992). Although prohibited use poses less of a problem as national testing companies and states are changing policies, Gilchrist (1993) found that while the need exists for students to learn to use calculators for preparing for many jobs, some teachers were reluctant to use calculators in the classroom because the use of calculators was still excluded on some standardized tests. In 2000, based on the expectation that students were using graphics calculators in the classroom, SAT revised testing to include using graphics calculators. With this revision, some opponents of calculator use lost ground in arguing against total integration of calculator use (Dion et al., 2000).

Currently, calculator use is emphasized in kindergarten through twelfth grade mathematics classrooms in Tennessee. The Tennessee State Board of Education (2003) requires students in Algebra I and Algebra II (other courses are also included) to take end-of-course examinations, Gateway Tests. The course descriptions with objectives and samples for Gateway Test preparation for Algebra I and Algebra II emphasize a technological world where students are shown the appropriate use of technology, with the Algebra II description specifically referencing graphing calculators (Tennessee State Board of Education, 2000; Tennessee State Board of Education, 2001). Teachers must keep in mind the requirements of the Gateway and the Tennessee Comprehensive Assessment Program (TCAP) tests. The TCAP tests evaluate benchmarks; mastery is required of students at third grade, eighth grade, and twelfth grade. All mathematics benchmarks require the use of calculators, with kindergarten through third grades requiring the use of calculators in problem-solving, fourth through eighth grades requiring students to make an appropriate choice (with one of the choices being calculators), and ninth through twelfth grades specifically requiring the use of graphics calculators (Tennessee State Board of Education, 2005).

Are guidelines and requirements for calculator use being implemented? Some teachers have expressed fear that students will not learn how to perform the manual calculations that other teachers and leaders feel are necessary (Gilchrist, 1993). Tharp, Fitzsimmons, and Ayers (1997) indicated that using calculators and thus, relinquishing a portion of the power in the classroom, is not easy for many mathematics instructors who prefer a teacher-centered environment. Some instructors of developmental mathematics classes believe that the use of calculators may undermine their efforts in what they feel are fundamental tasks in the mathematics classroom (Vasquez, 2003).

Many elementary school teachers lack the conceptual understanding of mathematics essential to teaching their students according to NCTM standards, yet they maintain that calculator usage will impede the learning of mathematical facts and procedures (Struyk, 1993). The fear that calculator-based exploration may spark questions for which teachers are unprepared to answer is a factor in calculator usage (Dunham & Dick, 1994; Heid, 1997). This fear of not being able to answer may be why some teachers emphasize rote memorization of rules and algorithms with virtually no concentration on conceptualization or real-world problem solving (Cangelosi, 1992). Teachers can avoid meaningful applications when they continue teaching without technology (Shore, 1999). Many teachers who avoid change fear technology, worrying that what they know and teach in their mathematics classrooms with pencil-and-paper will become obsolete with technology (Waits & Demana, 2001).

A New Mexico study of vocational/technical teachers', tutors', and technicians' assessment of the importance of basic mathematics competencies reported that teachers of mathematics and mathematics-related subjects view some of the basic competencies set by the Secretary of Labor's Commission on Achieving the Necessary Skills (SCANS) and NCTM, including the use of calculators, as unimportant (Sackett, 1994). Joining the old basic competencies (number facts, proofs, formulas, computational algorithms) are new views of essential skills (explanation of answer and process, verification of solutions, reasonable inference), all of which are enhanced with an emphasis on collaboration, problem-solving, verbal and written communication, the use of technology, and development of mathematical understanding (Gal & Stout, 1997/98; Shore, 1999; Vasquez, 2003; Vonder Embse, 1997).

Sackett (1994) called for formation of developmental and preparatory mathematics courses that meet the divergent needs of vocational and academic departments. In 1991, the National Research Council (NRC) reported that even though technology had made a profound impact on mathematics, most college mathematics classes were no different than in the 1960's (NRC, 1991). While some instructors are still reluctant to use calculators in the mathematics classroom, Seese (1994) found that changes had taken place within many mathematics departments throughout the country including acceptance of the use of calculators and computers in mathematics courses.

As many teachers are facing down their personal and professional technology-related fears, many administrators are beginning to face fears of technology related to copyright infringements, liability, and student privacy issues (National School Boards Association, 1999). However, leadership and support from administrators are essential in advocating the use of technology in the mathematics classroom (Glazer, 2000). Gningue (2003) reported that most of the teachers in the two groups studied, middle and high school teachers in workshops and training sessions, expressed concern about a lack of administrative support and the lack of assistance and leadership in determining the effective implementation of the use of technology in the mathematics classroom. However, these groups did express an improvement in beliefs and attitudes about using graphics calculator technology in their classrooms.

Heid (1997) emphasized the necessity of teachers having the mathematical knowledge, the technological knowing, and the understanding of how students learn before technology implementation occurs. Many teachers lack the training in educational theory that is necessary for any type of teaching other than a lecture where a teacher shows how the problem is done and stops (Pritchard, 1995). Professional development and ongoing support are essential in keeping teachers informed of research, updates, and limitations in current technology and the effective use of technology in the mathematics classroom (Milou, 1999, Waits & Demana, 2001; Zucker, 2001). With equipment, training, and continued professional development, teachers can become and remain equipped to integrate the use of technology into the classroom, producing a dynamic atmosphere for teaching and learning mathematics (Alagic, 2003; Dildine, 1999). Gningue (2003) found that teachers' opinions of students' ability to work with graphics calculators improved as their own confidence and proficiency with the graphics calculator increased.

After compiling results from over 360 voluntary comments regarding calculator usage, Ballheim (1999) reported that most respondents recommended training for teachers, then for students, prior to using calculators in the classroom. Balheim also reported that a majority of the respondents felt that the applicable mathematics should be taught prior to using calculators on the same concepts, with only a third of the respondents indicating that calculators should be available at all times. Tharp, Fitzsimmons, and Ayers (1997) reported that training instructors in the use of graphics calculators had a positive impact on their perceptions of using graphics calculators in the mathematics classroom. Waits and Demana (2001) recommended that teachers to be trained by other teachers, those who can model “best practice” conceptual and pedagogical activities in using calculators effectively as an integral part of the mathematics classroom.

Fey (1992) and Vonder Embse (1997) indicated that mathematicians believe that visual representations are the best medium for presenting and understanding algebraic expressions. The role of graphing calculators in providing graphical representations offers quick access for effective interpretation of relationships (Ozgun-Koca, 2001; Peressini & Knuth, 2005). Yet, some instructors still want to use the old pencil-and-paper ways of providing these visual representations, as well as the calculations. This reluctance exists even when students indicate that they prefer graphing calculators, because they can perform the operations in a fraction of the time while gaining a better understanding (Shore, 1999), and because they believe they are better at problem solving with graphing calculators (Slavit, 1996). Caldwell (1995) reported that teaching students how to use the calculator takes time, but that time is reclaimed when the laborious tasks are completed in seconds instead of minutes or hours.

Since integration of technology often prompts students to ask questions, some teachers avoid this classroom change because they fear a loss of classroom dominance and worry that they will be unable to predict and answer questions that may arise as students explore mathematics with graphing calculators (Heid, 1997; Shore 1999). Teachers’ beliefs and understandings of the teacher role and the role of mathematics are sometimes in conflict with reform movements, spurring a reluctance to use calculators (Reys et al., 1993). Teachers must examine their beliefs while analyzing what and how they teach in relation to the research on teaching, learning, and calculator usage to determine what changes they must make for the best learning environment (Caldwell. 1995; Heid, 1997; Heid, 2005; Howe, 1998; Milou, 1999; NCTM, 1991).

Simonsen & Dick (1997) reported teacher concerns regarding how to use the technology in the instruction of mathematics, the amount of time needed to learn the technology, and the fear that students will become dependent on calculators. Tharp et al. (1997) related that rule-based teachers are less likely to consider using calculators to explore mathematics to enhance understanding. Kramer (1996) reported that mathematics instructors are more adverse to change than teachers of other subjects.

The requirement of graphing calculators in developmental algebra is obvious; yet, some instructors still disagree and remain unwilling to spend the time required to learn to use and to teach with graphing calculators (Shore, 1999). Still to be rectified is the administrative challenge of involving aging faculty in professional development activities that will assist in their adjusting to changing student needs and instructional technologies (Seese, 1994). Further, some teachers have not experienced success with technology use and have become cynical about the use of technology (Alagic, 2003). Teachers must be assisted with professional development opportunities that offer effective training to encourage them to meet standards and integrate technology into everyday use in mathematics classrooms (Alagic, 2003; Peressini & Knuth, 2005; Tharp et al., 1997). Teachers must be empowered to locate and access opportunities for professional development (Heid, 2005).

Some progress is being made. Dion et al. (2000) reported that in high school Algebra II and Precalculus/Trigonometry classes fewer than 1% of the survey respondents did not allow calculators and that graphing calculators are the most used of any calculators. The mathematics community and mathematics students have profited from the rethinking of the mathematics curriculum as preparation for the integration of technology was planned; all would profit from more analysis of calculator integration into all facets of the mathematics curriculum (Dion et al., 2001; Heid, 1997).

Summary

With a high percentage of incoming freshmen at two-year colleges, requiring remediation in mathematics, educators must look for ways to successfully remediate these students. Efforts to set and achieve standards of calculator use in mathematics classrooms, kindergarten through college, are ongoing. These efforts are not totally successful. The preponderance of literature demands the use of calculators in the mathematics classroom. However, even when instructors believe in the usefulness, some instructors are either slow to integrate the use of technology or do not make any attempt to do so. Even though evidence shows increased student understanding of mathematical concepts and problem solving abilities attributed to the use of calculators, there are still administrators and instructors, kindergarten through college, who are either unwilling, unprepared, incapable, or reluctant to fully integrate the use of technology in their mathematics classroom. Research indicates students' perceptions of enhanced mathematical understanding and even favorable attitudes about mathematics result from the use of calculators in mathematics classrooms. Information points to the conclusion that mathematics educators should integrate technology in their classrooms and that graphics calculator technology has clear advantages over other types of technology.

CHAPTER III

METHODS AND PROCEDURE

In light of the benefits of graphics calculator usage established in the literature, the purpose of this study was to investigate the frequency of Tennessee community college full-time developmental mathematics instructors' classroom graphics calculator usage (percent of class time), various personal and professional descriptors of those instructors, and the graphics calculator policies at each college: number of years of full-time teaching at community college level, number of years teaching mathematics, level of education, amount of formal (workshop or class participant) professional development with graphics calculators, brand of graphics calculator used by their college, percentage of time a graphics calculator is used in the classroom for calculations, percentage of time a graphics calculator is used in the classroom to depict algebra graphically or numerically (table), percentage of time the graphics calculator is used in each developmental mathematics course (Basic Mathematics, Elementary Algebra, Intermediate Algebra), gender, academic rank, number of years their college has used graphics calculators for developmental mathematics, and the graphics calculator policy (not allowed, no policy, recommended, required) at each college for each of the developmental mathematics courses (Basic Mathematics, Elementary Algebra, Intermediate Algebra).

To develop answers to the research questions, the researcher examined data collected through the use of a forced-choice, web-based survey of developmental mathematics instructors and an email-based department head questionnaire. The instructor survey included 13 items, with the opportunity for comments, and the department head questionnaire included 4 items. The subjects, the procedures, the instrumentation, and the method of statistical analysis are described below.

Subjects

The population for this study consisted of the full-time community college teachers in Tennessee who taught at least one developmental mathematics course per semester during 2002 and the department heads of mathematics and developmental mathematics for each Tennessee community college in office in 2003. The subjects for the study were the instructors from the population who returned a completed, usable survey and the department heads from the population who responded to the department head questionnaire. The email addresses of full-time mathematics faculty members who received surveys and department heads who received questionnaires were taken from the website of each community college, with additions and deletions based on information provided by department heads and deans. The website for each community college was accessed from the website of the Tennessee Board of Regents (TBR), the governing entity for community colleges in Tennessee (Tennessee Board of Regents, 2003). The complete list of community colleges is listed in Table 1.1.

Since the information on the websites did not provide information for determination of which full-time mathematics faculty members qualified as instructors for the purpose of this study, all full-time mathematics faculty members were sent the survey. The survey included a qualifier question, question three, which allowed the researcher to determine which respondents qualified as instructors as defined in this study, full-time community college teachers in Tennessee who taught at least one developmental mathematics course per semester during 2002.

Procedures

During the Spring Semester 2003, every mathematics faculty member and every mathematics and developmental mathematics department head listed on the websites obtained from the TBR website (Appendix A) were sent an email cover letter (Appendix D) insuring confidentiality and anonymity and soliciting cooperation in the completion of the survey. The cover letter included a website address with hyperlink for accessing and completing the on-line survey (Appendix B). The procedure for responding to the survey on the researcher’s survey website was explained in the letter. As a motivating feature the researcher offered a copy of the research report or a summary of research findings to each respondent who completed the survey and included the option of providing the respondent’s email address. The survey also offered respondents the opportunity to provide an email address for inclusion in potential follow-up interviews. Participants’ comments and names and email addresses for receiving a copy of the research report and for potential participation in follow-up interviews were automatically recorded in files separate from participant responses to survey questions, as promised in the email cover letter.

Department heads were asked to request that full-time mathematics faculty members without email be given the letter. Academic vice presidents, deans, and mathematics and developmental mathematics department heads received a separate letter (Appendix E) requesting their support of this research along with a list of full-time mathematics faculty members and emails to verify the list of potential participants at each college. Department heads and deans notified the researcher of changes to the list of full-time mathematics faculty members for each college. These changes were due to retirements and new hires since the websites were updated. The researcher adjusted the lists and sent emails to new faculty members.

The total number of full-time mathematics faculty members who were sent the request for participation was 214. After three weeks, the researcher sent another email (Appendix F) to the faculty members thanking respondents for their cooperation and requesting that non-respondents complete the survey. Another request (Appendix G) was tendered a few weeks later. After the survey was closed there were 150 full-time mathematics faculty members who responded to the survey, representing a 70% response rate. Of the 150 full-time mathematics faculty members who responded, 122 met the criterion of instructor, as defined for participation in this study. These usable responses were from full-time mathematics faculty members who qualified as instructors because they taught at least one developmental mathematics course per semester (spring and fall) of 2002. This ($n = 122$) represented the number of participants. Table 3.1 shows

Table 3.1 Tennessee Community College Full-time Mathematics Faculty Member Survey Requests Sent and Responses	
Survey Requests Sent	214
Survey Responses	150 (70%)
Usable Responses (n)	122

Table 3.2 Tennessee Community College Department Head Questionnaire Population and Responses	
Population	13
Responses	13 (100%)

numbers of full-time mathematics faculty members who were sent requests for participation and responses.

Department heads from the 13 Tennessee community colleges were sent an email (Appendix H) with the short questionnaire (Appendix C) soliciting information on departmental requirements regarding graphics calculator usage (not allowed, no policy, recommended, required). After three weeks, the researcher sent another email (Appendix I) requesting that non-respondents complete the questionnaire. Follow-up phone calls were placed a few weeks later, resulting in completion. There was 100% participation rate in the department head questionnaire as shown in Table 3.2.

Instrumentation

Since no evidence existed of predesigned useful instruments, the instruments used in this study include a researcher-designed survey and questionnaire. A panel of experts (non-participants) reviewed the instruments and revisions were made prior to emailing. Former Tennessee community college developmental mathematics instructors who now work in Georgia and Ohio comprised the first panel of experts. Non-mathematics instructors reviewed the instruments for clarity and design. The dissertation committee further reviewed the survey and questionnaire. The resulting instruments, a survey for instructors (Appendix B) and a questionnaire for department heads (Appendix C), were utilized in the study.

Statistical Analysis

Descriptive statistics and a Spearman correlation coefficient matrix produced using Statistical Software for the Social Sciences (SPSS), 2005 version 10.0, were used for statistical analyses of the data to answer the 6 research questions in relation to the 13 instructor survey questions and the 4 department head questionnaire questions. The researcher used these tools to determine if there was a significant difference among the frequency of classroom calculator usage by full-time developmental mathematics instructors in Tennessee community colleges and personal and professional descriptors. Participant comments were examined for trends and categorized.

The panel of experienced researchers analyzed and confirmed the validity of the survey and the questionnaire. The reliability of the survey was determined using Cronbach’s Alpha, which resulted in a level of 0.769.

CHAPTER IV

RESULTS

In looking at the problem of a lack of graphics calculator usage in developmental mathematics courses in Tennessee community college classrooms and variables that related to this problem, the researcher sent survey participation request to 214 full-time mathematics faculty members in Tennessee community colleges. All 214 full-time mathematics faculty members in Tennessee community colleges who were sent the email request for participation did not meet the criterion for inclusion in the study. The survey included 13 forced-choice questions and statements and ended with an opportunity for comments. Survey question three, a qualifier question, allowed the researcher to determine which respondents qualified as instructors as defined in this study, full-time community college teachers in Tennessee who taught at least one developmental mathematics course per semester during 2002.

Of the 214 full-time mathematics faculty members in Tennessee community colleges who were sent the email request for participation, 150 (70%) responded to the survey. Of the 150 full-time mathematics faculty members who responded, 122 qualified, as defined, to be participants in the study. Since the researcher did not have access to personnel data, with teaching schedules, it is unknown what portion of the population of qualified teahers this 122 represents. Thus, the percentage of return of qualified instructors could not be determined.

To determine departmental policies and length of time Tennessee community colleges had been using graphics calculators, the researcher surveyed the department heads in mathematics or developmental mathematics in Tennessee's 13 community colleges with a four-item, forced-choice questionnaire. The return rate (100%) was excellent.

This chapter presents the findings of the study. The collection of data from usable surveys and questionnaires was analyzed as described in the previous chapter, predominantly by the descriptive statistics approach. In addition, participants were given the opportunity to add comments about anything related to the survey questions. The statistical findings are presented in tabular and narrative form, with participants' written comments inserted as support or to shed further light on the findings. Following the findings for research question three, participant comments were summarized.

Instructor Surveys

Descriptive Information

Survey Question three was used as a qualifier question.

> During the calendar year (Spring 2002, Fall 2002) did you teach at least one developmental mathematics (Basic Mathematics, Elementary Algebra, Intermediate Algebra) course during the spring and fall semesters?

A response of "yes" qualified a survey as usable and a response of "no" disqualified the survey. There were 122 surveys with yes as the response for survey question three.

Descriptive information using demographic and calculator usage data provided insight into the profile of faculty members and how much graphics calculators are being used in the developmental mathematics classrooms at community colleges in Tennessee. Descriptive data analysis of participant demographics is indicated in Table 4.1.

The majority (71.3%, 87) of the participants had been full-time college faculty members for 0 – 15 years (the range of first three categories combined), while the majority (67, 54.9%) of the participants had been teaching mathematics for 16 or more years (the range of last three categories combined). An overwhelming majority (91, 79.5%) held a Masters as the highest degree earned, with only (19, 15.6%) having achieved a Doctorate. Women represented a majority (77, 63.1%) of the participants and the majority (76, 62.3%) of the participants held the rank of Associate Professor and had been fully promoted.

It is important to note that 52 (43.0%) of the participants reported 0 – 10 contact hours of formal (workshop or class) professional development with graphics calculators and 25 (20.7%) reported 11 – 20 contact hours. Hence, a majority (77, 63.6%) had only received 20 or less contact hours of professional development with graphics calculators. This suggests that the call for initial and continued instructor training in effective classroom use of graphics calculators (Alagic, 2003; Dildine, 1999; Gningue, 2003; Milou, 1999, Peressini & Knuth, 2005; Seese, 1994, Tharp et al., 1997; Waits & Demana, 2001) had not been implemented at a level high enough to provide more than 20 contact hours for the majority of the participants in this study. One participant commented that, "I have just returned to teaching after retiring from an engineering job, which covered 22 years. I have a lot to learn about new instructional methods." This

Table 4.1 Tennessee Community College Full-time Mathematics Instructors—Participant Demographics		
Category	**Frequency**	**Percentage**
Years Community College Full-time		
0 – 5	28	23.0%
6 – 10	24	19.7%
11 – 15	35	28.7%
16 – 20	17	13.9%
21 – 25	5	4.1%
26 or more	13	10.7%
Total Responses	122	
Years Teaching Mathematics		
0 – 5	9	7.4%
6 – 10	16	13.1%
11 – 15	30	24.6%
16 – 20	25	20.5%
21 – 25	11	9.0%
26 or more	31	25.4%
Total Responses	122	
Highest Degree		
Bachelors	1	0.8%
Masters	97	79.5%
Specialist	5	4.1%
Doctorate	19	15.6%
Total Responses	122	
Gender		
Female	77	63.6
Male	44	36.4
Total Responses	121	
Academic Rank		
Lecturer	0	0.0%
Instructor	19	15.6%
Assistant Professor	27	22.1%
Associate Professor, Fully Promoted	76	62.3%
Associate Professor, Promotable	0	0.0%
Professor	0	0.0%
Total Responses	122	

both explains and reinforces the need for professional development. Descriptive data analysis of participant formal professional development is indicated in Table 4.2.

The graphics calculator brand used at most (97, 80.8%) of the participants' colleges was Texas Instruments. Only two participants named another brand, Casio (1, 0.8%) and Hewlett-Packard (1, 0.8%). The remainder of the participants (21, 17.5%) indicated that no specific brand was used. One participant attempted to give some insight into the results of the brand of choice, "The use in developmental classes varies from campus to campus, as does the brand. I prefer TI [Texas Instruments] because of the support provided by TI, and most students in our area used them in high school. . ." Descriptive data analysis of participant brand of graphics calculator used is indicated in Table 4.3.

Research Question 1: How frequently, as measured by percentage of class time, are full-time developmental mathematics instructors in Tennessee community colleges using graphics calculators in their classroom for calculations?

The question of how frequently full-time developmental mathematics instructors in Tennessee community colleges are using graphics calculators in their classroom for calculations was answered using responses to forced-choice survey question 7.

> The percentage of time I currently use a graphics calculator in the classroom for calculations is: 0% – 20%, 21% – 40%, 41% – 60%, 61% – 80%, 81% – 100%.

Table 4.2 Tennessee Community College Full-time Mathematics Instructors—Participant Calculator Formal Professional Development (Workshop or Class Participant)		
Category	**Frequency**	**Percentage**
Number of Contact Hours		
0 – 10	52	43.0%
11 – 20	25	20.7%
21 – 30	14	11.6%
31 – 40	6	5.0%
41 – 50	4	3.3%
51 or more	20	16.5%
Total Responses	121	

Table 4.3 Tennessee Community College Full-time Mathematics Instructors—Participant Brand of Graphics Calculator Used		
Category	**Frequency**	**Percentage**
Brand of Graphics Calculator		
Not specific	21	17.5%
Casio	1	0.8%
Hewlett-Packard	1	0.8%
Sharp	0	0.0%
Texas Instruments	97	80.8%
Total Responses	120	

Table 4.4 Survey Question 7: Tennessee Community College Full-time Mathematics Instructors—Percentage Of Time Currently Using A Graphics Calculator In The Classroom For Calculations					
Category	0% – 20%	21% – 40%	41% – 60%	61% – 80%	81% – 100%
Frequency	68	32	10	5	6
Percentage	56.2%	26.4%	8.3%	4.1%	5.0%

From the 122 participants, there was 1 blank response. Of the 121 who responded with an answer choice, a majority (68, 56.2%) indicated that they use a graphics calculator in the classroom for calculations 0% – 20% of the time. Table 4.4 provides the frequency and percentage of participant responses for all choices for survey question 7.

Research Question 2: How frequently, as measured by percentage of class time, are full-time developmental mathematics instructors in Tennessee community colleges using graphics calculators in their classroom for depicting algebra graphically and numerically (table)?

The question of how frequently full-time developmental mathematics instructors in Tennessee community colleges are using graphics calculators in their classroom for depicting algebra graphically and numerically (table) was answered from responses to forced-choice survey question 8.

> The percentage of time I currently use a graphics calculator in the classroom to depict algebra graphically or numerically (table) is: 0% – 20%, 21% – 40%, 41% – 60%, 61% – 80%, 81% – 100%.

Table 4.5 Survey Question 8: Tennessee Community College Full-time Mathematics Instructors—Percentage Of Time Currently Using A Graphics Calculator In The Classroom To Depict Algebra Graphically Or Numerically (Table)					
Category	0% – 20%	21% – 40%	41% – 60%	61% – 80%	81% – 100%
Frequency	71	31	7	8	4
Percentage	58.7%	25.6%	5.8%	6.6%	3.3%

Of the 121 who responded with an answer choice, a majority (71, 58.7%) indicated that they use a graphics calculator in the classroom to depict algebra graphically or numerically (table) 0% – 20% of the time. Table 4.5 provides the frequency and percentage of participant responses for all choices for survey question 8.

Research Question 3: How frequently, as measured by percentage of class time, are full-time developmental mathematics instructors in Tennessee community colleges using graphics calculators in their classroom in each developmental mathematics course (Basic Mathematics, Elementary Algebra, Intermediate Algebra)?

The question of how frequently full-time developmental mathematics instructors in Tennessee community colleges are using graphics calculators in their classroom in each developmental mathematics course was answered with responses to forced-choice survey question 9,

> In Basic Mathematics courses, the percentage of time I use a graphics calculator is: 0% – 20%, 21% – 40%, 41% – 60%, 61% – 80%, 81% – 100%.

survey question 10,

> In Elementary Algebra courses, the percentage of time I use a graphics calculator is: 0% – 20%, 21% – 40%, 41% – 60%, 61% – 80%, 81% – 100%.

and survey question 11.

> In Intermediate Algebra courses, the percentage of time I use a graphics calculator is: 0% – 20%, 21% – 40%, 41% – 60%, 61% – 80%, 81% – 100%.

The same pattern of the majority of responses (using the graphics calculator in classes 0% – 20% of the time) emerged for Basic Mathematics (84 of 105, 80.0%) and Elementary Algebra (65 of 119, 54.6%), and for Intermediate Algebra the highest response was 56 of 118 (47.5%) in the same category (0% – 20% of the time). All responses for survey questions 9, 10, and 11 are shown in Tables 4.6, 4.7, and 4.8, respectively.

Participant Comments

The participant comments were categorized into six trends. The largest number of comments (10) fit into the trend category of “explanation of use,” with participants providing an explanation of how they and/or their colleagues use calculators at their colleges. The second highest number of comments (8) fit into the category “negative, no use, or limited use,” with participants indicating personal, professional, or departmental choices of not using or limiting the use of graphics calculators. The third highest number of comments (5) fit into the trend

Table 4.6 Survey Question 9: Tennessee Community College Full-time Mathematics Instructors— Percentage Of Time Using A Graphics Calculator In Basic Mathematics					
Category	0% – 20%	21% – 40%	41% – 60%	61% – 80%	81% – 100%
Frequency	84	12	6	3	0
Percentage	80.0%	11.4%	5.7%	2.9%	0.0%

Table 4.7 Survey Question 10: Tennessee Community College Full-time Mathematics Instructors— Percentage Of Time Using A Graphics Calculator In Elementary Algebra					
Category	0% – 20%	21% – 40%	41% – 60%	61% – 80%	81% – 100%
Frequency	65	35	11	4	4
Percentage	54.6%	29.4%	9.2%	3.4%	3.4%

Table 4.8 Survey Question 11: Tennessee Community College Full-time Mathematics Instructors— Percentage Of Time Using A Graphics Calculator In Intermediate Algebra					
Category	0% – 20%	21% – 40%	41% – 60%	61% – 80%	81% – 100%
Frequency	56	33	17	7	5
Percentage	47.5%	28.0%	14.4%	5.9%	4.2%

category of “clarification,” with participants providing information to clarify their choices or their thinking about the use of calculators at their colleges. The other categories had two comments each. These categories were: “Basic Mathematics, Elementary Algebra, and Intermediate Algebra,” with participants giving information specific to these courses; “algebra prior to calculator,” with participants indicating that students should learn concepts before using a graphics calculator with the concepts; “caution,” with participants warning of the overkill or misuse of graphics calculators; and “other questions, topics, uses,” with participants offering questions for further research and indicating other topics and uses of graphics calculators. The results of the trend categorization of comments are shown in Table 4.9.

Instructor comments offered various perspectives of the category results. One instructor’s comment may represent the trend of the category of use, 0% – 20%. “We use the graphics calculator more in Intermediate Algebra. I use a scientific calculator in Basic and Elementary.” The descending percentages with

Table 4.9
Tennessee Community College Full-time Mathematics Instructors—Participant Comments

Trend Category	**Frequency**
Basic Mathematics, Elementary Algebra, and Intermediate Algebra	2
Algebra Prior To Calculator	2
Caution	2
Clarification	5
Explanation of use	10
Negative, no use, limited use	8
Other questions, topics, uses	2

this category choice for 80.0% in Basic Mathematics, 55.1% in Elementary Algebra, and 47.9% in Intermediate Algebra indicated that as course levels increased calculator use increased. Other instructors were succinct in their comments, which represented the absolute description of zero graphing calculator use. “I do not use a graphing calculator as a teaching tool in any developmental course.” “We do not use graphing calculators in Developmental Mathematics at [my college].” “We do not permit our students to use calculators in [Developmental Studies Program-Mathematics] DSPM at [my college].”

Another instructor’s comment indicated a definite bias against using graphics calculators in any developmental mathematics course, “I think the graphics calculator is overkill for the developmental studies math courses. Basic skills (arithmetic) and reasoning skills are more important and in a greatly need for our developmental students. I can see the use of a graphics calculator for college level math. However, for development math we can at best provide instruction on the proper use for ordinary operations. These are just my thoughts.”

A specific choice, not a departmental or college choice, against using graphics calculators in developmental mathematics was indicated by an instructor’s comment. “Graphing calculators are required or recommended for the majority of our college level math courses. I choose to not use them in developmental classes.” In contrast, another participant, who uses calculators in class daily, comments, “Percentages of calculator usage are approximate. Calculator is used daily; more on some days than others.” Another participant described a different view of the individual choices within a department. “We have departmental sets that we can use in class. Some instructors use them often and others never. We run the traditional gamut of about half the department (18 full-time faculty) for and half against.”

One participant’s comment may be indicative of why the response of choice was most often, 0% – 20% of the time, “I have found the graphics calculator to be useful in some of my college level courses, but rarely in my developmental courses” Another participant offered the potential for even more insight with respect to departmental decisions. “Although I use the graphing calculator quite a bit in collegiate level courses, the math faculty at [my college] seem to be against its use in the developmental courses so it is used very little in those classes.” However, other instructors gave different perspectives in relation to calculator usage. “Even though I marked 0 – 20 percent of the time I give for the graphing calculator, I encourage them to use their calculator. I use them for the chapters that deal with graphing. I carry class sets to class for anyone who does not have one. I also taught the graphing calculator class when we offered it.” “I use graphing calculators to a great extent in my credit level courses, college algebra and math for liberal arts. I think it is important for the elementary algebra student to learn how to use them. It is a skill they need for later math courses and for life. Also, graphing calculators are teaching tools, not just calculators.”

One instructor cautioned, “Must be EXTREMELY careful that we use the calculator to teach ALGEBRA and NOT vice-versa (SOME would use Algebra to teach how to use the calculator!!).” While another participant indicated that at least one more college is moving toward research-based change. “[My college] has recently changed the Developmental text. We have also standardized on the TI-86. Hopefully this will encourage calculator use among our teachers as well as students.”

Other instructors shared their plan of teaching and learning concepts where students learn to work with pencil-and-paper prior to using the graphics calculator. “I require my students to learn the algebra without a calculator first. Then after they have done homework without the calculator, I show them how to do the same thing on the calculator. I guess I am still a little old fashioned.” “I think ‘tools’ like calculators are wonderful, but students need to know how to get answers without them (paper and pencil method).” Both instructors’ comments reflected Balheim’s (1999) report in which a majority of the teachers in the study believed the applicable mathematics should be taught prior to using calculators with the concept.

Another instructor’s comment related to Balheim’s (1999) findings that one-third of the respondents indicated that calculators should always be available. While supporting calculator use, this instructor shared the belief in the importance of the algebraic understanding. “I believe that the implementation of the graphics calculators in all levels of mathematics has had a positive impact on mathematics education. In particular, I see them as tools, which allow the instruction of a great many more topics in mathematics than was possible before their implementation. This is particularly true in college-level courses. For developmental courses the visual aid of the graph is extremely helpful; however, I also feel that the algebraic methods of solving must still be emphasized more than the graphic and numeric methods. I see this as the basis of math education - learning the thinking processes used for solving problems."

Research Question 4: Is there a relationship among the frequency of classroom calculator usage by full-time developmental mathematics instructors in Tennessee community colleges and:

a. Instructors' number of years (0 – 5, 6 – 10, 11 – 15, 16 – 20, 21 – 25, or 26 or more) of full-time teaching at community college level?
b. Instructors' number of years (0 – 5, 6 – 10, 11 – 15, 16 – 20, 21 – 25, or 26 or more) teaching mathematics?
c. Instructors' level of education (Bachelors, Masters, Specialists, Doctorate)?
d. Instructors' number of contact hours (0 – 10, 11 – 20, 21 – 30, 31 – 40, 41 – 50, or 51 or more) of formal (workshop or class participant) professional development with graphics calculators?
e. Instructors' brand of graphics calculator used by their college (Not specific, Casio, Hewlett-Packard, Sharp, or Texas Instruments)?
f. Instructors' gender (female or male)?
g. Instructors' academic rank (lecturer, instructor, assistant professor, associate professor—fully promoted, associate professor—promotable, or professor?

The question of relationships among calculator usage and personal and professional descriptors was answered using analysis in a Spearman correlation coefficient matrix, which compared the responses to forced-choice survey question 1,

> How many years have you been a full-time community college faculty member? 0 – 5, 6 – 10, 11 – 15, 16 – 20, 21 – 25, 26 or more

survey question 2,

> How many years have you been teaching mathematics? 0 – 5, 6 – 10, 11 – 15, 16 – 20, 21 – 25, 26 or more

survey question 4,

> What is your highest degree earned? Bachelors, Masters, Specialist, Doctorate

survey question 5,

> How many contact hours of formal (workshop or class) professional development have you received with graphics calculator(s)? 0 – 10, 11 – 20, 21 – 30, 31 – 40. 41 – 50, 51 or more

survey question 6,

> What brand of graphics calculator does your college use in developmental mathematics? No Specific Brand, Casio, Hewlett Packard, Sharp, Texas Instruments

survey question 12,

> My Gender is: Female, Male

and survey question 13,

> My academic rank is: Lecturer, Instructor, Assistant Professor, Associate Professor, Fully Promoted (Lack of terminal degree prohibits promotion to

Professor), Associate Professor, Promotable (Terminal degree achieved, working toward promotion to Professor), Professor

to responses for survey question 7,

The percentage of time I currently use a graphics calculator in the classroom for calculations is: 0% – 20%, 21% – 40%, 41% – 60%, 61% – 80%, 81% – 100%

survey question 8,

The percentage of time I currently use a graphics calculator in the classroom to depict algebra graphically or numerically (table) is: 0% – 20%, 21% – 40%, 41% – 60%, 61% – 80%, 81% – 100%

survey question 9,

In Basic Mathematics courses, the percentage of time I use a graphics calculator is: 0% – 20%, 21% – 40%, 41% – 60%, 61% – 80%, 81% – 100%

survey question 10,

In Elementary Algebra courses, the percentage of time I use a graphics calculator is: 0% – 20%, 21% – 40%, 41% – 60%, 61% – 80%, 81% – 100%

and survey question 11.

In Intermediate Algebra courses, the percentage of time I use a graphics calculator is: 0% – 20%, 21% – 40%, 41% – 60%, 61% – 80%, 81% – 100%

Answering the research question required comparison of the frequency of classroom graphics calculator usage by full-time developmental mathematics instructors in Tennessee community colleges (survey questions 7 – 11) and instructors' number of years of full-time teaching at community college level (survey question 1), instructors' number of years teaching mathematics (survey question 2), instructors' level of education (survey question 4), instructors' amount of formal (workshop or class participant) professional development with graphics calculators (survey question 5), instructors' brand of graphics calculator used by their college (survey question 6), instructors' gender (survey question 12), and instructors' academic rank (survey question 13) using a Spearman correlation coefficient matrix. The Spearman correlation coefficient matrix is shown in Table 4.10.

At the $p < 0.01$ level (2-tailed test) instructors' amount of formal (workshop or class participant) professional development with graphics calculators correlated significantly with all frequency of calculator use survey question responses (calculator use for calculations, to show algebra graphically and numerically, and calculator use in Basic Mathematics, Elementary Algebra, and Intermediate Algebra). Instructors' brand of graphics calculator used related significantly at the $p < 0.01$ level (2-tailed) with four of the five frequency of calculator use survey question responses (calculator use for calculations, to show algebra graphically and numerically and calculator use in Elementary Algebra and Intermediate Algebra), and correlated at the $p < 0.05$ level (2-tailed) with frequency of use in Basic Mathematics.

Table 4.10 Tennessee Community College Full-time Mathematics Instructors—Spearman Correlation Coefficient Matrix: Correlation Among Survey Question Responses

		Q1	Q2	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13
Q1	r	---	.530**	.080	.073	-.223*	-.071	-.066	-.034	-.011	.016	.075	.703**
	N		122	122	121	120	121	121	105	119	118	121	122
Q2	r		---	.215*	.240*	-.099	.072	.019	.202*	.113	.104	-.083	.457**
	N			122	121	120	121	121	105	119	118	121	122
Q4	r			---	.296**	.181*	.038	.067	.134	.047	.041	-.155	.248**
	N				121	120	121	121	105	119	118	121	122
Q5	r				---	.242**	.345**	.379**	.413**	.383**	.401**	-.251**	.305**
	N					119	120	120	104	118	117	120	121
Q6	r					---	.414**	.396**	.251*	.404**	.371**	-.020	-.205*
	N						120	120	104	118	117	119	120
Q7	r						---	.768**	.639**	.755**	.799**	-.020	-.089
	N							120	105	119	118	120	121
Q8	r							---	.664**	.803**	.802**	-.024	-.026
	N								105	119	118	120	121
Q9	r								---	.717**	.636**	-.073	.053
	N									105	105	104	105
Q10	r									---	.886**	.040	.007
	N										116	118	119
Q11	r										---	.028	-.033
	N											117	118
Q12	r											---	-.080
	N												121
Q13	r												---
	N												

**. Correlation is significant at the 0.01 level (2-tailed)

*. Correlation is significant at the 0.05 level (2-tailed)

As one might expect, there were positive, significant correlations among the responses on the five survey questions regarding frequency of use; these were significant at the $p < 0.01$ level (2-tailed). Other expected positive correlations among personal and professional descriptors were revealed in the Spearman correlation coefficient matrix, with significance at the $p < 0.01$ level (2-tailed):

- Instructors' years as a full-time community college faculty member and instructors' years teaching mathematics,
- Instructors' years as a full-time community college faculty member and academic rank,
- Instructors' years teaching mathematics and academic rank, and
- Instructors' highest degree earned and academic rank.

There were other positive correlations revealed in the Spearman correlation coefficient matrix, with significance at the $p < 0.01$ level (2-tailed):

- Instructors' years teaching mathematics and contact hours of formal (workshop or class participant) professional development
- Instructors' highest degree earned and contact hours of formal (workshop or class participant) professional development,
- Instructors' contact hours of formal professional development and brand of graphics calculator used, and
- Instructors' contact hours of formal professional development and academic rank.

There were also positive correlations revealed in the Spearman correlation coefficient matrix, with significance at the $p < 0.05$ level (2-tailed):

- Instructors' years teaching mathematics and highest degree earned, and
- Instructors' highest degree earned and brand of graphics calculator used.

There was one negative, significant correlation at the $p < 0.01$ level (2-tailed):

- Instructors' contact hours of formal professional development and gender;

and there were two negative, significant correlations at the $p < 0.05$ level (2-tailed).

- Instructors' years as a full-time community college faculty member and brand of graphics calculator used, and
- Instructors' brand of graphics calculator used and academic rank.

Relationships will be discussed in the next chapter.

<u>Department Head Questionnaires</u>

The Department Head Questionnaires solicited information about the policies regarding use of graphics calculators in Basic Mathematics, Elementary Algebra, and Intermediate Algebra in the mathematics and developmental mathematics departments at each community college. Specifically, are graphics calculators not allowed, recommended, required, or is there no policy? The results are shown in Table 4.11, Table 4.12, and Table 4.13. The questionnaire

Table 4.11 Tennessee Community College Mathematics— Department Head Questionnaire Responses, Questionnaire Question 2: Student Use of Graphics Calculators in Basic Mathematics				
Policy	No Policy	Not Allowed	Recommended	Required
Frequency	4	4	2	3
Percentage	30.8%	30.8%	15.4%	23%

Table 4.12 Tennessee Community College Mathematics— Department Head Questionnaire Responses, Questionnaire Question 3: Student Use of Graphics Calculators in Elementary Algebra				
Policy	No Policy	Not Allowed	Recommended	Required
Frequency	4	4	0	5
Percentage	30.8%	30.8%	0.0%	38.5%

Table 4.13 Tennessee Community College Mathematics— Department Head Questionnaire Responses, Questionnaire Question 4: Student Use of Graphics Calculators in Intermediate Algebra				
Policy	No Policy	Not Allowed	Recommended	Required
Frequency	6	1	1	5
Percentage	46.2%	7.7%	7.7%	38.5%

also requested that each department head at the college indicate the number of years the college had used graphics calculators in developmental mathematics. The results for this question are shown with research question six.

Research Question 5: What are the classroom graphics calculator usage policies (not allowed, no policy, recommended, required) at Tennessee community colleges for each developmental mathematics course (Basic Mathematics, Elementary Algebra, Intermediate Algebra)?

The question of what the classroom graphics calculator usage policies (not allowed, no policy, recommended, required) at Tennessee community colleges are for each developmental mathematics course (Basic Mathematics, Elementary Algebra, Intermediate Algebra) was answered using responses to questionnaire question two,

> What is the policy of your college for student use of graphics calculators in Basic Mathematics? Not Allowed, No Policy, Recommended, Required

questionnaire question three,

> What is the policy of your college for student use of graphics calculators in Elementary Algebra? Not Allowed, No Policy, Recommended, Required

and questionnaire question four

> What is the policy of your college for student use of graphics calculators in Intermediate Algebra? Not Allowed, No Policy, Recommended, Required

from the Department Head Questionnaire.

Of the 13 colleges, 30.8% had no policy for graphics calculator use in Basic Mathematics and Elementary Algebra, and 46.2% had no policy for

Intermediate Algebra. One school had just begun to have instructors use graphics calculator in the classroom. However, the same college had no policy on student use.

Some colleges, 30.8%, did not allow graphics calculator use in Basic Mathematics and Elementary Algebra, but only 7.7% did not allow graphics calculator use in Intermediate Algebra. The one college that reported, "no policy in Basic Mathematics and Elementary Algebra and not allowed in Intermediate Algebra," indicated that graphing calculators are allowed, but scientific calculators are recommended. This same college reported they had used graphing calculators in developmental mathematics for nine or more years. The one college that reported, "not allowed in any classes," indicated that graphing calculators are never allowed for graphing, but they can be used when a scientific calculator is allowed.

No school recommended graphics calculator use for Elementary Algebra, but 15.4% of the colleges recommended graphics calculator use for Basic Mathematics and 7.7% of the colleges recommended graphics calculator use in Intermediate Algebra. The one college that indicated, "recommended Intermediate Algebra" and "used for three to four years," reported that some teachers at the college do not use calculators in the classroom. Required graphics calculator use in Elementary and Intermediate Algebra was reported by five schools (38.5%) and by three schools (23%) in Basic Mathematics. One of the colleges with no policy was going to begin requiring calculator use in Elementary and Intermediate Algebra in the fall of 2003.

Table 4.14 Tennessee Community College Mathematics— Department Head Questionnaire Responses, Questionnaire Question 1: Years Of Graphics Calculator Use In Developmental Mathematics						
Years	0	1 – 2	3 – 4	5 – 6	7 – 8	9 or more
Frequency	5	0	1	1	0	6
Percentage	38.5%	0.0%	7.7%	7.7%	0.0%	46.2%

Research Question 6: How many years have Tennessee community colleges used graphics calculators for developmental mathematics courses?

The question of how many years Tennessee community colleges have used graphics calculators for developmental mathematics courses was answered using responses to forced-choice questionnaire question one

> How many years has your college used graphics calculators in developmental mathematics? 0, 1 – 3, 5 – 6, 7 – 8, 9 or more

from the Department Head Questionnaire. The results for questionnaire question one are shown in Table 4.14.

Though five of the colleges (38.5%) indicated that they had never used graphics calculators in developmental mathematics, six colleges (46.2%) had used graphics calculators in developmental mathematics for nine or more years. Two more colleges had used graphics calculators in developmental mathematics for three to four years and five to six years.

Summary

Chapter IV conveyed a presentation of the results of the analysis of data; first with demographic information from instructor survey responses, then with answering research questions using information from instructor survey responses, next with answering research questions using responses from department head questionnaires, and last with a summary of trend categories from survey participants' comments. The demographic information garnered from descriptive data analysis of the results from the instructors' survey responses, provided an impression of the personal and professional descriptors of the majority of the instructors in the 13 community colleges in Tennessee.

If an instructor were depicted as having all the traits of the majority of the participants' responses, the following would be "the" Tennessee community college developmental mathematics instructor. This instructor would be a female Associate Professor (fully promoted) with a Masters Degree. She would have been a full-time college faculty member for 15 years or less and would have been teaching mathematics 16 or more years. She would have had 20 or less contact hours of professional development with graphics calculators, and she would use a Texas Instruments graphics calculator in the classroom 0% – 20% of the time. Along with these majority traits from the survey responses, there were significant correlations, which emerged from analysis of these and other categories.

The percentage of classroom usage of graphic calculators and correlations between the percentage of use and personal and professional descriptors was represented in the next portion of this chapter, as the analysis of data from responses to instructor surveys was used to answer research questions regarding classroom usage. The correlation matrix indicated the following significant relationships: instructors' brand of graphics calculator used and instructors' frequency of graphics calculator usage for all categories (calculations, depicting algebra graphically and numerically (table), and calculator use in Basic Mathematics, Elementary Algebra, and Intermediate Algebra), and instructors' amount of formal professional development correlated with all frequency of use categories.

Significant correlations emerged from the correlation matrix as follows:

- Among all frequency of use categories, and between
- Instructors' years as a full-time community college faculty member and instructors' years teaching mathematics,
- Instructors' years as a full-time community college faculty member and academic rank,
- Instructors' years teaching mathematics and academic rank,
- Instructors' highest degree earned and academic rank,
- Instructors' years teaching mathematics and contact hours of formal (workshop or class participant) professional development,
- Instructors' highest degree earned and contact hours of formal (workshop or class participant) professional development,
- Instructors' contact hours of formal professional development and brand of graphics calculator used,
- Instructors' contact hours of formal professional development and academic rank,
- Instructors' years teaching mathematics and highest degree earned,

- Instructors' highest degree earned and brand of graphics calculator used,
- Instructors' contact hours of formal professional development and gender;
- Instructors' years as a full-time community college faculty member and brand of graphics calculator used, and
- Instructors' brand of graphics calculator used and academic rank.

With a view of these significant correlations from analysis of instructors' survey responses, the next portion of the investigations moved to departmental policies at each college as reported in the department head questionnaire responses.

As for guidance from their colleges/departments, developmental mathematics instructors across the state had varied direction regarding calculator usage policies. The information garnered from the analysis of the responses to the department head questionnaires offered a scene of diversity. The developmental mathematics policies for use of graphics calculators varied among the courses (Basic Mathematics, Elementary Algebra, and Intermediate Algebra) at each college. Some colleges indicated that instructors were using graphics calculators in developmental mathematics, but the colleges had no policy on student use. Five colleges indicated they have never used graphics calculators in developmental mathematics and six colleges indicated they have used graphics calculators in developmental mathematics for nine or more years. After looking at colleges' policies or lack of policies, trends from comments from survey participants provided a final look at instructors' perspectives of calculator usage in developmental mathematics at Tennessee community colleges.

The six trends that emerged from participant comments included the following categories: algebra prior to calculator; Basic Mathematics, Elementary Algebra, and Intermediate Algebra; caution; clarification; explanation of use; negative, no use, or limited use; and other questions, topics, and uses. The category, explanation of use, with participants providing an explanation of how they and/or their colleagues use calculators at their colleges was the trend most (10) mentioned; and the category, negative, no use, or limited use, with participants indicating personal, professional, or departmental choices of not using or limiting the use of graphics calculators was next, with eight comments. Like results from analysis of department head questionnaire responses, the comments painted a mural of diversity in choices and thoughts on the use or non-use of graphics calculators in developmental mathematics.

Thus, chapter IV offered the results of the many facets of "the developmental mathematics instructor" in Tennessee community colleges. This included personal and professional descriptors, percentages of classroom graphics calculator uses, colleges' policies on the use of graphics calculators, and personal perspectives with instructor comments. The graphics calculator usage in Tennessee community colleges was as varied as the states' topography.

CHAPTER V

DISCUSSION

The teaching and learning of mathematics with technology is in a state of constant change, with technology changing at a faster rate than ever before. The price of more powerful technology is decreasing along with innovations. At times, it seems that the only part of the Tennessee community college education system that is lagging in technology use is a group of administrators and instructors. Previous studies have indicated a need for using graphics calculators in the teaching and learning of mathematics and developmental mathematics. Yet, this study suggests that we still have college administrators and faculty members who are not responding to the call for reform that is based on the studies cited. Many are functioning just as they did many years ago, with their only innovations being a move from the chalkboard to the marker board, if that. Effective teaching and learning in developmental mathematics is more important than ever, with more students requiring remediation and development in arithmetic and algebra (Shore, 2002).

Research Problem

In order to comprehend what can be done to promote the effective use of graphics calculators in Tennessee community college developmental mathematics teaching and learning environments, it was essential to ascertain the level of graphics calculator usage and the connection to factors that may influence classroom usage. Specifically stated, the purpose of this study was to investigate:

1. frequency of Tennessee community college full-time developmental mathematics instructors' classroom graphics calculator usage (as percent of class time),
2. graphics calculator policies at each college, and
3. various personal and professional descriptors of those instructors.

Professional Practice

The research questions were answered using data analysis of the responses to instructors' survey and department heads' questionnaire, the personal and professional demographics, the graphics calculator usage, and colleges' graphics calculator policies of instructors of developmental mathematics in the 13 Tennessee community colleges. The personal and professional demographics portray instructors who are predominantly women with Masters Degrees; who are experienced as fulltime college faculty members for 15 or less years, but with 16 or more years of mathematics teaching experience; who have had 20 or less contact hours of professional development with graphics calculators; who most often use Texas Instruments calculators; and who use graphics calculators in the classroom 0% – 20% of the time.

The dominant percentage range of classroom usage of graphic calculators in the developmental mathematics classroom in all categories (calculations, depicting algebra graphically and numerically (table), and calculator use in Basic Mathematics, Elementary Algebra, and Intermediate Algebra) was 0% – 20% of the time. Significant correlations between the percentage of use and personal and professional descriptors emerged as the Spearman correlation coefficient matrix was used to analyze survey responses.

Instructors' amount of formal (workshop or class participant) professional development and all frequency of use categories correlated significantly; as did instructors' brand of graphics calculator used and instructors' frequency of graphics calculator usage for all categories. If any of the instructors had formal professional development such as Texas Instruments' Teachers Teaching Teachers (T^3) Program, which was initiated by Waits and Demana in 1988 (Waits & Demana, 1998), this professional training could have influenced the frequency of classroom usage and the brand of graphics calculator.

Significant correlations emerged among all frequency of use categories, along with other significant correlations. Some of the personnel and professional data and the graphics calculator usage data of instructors may have correlations linked to the college policies for use of graphics calculator and requirements for professional rank at the individual colleges. There were significant correlations between instructors' years teaching mathematics and the two categories, years as a full-time community college faculty member and academic rank. Not surprisingly, another correlation was between instructors' years as a full-time community college faculty member and academic rank, since achieving academic rank requires, among other things, specified years of experience at each rank increase level.

Instructors' highest degree earned correlated with both academic rank and contact hours of formal (workshop or class participant) professional development with graphics calculators. Since academic rank is predicated on degree attainment, the correlation of these two categories was expected. A person who earns advanced degrees suggests a person with drive to attain knowledge, the same type of drive that would push an instructor to access formal professional development in technology.

Instructors' contact hours of formal workshop professional development with graphics calculators correlated with three categories: brand of graphics calculator used, gender, and academic rank. Instructors' brand of graphics calculator used also correlated with academic rank. Since these three categories (brand of graphics calculator used, gender, and academic rank) represented the majority of participants at a rate of more than 60%, correlations among them is not surprising.

Participants' comments suggested or spurred further questions. One participant commented, "We do not require the use of a graphics calculator so we use a scientific calculator unless we are demonstrating something on the graphic calculator." This prompts the following questions. Why is a scientific calculator better to use at all times, except when graphing? Why not use the more powerful graphics calculator for all calculator purposes? Do instructors know what the research has shown about the effectiveness of using graphics calculators in the classroom?

Another instructor related a requirement and a lament, "I have to use the graphing calculator because of the text we use. I would not be able to do all the assigned material without the calculator. I have taught developmental, before the time of the graphing calculator, and I believe that the students were better prepared for college level without it.” This spurs more questions than answers. In the past, were students better prepared when they got to developmental mathematics courses? Are instructors “covering” enough or too much material in developmental mathematics classes? What effect does the choice of text have on the amount of time using graphics calculators in the classroom? Who makes the decision regarding what text a department will use?

One participant shared questions, “I would also be interested in the answers to: Is the emphasis placed on calculator usage in Developmental Mathematics too much, about right, not enough? How does the amount of time you devote to calculator usage in Developmental Mathematics compare to the amount of time you devoted to calculator usage three years ago? more, about the same, less?” Another participant commented, “The TI-83 graphics calculator is fully integrated into our DSPM 0800/0850 [Elementary Algebra and Intermediate Algebra] courses.” This lends itself to follow-up survey questions. What is the perception of each instructor regarding “fully integrated?” Do all instructors of the Elementary Algebra and Intermediate Algebra courses at that college support the “fully integrated” policy?

<u>Graphics Calculator Policies</u>

The developmental mathematics policies for use of graphics calculators varied among the courses (Basic Mathematics, Elementary Algebra, and Intermediate Algebra) at each college as indicated by the responses from the Department Head Questionnaires. Of the 13 Tennessee community colleges, 5 indicated they have never used graphics calculators in developmental mathematics and 6 indicated they have used graphics calculators in developmental mathematics for 9 or more years. The other two colleges reported using graphics calculators in developmental mathematics for three to four years and five to six years. In Basic Mathematics, four colleges did not allow graphics calculators, two recommended, three required, and four had no policy. In Elementary Algebra, four colleges did not allow graphics calculators, zero recommended, five required, and four had no policy. In Intermediate Algebra, one college did not allow graphics calculators, one recommended, five required, and six had no policy. It is clear that there is no system-wide policy for graphics calculator usage in Tennessee community colleges, as some colleges have not taken steps necessary to address current reform standards for the use of technology in all mathematics classrooms.

Trends from 31 voluntary comments from survey participants offered another perspective of developmental mathematics instructors in Tennessee community colleges. The six trends included the following categories: algebra prior to calculator; Basic Mathematics, Elementary Algebra, and Intermediate Algebra; caution; clarification; explanation of use; negative, no use, or limited use; and other questions, topics, and uses. Ten instructors provided explanations of graphics calculator uses including: taking classroom sets to have for students who do not have one and encouraging students to use them, emphasizing the calculator used as visual tool and for enhancing the understanding of basic algebra, using daily, expressing limitations of an Internet course and hope for more usage at the college, relating that half of colleagues use and half do not, using as a teaching tool, using for demonstration only, and having students coming from high schools where calculators were used. Eight instructors expressed no use, negative feelings, or limited use of graphics calculators in developmental mathematics including: limiting use to College Algebra, using not permitted by college, requiring use because of text and believing that students were better prepared without calculators, using rarely for developmental mathematics, choosing not to use, and using no calculators at all.

Further Research and Recommendations

Other questions to be considered in the mathematics community: Should there be professional development for administrators and instructors regarding the awareness of current research and reforms? Tharp, Fitzsimmons, and Ayers (1997) emphasized different styles of teaching mathematics, rule-based and non-rule-based. What are the styles of instructors of developmental mathematics? Is more intensive training beneficial for instructors and administrators who have a rule-based style in mathematics classrooms?

Based on the majority choice of Texas Instruments graphics calculators in this study, there are other questions to be answered: Are Texas Instruments graphics calculators the brand of choice for most trainers? Do programs such as the Texas Instruments program, Teachers Teaching with Technology (T^3) have impact on the brand of choice for trainers and instructors? Nationally, what is the brand of choice of graphics calculators?

As the data were gathered and analyzed and comments were categorized, the researcher discovered items that would be of assistance to anyone undertaking a study like this one. The choice of brand of graphics calculator could have been a department head question, since departments often make that decision when there is a calculator usage policy.

Completing the department head questionnaire research first would have alerted the researcher to the fact that 5 of the 13 Tennessee community colleges had never used graphics calculators in developmental mathematics. Since these 5 colleges included 66 full-time mathematics faculty members, 30.8% of the 214 full-time mathematics faculty members who were sent the survey participation requests, one may speculate that some of these full-time mathematics faculty members did not respond to the request for participation because they felt the study was of no importance to them. Offering a copy of the research report to these instructors may have been of no use to these full-time mathematics faculty members. It is possible that some of these faculty members read in the request letter that the survey was researching graphics calculator use and they ignored the survey since they had no graphics calculator use.

Another department head question,

> Approximately how many of your college's full-time mathematics faculty members taught at least one developmental mathematics course each semester of the calendar year?

would allow the researcher to determine a percentage of qualified respondents to the approximate number of full-time mathematics faculty members who would qualify to respond.

If one is considering replicating this study, it might be best to consider an additional choice of “do not use graphics calculator” or “0” when requesting a choice for any question that requires a choice relating to the percentage of classroom time calculator is used. When a choice of “do not use the graphics calculator” or “0” is indicted, having the survey divert to choices or a comment section regarding why the graphics calculator is not used would provide useful information to any researcher.

Another choice, “do not teach,” was indicated by one participant, who commented, “I have never taught Basic Mathematics.” Providing a choice of “none” for the number of contact hours of formal (workshop or class) professional development with graphics calculator would provide an option that could be informative. Also, offering quick choices, using a list of comments and having participants indicate strongly agree to strongly disagree with a Likert-type scale would be helpful in analyzing instructor beliefs.

A participant’s comment indicated the need of offering the choice, none, when asking about the brand of graphics calculator used. “No calculators of any kind are permitted in developmental courses. My response to item six is not correct, but there was no appropriate response.” An instructor’s comment, with a bit of humor, indicated that a definition of “use” would be appropriate for any further study of classroom calculator usage. “I am a little unclear on how to interpret the percentage use of a graphics calculator. I assume that you mean in any given length of time the percentage of that time that is spent with calculator on and functioning [other than a paperweight:-)]."

One participant's observation indicated that just participating in a study could have a reflective effect for instructors. "This survey should reveal good information. I am not sure I have ever thought about the amount of time I use this tool in remedial/developmental mathematics." Future studies may need to include a question about the amount of time spent reflecting on the value of graphics calculator usage; and offer participants the opportunity to respond to, "after reflecting about my classroom usage of graphics calculators in developmental mathematics, I have made the following changes," in an open-ended comment space.

Including questions in the survey about instructors perception of student feelings about using graphics calculators as well as instructors feeling about using graphics calculators could be useful in preparation of workshops for instructors. A graphics calculator survey of students who withdraw from developmental mathematics courses may provide useful information for integration of the technology. A comparison of surveys at individual schools that require, allow, or do not allow graphics calculator usage in developmental mathematics courses may provide more insight into the dynamics of usage.

Implications

This research described a view of Tennessee community college developmental mathematics classrooms, where graphics calculators were utilized by a majority of the participants for teaching and learning from 0% to 20% of the time. With 5 of the 13 community colleges reporting that they have never used graphics calculators in developmental mathematics classes, there is work to be done to rectify this situation. While there are many factors that administrators and instructors cannot control in the developmental mathematics classroom, one aspect of the classroom experience for assisting students in learning and assisting instructors in teaching is being underutilized in developmental mathematics classes in Tennessee community colleges. The use of graphics calculators has been researched and shown to be an effective classroom tool (Gningue, 2003; MacDonald, Vasquez, & Caverly, 2002) for enhancing how we think about mathematics teaching and learning (Heid, 2005). Based on sound statistical research, the members of the mathematics community have been asked to heed the call for reform in the use of technology. It appears from this study that at least some college administrators and instructors are complacent with the status quo and do not wish to join in this movement to meet the needs of mathematics students by using the technology that has been shown to enhance understanding (MacDonald, Vasquez, & Caverly, 2002). Eschewing the use of research-based best practices to engage our students in a technologically-based environment of active learning that promotes critical thinking and reasoning (Walston, 2001) is like depriving students of basic nutrition. The interaction among student, teacher, and graphics calculators could be accomplished in a way that would best benefit students

(Connell, Lowery, & Harnich, 2002), if administrators and instructors worked together to make this happen.

Using the significant correlation between instructors' amount of formal professional development and instructors' frequency of classroom calculator usage, which emerged from this research, and other research which has shown the effectiveness of using graphics calculators in the mathematics classroom (Alagic, 2003; Kissane, Bradley, & Kemp, 1994; Doerr & Zangor, 2000; Knuth & Peterson, 2003; O'Callaghan, 1997; Peressini & Knuth, 2005; Shoaf-Grubbs, 1993; Shore, 1999; Simonsen & Dick, 1997; and Vonder Embse, 1997) as rationale, administrators can support expenditures to assist the instruction process by initiating and providing continuous professional development in the use of graphics calculators in the mathematics classroom (Alagic, 2002; Alagic, 2003; Milou, 1999; Peressini & Knuth, 2005; Waits & Demana, 2001; Tharp et al., 1997; Walston, 2001; Zucker, 2001). If administrators are not initiating and providing this training, developmental mathematics instructors who are aware of the research-supported benefits of using graphics calculators in the mathematics classroom can share this awareness and request such training for the benefit of all, administrators, instructors, and, most of all, students. Enthusiastic teachers who care about students are essential for developmental mathematics students (Milou, 1999).

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APPENDICES

Appendix A

2003 Tennessee Community Colleges With Websites For Instructor Emails
Chattanooga State Technical Community College http://www.cstcc.cc.tn.us/ http://www.cstcc.cc.tn.us/Math/Default.htm http://www.cstcc.cc.tn.us/Math/facultyandstaff.htm#Full-Time%20Faculty http://www.cstcc.cc.tn.us/Math/fulltime.htm#Sherri%20L.%20Barnes
Cleveland State Community College http://www.clscc.cc.tn.us/ http://www.clscc.cc.tn.us/humanres/faculty.html
Columbia State Community College http://www.coscc.cc.tn.us/ http://www.coscc.cc.tn.us/directory.cfm
Dyersburg State Community College http://www.dscc.cc.tn.us/ http://ntsrv3.dscc.cc.tn.us/facultyweb.htm
Jackson State Community College http://www.jscc.cc.tn.us/ http://www.jscc.cc.tn.us/users/math/faclst.htm
Motlow State Community College http://www.mscc.cc.tn.us/
Nashville State Technical Institute http://www.nsti.tec.tn.us/ http://www.nsti.tec.tn.us/depart/mathsci/mathfac.html
Northeast State Technical Community College http://www.nstcc.cc.tn.us/
Pellissippi State Technical Community College http://www.pstcc.cc.tn.us/ http://www.pstcc.cc.tn.us/departments/mathematics/ http://www.pstcc.cc.tn.us/departments/mathematics/faculty/faculty.htm
Roane State Community College http://www.rscc.cc.tn.us/ http://www.rscc.cc.tn.us/phone/phone.doc then search in http://mailsrv.rscc.cc.tn.us/galsearch/askname.asp
Southwest Tennessee Community College http://www.stcc.cc.tn.us/ http://www.stcc.cc.tn.us/directory/deans.htm http://www.stcc.cc.tn.us/directory/
Volunteer State Community College http://www.vscc.cc.tn.us/ http://www.vscc.cc.tn.us/academic/math/FAC/chairs.htm http://www.vscc.cc.tn.us/academic/math/FAC/mat.htm

2003 Tennessee Community Colleges With Websites For Instructor Emails
Walters State Community College http://www.vscc.cc.tn.us/academic/math/FAC/mat.htm http://www.wscc.cc.tn.us/math/ http://www.wscc.cc.tn.us/math/directory.htm

Appendix B

http://slug.ceca.utc.edu/jsmith/

Tennessee Developmental Mathematics Faculty Survey

If you are a full-time community college faculty member, please answer the following.
If you are uncertain of the answer, please choose the answer "closest" to describing you, your teaching, or your college.

1. How many years have you been a full-time community college faculty member? ○ 0-5 ○ 6-10 ○ 11-15 ○ 16-20 ○ 21-25 ○ 26 or more
2. How many years have you been teaching mathematics? ○ 0-5 ○ 6-10 ○ 11-15 ○ 16-20 ○ 21-25 ○ 26 or more
3. During the calendar year (Spring 2002, Fall 2002) did you teach at least one developmental mathematics (Basic Mathematics, Elementary Algebra, Intermediate Algebra) course during the spring and fall semesters? ○ Yes ○ No
*If # 3 is **No**, please do not continue with the survey. Thank you for your time.* [Save and Quit] *If # 3 is **Yes**, please continue. Your time is appreciated.*
4. What is your highest degree earned? ○ Bachelors ○ Masters ○ Specialist ○ Doctorate
5. How many contact hours of formal (workshop or class) professional development have you received with graphics calculator(s)? ○ 0-10 ○ 11-20 ○ 21-30 ○ 31-40 ○ 41-50 ○ 51 or more
6. What brand of graphics calculator does your college use in developmental mathematics? ○ No Specific Brand ○ Casio ○ Hewlett Packard ○ Sharp ○ Texas Instruments
*For 7-11, thinking about the **remedial/developmental mathematics classes you teach** and the time you use graphics calculators in class please indicate your response.* *If unsure of a response, please indicate the response closest to your best estimate.*
7. The percentage of time I currently use a graphics calculator in the classroom for calculations is:

0-20 21-40 41-60 61-80 81-100

8. The percentage of time I currently use a graphics calculator in the classroom to depict algebra graphically or numerically (table) is:
0-20 21-40 41-60 61-80 81-100

9. In Basic Mathematics courses, the percentage of time I use a graphics calculator is:
0-20 21-40 41-60 61-80 81-100

10. In Elementary Algebra courses, the percentage of time I use a graphics calculator is:
0-20 21-40 41-60 61-80 81-100

11. In Intermediate Algebra courses, the percentage of time I use a graphics calculator is:
0-20 21-40 41-60 61-80 81-100

For questions 12-13, please respond as applicable.

12. My Gender is:
Female Male

13. My academic rank is:
Lecturer
Instructor
Assistant Professor
Associate Professor, Fully Promoted*
Associate Professor, Promotable**
Professor

*Lack of terminal degree prohibits promotion to Professor.
**Terminal degree achieved, working toward promotion to Professor.

Comments?

Thank you for the time you have taken to complete this survey. Please enter your email address below to indicate you have completed the survey.

Email Address:

Entering your email address here identifies that you have completed the survey. The email address and the responses are linked to SEPARATE files and will NEVER be associated.
The file of email addresses will only be used to determine whom to contact for follow-up requests.
The file of email addresses will be destroyed after sufficient data has been collected.
The researcher is the only one who will ever see the list of email addresses.
The researcher will not share this information with anyone.

If you would be interested in participating in potential follow-up interviews, please include your email address.

Email Address:

Save and Finish

Appendix C

Department Head Questionnaire

1. How many years has your college used graphics calculators in developmental mathematics?

____0 _____1 – 2 _____3 – 4 _____5 – 6 _____7 – 8 _____9 or more

2. What is the policy of your college for student use of graphics calculators in Basic Mathematics?

____Not allowed ____No Policy ____Recommended _____Required

3. What is the policy of your college for student use of graphics calculators in Elementary Algebra?

____Not allowed ____No Policy ____Recommended _____Required

4. What is the policy of your college for student use of graphics calculators in Intermediate Algebra?

____Not allowed ____No Policy ____Recommended _____Required

Appendix D

Letter to Mathematics Faculty Members at each Tennessee Board of Regents Community College (included in letter to academic vice presidents, deans and department heads)

Date

Name, Title
College, Address

Dear Dr. ______,

As a doctoral degree student at The University of Tennessee I am interested in including your information in the research data for the completion of my dissertation. Your participation is an integral part of this research.

This research will identify perceptions of graphics calculator usage and factors related to community colleges and the developmental mathematics instructors in Tennessee. Using your survey responses and those of other mathematics faculty members across the state of Tennessee, data will be analyzed to determine perceptions. All responses are confidential. All data will be analyzed aggregately; no college or instructor will be identified separately.

Please click on the following link or copy and paste the address into your Internet browser address line and complete the survey.

http://slug.ceca.utc.edu/jsmith/

If you choose the option available, the findings of the research will be shared with you. If you have any questions, please contact me by email at, Joyce.Smith@chattanoogastate.edu, phone (423) 697-2528—work or (423) 892-5283—home, or Joyce Smith, Department of Mathematics, Chattanooga State Technical Community College, 4501 Amnicola Highway, Chattanooga, TN 37406 or Joyce Smith, 1021 Wedgewood Drive, Chattanooga, TN 37421.

Thank you in advance for your support and participation.

Sincerely,

Joyce Smith

Appendix E

Letter to Academic Vice President, Dean, and Mathematics and Developmental Mathematics Department Head at each Tennessee Board of Regents Community College

Date

Name, Title
College, Address

Dear Dr. ______,

As a doctoral degree student at The University of Tennessee I am interested in including your information in the research data for the completion of my dissertation. The participation of faculty members is an integral part of this research. Please ask each of your full-time mathematics faculty members to participate in this research. At the end of this message I have included the list of full-time mathematics faculty members as listed on your college website. If you have additional full-time mathematics faculty members, please forward the link or send their name and email address to me.

This research will identify perceptions of graphics calculator usage and factors related to community colleges and the developmental mathematics instructors in Tennessee. Through surveys completed by your faculty members and others across the state of Tennessee, perceptions will be analyzed. All data will be analyzed aggregately; no college or instructor will be identified separately. The survey is available online at http://slug.ceca.utc.edu/jsmith/

The findings of the research will be shared with you. If you have any questions, please contact me by email at, Joyce.Smith@chattanoogastate.edu, phone (423) 697-2528—work or (423) 892-5283—home, or Joyce Smith, Department of Mathematics, Chattanooga State Technical Community College, 4501 Amnicola Highway, Chattanooga, TN 37406 or Joyce Smith, 1021 Wedgewood Drive, Chattanooga, TN 37421.

Thank you in advance for your support and participation.

Sincerely,

Joyce Smith

Appendix F

Letter to Mathematics Faculty Members at each Tennessee Board of Regents Community College (follow-up letter)

Date

Name, Title, College, Address

Dear Dr. ______,

I am contacting you again to request your participation in the study of graphics calculator usage and factors related to community colleges and the developmental mathematics instructors in Tennessee. If you have already completed the survey, I appreciate your time and interest in this research. If you have not completed the survey, I am once again requesting your cooperation. Since the research can be useful to all colleges, I am certain that you want to include your perceptions as part of the information.

As a doctoral degree student at The University of Tennessee I am again requesting your participation as I gather research data for the completion of my dissertation. Each person's participation is an integral part of this research.

This research will identify perceptions of graphics calculator usage and factors related to community colleges and the developmental mathematics instructors in Tennessee. Through surveys, your responses and those of other mathematics faculty members across the state of Tennessee will be analyzed to determine perceptions. All responses are confidential. All data will be analyzed aggregately; no college or instructor will be identified separately.

Please click on the following link or copy and paste the address into your Internet browser address line and complete the survey.
http://slug.ceca.utc.edu/jsmith/

If you choose the option available, the findings of the research will be shared with you. If you have any questions, please contact me by email at, Joyce.Smith@chattanoogastate.edu, phone (423) 697-2528—work or (423) 892-5283—home, or Joyce Smith, Department of Mathematics, Chattanooga State Technical Community College, 4501 Amnicola Highway, Chattanooga, TN 37406 or Joyce Smith, 1021 Wedgewood Drive, Chattanooga, TN 37421.

Thank you in advance for your support and participation.

Sincerely,
Joyce Smith

Appendix G

Last Call for Tennessee Developmental Mathematics Faculty Survey

--It takes approximately 1-3 minutes

Dear Colleagues,

Thanks to all of you who have taken the survey or emailed to let me know you would not be a participant. I appreciate the support many of you have indicated. Your time and responses are valuable. Currently, 135 teachers have taken the survey.

The members of my committee have suggested the need for more participation; approximately 40 more responses will help. If you have not responded, even if your college does not use graphics calculators, please take a few moments to respond to the 13 question survey. As a doctoral degree student at The University of Tennessee I am interested in including your information in the research data for the completion of my dissertation.

This research will identify perceptions of graphics calculator usage and factors related to community colleges and the developmental mathematics instructors in Tennessee. Through surveys, your responses and those of other mathematics faculty members across the state of Tennessee will be analyzed to determine perceptions. All responses are confidential. All data will be analyzed aggregately; no college or instructor will be identified separately.

Please click on the following link or copy and paste the address into your Internet browser address line and complete the survey.

http://slug.ceca.utc.edu/jsmith/

If you choose the option available, the findings of the research will be shared with you. If you have any questions, please contact me: by email at, Joyce.Smith@chattanoogastate.edu; by phone at, (423) 697-2528—work or (423) 892-5283—home; or by mail at, Joyce Smith, Department of Mathematics, Chattanooga State Technical Community College, 4501 Amnicola Highway, Chattanooga, TN 37406 or Joyce Smith, 1021 Wedgewood Drive, Chattanooga, TN 37421.

Thank you in advance for your support and participation.

Sincerely,
Joyce Smith, Associate Professor, Mathematics
Chattanooga State Technical Community College

Appendix H

Letter to Mathematics and Developmental Mathematics Department Head at each Tennessee Board of Regents Community College

Date

Name, Title
College, Address

Dear Dr. ______,

I am writing to request your support and participation as I gather research data for the completion of my dissertation at The University of Tennessee. Your participation is an integral part of this research. I am requesting that you answer the following questions in your reply to my email. If you prefer, you can call me at the number below.

This research will identify perceptions of graphics calculator usage and factors related to community colleges and the developmental mathematics instructors in Tennessee. All data will be analyzed aggregately; no college or person at a college will be identified separately. The questionnaire is below.

The findings of the research will be shared with you. If you have any questions, please contact me by email at, Joyce.Smith@chattanoogastate.edu, phone (423) 697-2528—work or (423) 892-5283—home, or Joyce Smith, Department of Mathematics, Chattanooga State Technical Community College, 4501 Amnicola Highway, Chattanooga, TN 37406 or Joyce Smith, 1021 Wedgewood Drive, Chattanooga, TN 37421.

Thank you in advance for your support and participation.

Sincerely,

Joyce Smith

[*The Department Head Questionnaire followed the signature*.]

Appendix I

Follow-up Letter to Mathematics and Developmental Mathematics Department Head at each Tennessee Board of Regents Community College

Date

Name, Title
College, Address

Dear Dr. ______,

I am writing to again request your support and participation as I gather research data for the completion of my dissertation at The University of Tennessee. Your participation is an integral part of this research and will be appreciated. I am requesting that you answer the following questions in your reply to my email. If you prefer, you can call me at the number below.

This research will identify perceptions of graphics calculator usage and factors related to community colleges and the developmental mathematics instructors in Tennessee. All data will be analyzed aggregately; no college or person at a college will be identified separately. The questionnaire is below.

The findings of the research will be shared with you. If you have any questions, please contact me by email at, Joyce.Smith@chattanoogastate.edu, phone (423) 697-2528—work or (423) 892-5283—home, or Joyce Smith, Department of Mathematics, Chattanooga State Technical Community College, 4501 Amnicola Highway, Chattanooga, TN 37406 or Joyce Smith, 1021 Wedgewood Drive, Chattanooga, TN 37421.

Thank you in advance for your support and participation.

Sincerely,

Joyce Smith

[*The Department Head Questionnaire followed the signature*.]

VITA

Joyce Ann Petty Smith was born in Columbia, Tennessee. She attended Spring Hill High School in Spring Hill, Tennessee. She received her Associates Degree in Mathematics from Columbia State Community College in 1970 and her Baccalaureate Degree in Secondary Education with a concentration in Social Studies and Mathematics from Tennessee Technological University in 1973.

Joyce began her teaching career at Orchard Knob Junior High School, and then transferred to East Side Junior High School in Chattanooga, Tennessee. During her eight-year tenure of teaching at these schools she taught arithmetic, algebra, typing, and geography. Joyce taught developmental mathematics as an adjunct instructor at Chattanooga State Technical Community College until 1987, when she joined the faculty, teaching developmental mathematics. She is currently an Associate Professor of Mathematics. At Chattanooga State she teaches basic mathematics, elementary algebra, intermediate algebra, college algebra, pre-calculus, and mathematics for elementary teachers.

Joyce received her Master's Degree in Mathematics Education in 1997 from The University of Tennessee, Chattanooga. She has worked with local public and private school teachers of mathematics in workshops funded by Eisenhower Grants secured through the Tennessee Higher Education Commission.

Joyce has coauthored two graphics calculator manuals to accompany developmental mathematics textbooks. She authored all the graphics calculator materials for a text that was custom designed for developmental mathematics by the Kaplan Corporation.

Since 1971, Joyce has been married to Bill Smith, an outdoor enthusiast. They have one child, Dru, who is pursuing his Baccalaureate Degree in Education, Middle School Mathematics, at The University of Tennessee, Chattanooga, and who has a passion for kayaking.