Professional Development for Graphing Calculators

Steven J. Colabufo
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Introduction

The New York State Department of Education has developed content and performance standards that high school students need to meet to graduate. The implementation of these higher standards caused a pedagogical change in the way mathematics is being taught in New York State public high schools.

Two of the biggest changes involve the number of courses students must pass to graduate and the format of assessments aligned to these courses. Students are now required to complete three credits of mathematics to graduate as opposed to the previous two credits. The three credits must be ordered in a way that demonstrates a progressive knowledge level of the students.

Another noticeable difference is that the State Education Department has not only allowed, but also required, the use of calculators on the final exams at the high school level. According to the SED,

Scientific calculators are required for the Math A Regents examinations.

Graphing calculators that do not allow for symbolic manipulation will be required for the Math B Regents examinations and will be permitted (not required) for the Math A Regents examination starting in June 2000 (The University of the State of New York, p. 117).

All students must pass the Mathematics A Regents Examination in order to meet the State requirements for graduation.

There is a big debate among the circles of mathematics teachers about the use of graphing calculators in mathematics pedagogy. Some math teachers fear that the use of graphing calculators will produce students with weaker math skills. The fear is that
students will not have the basic arithmetic skills needed to help them more easily solve the higher-level math problems. Other teachers believe that graphing calculators are important tools to aid in the pedagogical strategies to help students learn and understand the important mathematical concepts.

I believe the real underlying issue teachers have with the use of graphing calculators is that teachers do not feel comfortable or knowledgeable enough on how to use them. To overcome this fear school districts need to spend the time and money on professional development so teachers can learn how the graphing calculators can be utilized into their classrooms.

I teach at East High School in the Rochester City School District. East High School is one of the schools on New York State's failure list for mathematics. Almost all of the middle schools that feed into East High School are also on the state's failure list. I, along with the other math teachers in my department, have the important task of teaching students the skills to prepare them to pass the Mathematics A Regents Exam so, in turn, they can graduate and become productive citizens in our society.

In 1999 I took a graduate course called Math in the Technological Age. The course was taught by William Caroscio, a high school math teacher knowledgeable about what students need to know and be able to do to pass the Mathematics A exam. William Caroscio taught the participants how to implement the graphing calculator and computer programs into the Mathematics A curriculum, and showed the many advantages that graphing calculators offer. I left the course with a greater understanding of how graphing calculators can enhance my mathematics pedagogy.
As a result to become involved with graphing calculators, the Rochester City School District paid me to attend a week long graphing calculator workshop. Mr. Caroscio also taught this workshop. Once again I was reminded of things I learned the year before in class and showed me even more insight to the use of the graphing calculator on the Mathematics A exam. He went through the entire Math A exam from June 2001 and figured out ways to use the graphing calculator on each question.

After going through this training I offered an opportunity to conduct workshops to Rochester City School District middle school teachers on how to use the graphing calculators in mathematics classes. As part of my compensation for conducting this workshop, the district gave me twenty-seven TI-83 calculators for use in my classroom.

This allowed me to get started with using graphing calculators in my classroom right from the first week of school to implement strategies from Mr. Caroscio's workshop. From this I got interested in becoming a graphing calculator specialist for the East High School's Mathematics Department.

Several months later my department head became very enthused with my use of the graphing calculators in my classroom. My department head saw that lack of graphing calculator use in the classrooms at East High School was a problem. We both felt that teachers were not using graphing calculators in class. We concluded they do not feel comfortable or knowledgeable enough to enhance their lessons with graphing calculators. We came to the conclusion that mathematics teachers at East High School need extensive professional development to encourage the use of graphing calculators.

As a result my department head asked me to demonstrate to the other math teachers at East High how to use graphing calculators during a Superintendent's
Conference Day. During that conference day I had one hour to demonstrate how to implement the graphing calculators into the State Mathematics Standards. There were twenty mathematics and special education teachers, my department head, and the Director of Mathematics for the Rochester City School District at my presentation. To get participants engaged I started off the workshop by introducing the graphing calculator with a “Scavenger Hunt for the TI-83+” (see appendix A). This was the same activity that I started off the school year with that allows the students to just learn how to use the buttons on the graphing calculator. After briefly going over this packet, I moved on to how to enter statistical information into their calculators, construct a box and whisker plot, and perform calculations such as mean, median, quartiles from statistical information. I chose this topic because this was the area that was being studied in the Math I classes at the time.

Some teachers said how they were having a hard time getting their students to factor a quadratic equation. I demonstrated how the graphing calculator could be used to aid in this topic. We talked about why we factor and what roots of the equation are.

I felt this presentation was a good motivator to help the other teachers see how they could use the graphing calculator into their classroom. I thought some of the presentation was too much information in too short of a time, and this might have caused some of the teachers not to understand how to do all of the different features that I showed them. I think some of the teachers still do not feel comfortable implementing the graphing calculators into their classes.

Since the workshop, I've had a couple teachers come to me asking how they could do more with the graphing calculator. This has sparked an interest in me to become
a teacher-leader for East High for use of graphing calculators. This paper will help answer the question, "How can I assist my colleagues to become more knowledgeable and comfortable using the graphing calculator?" My expectations for this project will have two areas of consideration. First, I will develop my own capacity as a teacher-leader for other mathematics teachers in the area of graphing calculators. To do this I need to develop my knowledge and practice of the graphing calculator so that in turn I can present how to use them to colleagues. Secondly, as a result of the leadership I provide the mathematics teachers at East High School will feel more comfortable using graphing calculators, and will use graphing calculators more frequently in their classrooms.
Literature Review

Educational systems are reforming mathematics education by trying to incorporate more student-centered learning, focusing on mathematical concepts, using graphing calculators, and using state or NCTM standards as a guide. This reform is slow going. One reason why reform is slow going is that teachers have not been sufficiently prepared for the changes. School districts may have offered professional development for the change, but the professional development was not done properly.

The standards New York State has developed for the instruction of mathematics tie in the knowledge of how students learn and the use of technology into the classroom. With all of this knowledge, students should be excelling in mathematics. However, state assessments show otherwise. The missing piece to the puzzle of students’ understanding of mathematics is in part because of the teaching. Teachers are worried about covering content, rather than developing students’ understanding of the main concepts in mathematics. Graphing calculators can be used to help develop conceptual understanding, but teachers do not know how to use graphing calculators or they don’t know how to use them effectively. Teachers are not offered sufficient professional development.

Standards on Mathematics

New York State’s mathematics standards reflect the standards from NCTM. The mathematics standard from the New York State Department of Education (USONY, 1999) states that “students will understand mathematics and become mathematically confident by communicating and reasoning mathematically, by applying mathematics in real-world settings, and by solving problems through the integrated study of number systems, geometry, algebra, data analysis, probability, and trigonometry” (p. 3). This
statement represents a change from the past teachings of mathematics in that students will
apply mathematics in real-world settings. Before, students were expected to memorize
how to solve mathematical problems in a static form and were never required to apply the
mathematics in a real-world setting. Back then, educators assumed that students would be
able to use their knowledge and apply it if and when it ever came up in their jobs or lives.

New York State Department of Education has developed seven key ideas, which
are the main concepts that mathematics educators should emphasize. The first key idea is
mathematical reasoning. According to the SED (1999), “students use mathematical
reasoning to analyze mathematical situations, make conjectures, gather evidence, and
construct argument” (p. 3). This means a student must be able to use information to
make an analysis to help them solve problems, which is an integral part if students are
applying their knowledge to real-world examples. Students could use graphing
calculators to help determine which set of factors would be the solution to a quadratic
equation by graphing, or students could enter statistical data and test and graph the results
and find a regression line to extrapolate the information.

The second key idea is number and numeration. According to SED (1999)
“students use number sense and numeration to develop an understanding of the multiple
uses of numbers in the real world, the use of numbers to communicate mathematically,
and the use of numbers in the development of mathematical ideas” (p. 3). There are some
students who just think with numbers, and could look through the graphing calculator
generated table of values to determine the solution.

The third key idea is operations. According to SED (1999), “students use
mathematical operations and relationships among them to understand mathematics” (p.
There is an expectation that students must still know their basic arithmetic procedures of multiplication, division, addition, and subtraction. The students must also know the properties and systems of numbers and have an understanding of how the properties of numbers can be applied to help solve problems. Graphing calculators can be used to help develop the concept of systems of numbers. The student can use test logic features to help determine how to multiply and divide numbers and variables with exponents. The student can evaluate for variables to see what the relationship is.

The fourth key idea is modeling/multiple representation. According to SED (1999), "students use mathematical modeling/multiple representation to provide a means of presenting, interpreting, communicating, and connecting mathematical information and relationships" (p. 4). Modeling is a concept that allows students to interpret their mathematical understanding, and represent that information in various ways. Whereas, before, students were expected to graph a function, now, students are given a graph and expected to interpret the meaning of the data. Students using calculator based laboratories (CBL's) and calculator based rangers (CBR's) in their mathematics classes would be able to produce graphs from real data that they provide, and will be able to interpret their graphs from the lab. These labs would build students' interpretation skills of reading graphs they might see in the future.

The fifth key idea is measurement. According to SED (1999), "students use measurement in both metric and English measure to provide a major link between the abstractions of mathematics and the real world in order to describe and compare objects and data" (p. 4). Measurement is a concept that allows people to communicate information to other people, ties mathematics to other subjects such as science and social
studies, and involves the physical act of measuring and applying formulas to solve area, volume, surface area, etc. Students could measure the areas and circumferences of different sized circles and place their results into a statistical plot on a graphing calculator. Students could then make conjectures about the area and circumference of another sized circle that they did not measure. Students could also use the solver feature on a graphing calculator to analyze formulas for a variable.

The sixth key idea is uncertainty. According to SED (1999), “students use ideas of uncertainty to illustrate that mathematics involves more than exactness when dealing with everyday situations” (p. 4). The concept of uncertainty in mathematics forces students to estimate in real-world situations when an exact number is not necessarily available or the best-fit solution. Students may get a problem where they are given two constraints and are trying to find the point at which their solution would be maximized. Students could use a graphing calculator to calculate the intersection of the functions, and if the intersection is not an integer, the students would have to figure out what would make the most sense in the context in which they were given.

The seventh key idea is patterns/functions. According to SED (1999), “students use patterns and functions to develop mathematical power, appreciate the true beauty of mathematics, and construct generalizations that describe patterns simply and efficiently” (p. 4). Mathematics is sometimes thought of as the science of patterns. Graphing calculators can help students interpret patterns in either graphical or tabular forms. Students would be able to analyze data and hypothesize how the results would be in different contexts.
**Standards on Technology in Math**

The National Council of Teachers of Mathematics (NCTM) has published their standards and principles for mathematics education. NCTM is an organization of mathematics educators whose goal is improving the teaching of mathematics. One of the Principles that the NCTM (2000) has stated is “that technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students’ learning” (p. 11). NCTM feels technology is so important in today’s education that they have implemented it as one of the main “Principles for School Mathematics.” The most practical way of enhancing mathematics education with technology is with graphing calculators. For the price of one computer a school could buy ten graphing calculators, which would allow that many more students access to technology.

The New York State standards, which were modeled from the NCTM standards, also have a distinct link with a standard for math, science, and technology. The State standard for math even has a specific role for technology. According to SED (1999), “Appropriate grade-level calculators should be made available to students in the classroom. They may be used to assist students in their understanding of concepts and procedures. The use of calculators should not be a substitute for a student’s understanding of quantitative concepts and relationships or proficiency in basic computations. Research has shown that the appropriate use of calculators in the classroom does not interfere with student knowledge of “number facts” or with their ability to perform calculations. The classroom use of calculators has been shown to contribute to improved student attitudes toward mathematics and their problem-solving ability” (p. 8).
The SED believes that the use of technology will improve students' mathematical knowledge and problem solving skills if that technology is used effectively. The technology that the SED is referring to is calculators. According to SED (1999), "scientific and graphing calculators are appropriate for secondary mathematics students" (p. 8). However, to effectively use the technology in the classroom, teachers need to be given professional development.

**Mathematical Pedagogy**

The way that teachers actually teach mathematics is changing. Teachers are moving from teaching a rule for students to memorize and students working on a page of problems that were all solved using the same algorithm. They would then go on to the next topic and a new algorithm. Now, teachers are moving towards posing problems to their students, who work to figure out how to solve them. The teachers link their students' knowledge to the concept that they are studying. Now, students develop the same rules that were taught in the past, but they understand how the rule was developed. "Rules learned without understanding interfere with students' abilities to see mathematical relationships" (Behrend, 2001, p. 39). Students need to be able to make the relationships and connections in mathematics.

The standards developed by NYSED and NCTM suggest strategies to improve mathematics education. According to the SED (1999), "meaningful curriculum and assessment take into consideration three categories of cognitive functioning. These categories are procedural knowledge, conceptual understanding, and problem solving" (p. 5). In the older methods of mathematics, teachers focused on procedural knowledge and conceptual understanding. Today, problem solving is the main concept of mathematics.
teaching and the strand that ties procedural knowledge to conceptual understanding.

According to West (1995),

"The standards argue that most math teaching places too much emphasis on rote memorization and includes too many exercises divorced from real-world applications of math. Instead, the curriculum should include: an emphasis on math as a problem-solving activity with broader applications for the world outside the classroom; the idea of math as a means of communicating information and ideas, in equations or in prose; an emphasis on reasoning to find the appropriate solution to a problem, rather than depending on teachers to provide answers; and making explicit the 'mathematical connections' between apparently unrelated subjects" (p. 2).

The role of a mathematics educator needs to change. Today's math teachers need to teach students how math can be used to communicate information, how to solve problems, and how topics are connected together under the main concepts.

As teachers move away from students memorizing algorithms and rules to problem solving, the education of mathematics becomes more meaningful to students as they discover the rules through their own experiences. According to SED (1999), "students developing their own meanings of mathematical concepts and procedures when given the opportunity to become actively involved in learning" (p. 6). Students actively involved in learning and developing their own meanings of mathematical concepts and procedures allows students to learn at their own pace, and to understand the content more deeply and in more meaningful ways.
Building knowledge and meaning from previous knowledge is the main concept of constructivist education. According to Lopez (2001), “constructivism is based on the premise that knowledge cannot be ‘given’ to anyone; rather it is something that people must construct for themselves” (p. 117). This concept of building knowledge from previous knowledge is what NCTM envisions in mathematics teaching. According to Pugalee (2001), “the teaching and learning methods recommended by the NCTM are grounded in the central tenets of constructivist philosophy. First, the student actively constructs knowledge. Second, a person acquires knowledge through an adaptive process derived from experience” (p. 172). Constructivism allows students to be able to make their own connections, and build from their present knowledge base.

David Pugalee (2001) conducted a study on the role of technology and constructivism in an algebra course for at-risk students. His strategy was to use the graphing calculator as a tool to make connections from a concrete level to the abstract level of thinking. Pugalee (2001) designed this exploratory study (a) to substantiate the usefulness of a constructivist approach in teaching algebraic concepts to students who are typically left out of the mainstream mathematics education reform and (b) to substantiate the usefulness of the technology in this process.

He started the exercise by having his students graph two equations onto the calculator. The students described that the graphs had intersected; some calling it the point of intersection, and a few that could identify the coordinates of the point of intersection. He then had the students examine the equations when they were written in terms of $y =$. Through his questioning and students’ observations, the students were able to understand how the role of the $y$-intercept affects the graph. Then, the class discussed
the slope of the line. The students developed the formula for the slope of the line from what they knew about slope and from the graph on their calculators. Most teachers would just have given the students the rule to find the slope, and the students would have to memorize the formula and know how to apply it. According to Pugalee (2001),

"Two primary themes emerged from the data analysis: (a) the importance of technology and (b) the role of discourse in mathematics teaching and learning. The data showed that the instructional activities implemented for the unit enabled the students to generate their own conceptualizations of mathematics from the information made available via graphics calculators and from the discourse among students and between the students and the teacher. Such findings are consistent with the constructivist practices that the teacher sought to implement" (p. 173).

The graphing calculator can be a great tool to aid in this type of education. Students already have some knowledge of the mathematical concept. The students might not know the vocabulary to articulate the knowledge, but this can be brought out from the discourse that goes along with the activity. Pugalee was able to build his students' knowledge of slope from being the steepness of a line to developing the formula for slope from the use of graphing calculators.

The visualization of graphing calculators helps students to create their own knowledge. According to Lopez (2001), "it is a reasonable assertion that all students learn certain concepts better by thinking visually about them, that is, by constructing mental images of concepts" (p. 117). The graphing calculator provides a concrete imagery to help students construct these mental images.
Multiple representations are another way that benefits student understanding. According to SED (1999), "instruction that employs a wide range of representations and contextual environments enhance student growth in both affective and cognitive dimensions" (p. 7). Students need to be able to verbalize or write their ideas. They need to be able to interpret a graph with equations or tables of value.

Graphing calculators help present problems in multiple representations. Many researchers in the past made a point to say that the best way to teach is by multiple representations. According to Beckmann, Thompson, and Senk (1999), "graphing calculators allow the investigation of functions through tables, graphs, and symbolic representations" (p. 451). The graphing calculator makes it more feasible to investigate functions through tables, graphs, and symbolic representations by being able to produce and switch back and forth easily from the equation to the graph to the table of values. Being able to show a function in these three different forms helps students with different learning styles to learn and understand the math. Some students might be visual learners, and will be able to solve the problems from looking at the graph and using a trace feature to find certain points. Other students might be numerically minded learners and will be able to solve the problems easier by using a calculator-generated table of values for the solutions, or be good at determining the best window range to view the graph in. The algebraic thinker can solve the equations and/or figure out similarities and differences just from looking at the equations or using the solver feature.

Multiple representation can also help aid in students' abilities to model graphs and functions with the real world and physical concepts. According to Lapp and Cyrus (2000),
"Microcomputer-Based Laboratory (MBL), Calculator-Based Laboratory (CBL), and Calculator-Based Ranger (CBR) are devices that collect data with various probes and then store the data into a computer or calculator. The data can be analyzed and displayed in different formats, and the student can graph as data are collected or at a later time" (p. 505).

Through these Calculator-Based Laboratories, students can create graphs involving heat, voltage, and distance all against time. These labs help link students’ knowledge to real-world situations. According to McDermott, Rosenquist, and van Zee (1987), “to connect graphs with physical concepts, students need to see a variety of graphs representing different physical events” (p. 503).

**Standards on Professional Development**

In order to serve students effectively, there needs to be equity of technology and knowledge of how to use that technology among teachers, schools, districts, and states. For the technology to be used well in classrooms, all teachers must be able to use the technology themselves. According to NCTM (2000),

“‘To make technology an essential part of classrooms, the technological tools must be selected and used in ways that are compatible with the instructional goals. When technological tools are considered essential instructional materials for all students, then decisions about resources must reflect this view, despite the costs of purchases and upgrades. Schools, districts, or provinces that integrate technology in mathematics teaching and learning face challenging issues of equity. The need for high-quality technology is as great in urban and rural settings as in suburban schools—perhaps greater’” (p. 372-3).
If a school’s goal is to use graphing calculators in all mathematics classrooms, then there needs to be some professional development for their teachers to learn how to effectively use them. According to NCTM (2000),

“Mathematics teachers must develop and maintain the mathematical and pedagogical knowledge they need to teach their students well. One way to do that is to collaborate with their colleagues and to create their own learning opportunities where none exist. They should also seek out high-quality professional development opportunities that fit their learning needs” (p. 373).

The NCTM suggests schools to have a “teacher-leader”. According to NCTM (2000), “there is an urgent and growing need for mathematics teacher-leaders—specialists positioned between classroom teachers and administrators who can assist with the improvement of mathematics education” (p. 375). The role of a teacher-leader can vary depending on the needs of the school or district. According to the NCTM (2001),

“Teacher-leaders can have a significant influence by assisting teachers in building their mathematical and pedagogical knowledge. Teacher-leaders in some settings work with their colleagues to design professional development plans for individual teachers, for a school, or for a larger system. Teacher-leaders’ support on a day-to-day basis—ranging from conversations in the hall to in-classroom coaching to regular grade-level and department seminars focused on how students learn mathematics—can be crucial to a teacher’s work life” (p. 375).

The role of a teacher-leader could be a small part that a teacher takes on himself or herself, or it could be a whole new job. A teacher may see that there needs to be a change in their department. This teacher can start researching on his or her own to try to find a
new idea to help implement into their own teaching. After reflecting on the new idea, the
teacher may want to share with his or her colleagues. This teacher could just have
informal conversations with the other teachers in their department or he or she could offer
professional development for the department at assigned times. This teacher would
become a teacher-leader. Some schools may see that a teacher-leader is an important
addition to a department to help keep pedagogy current. The school may release the
teacher-leader from some of their classroom duties to spend more time doing research
and helping other teachers in their department. The teacher-leader role is to fit the needs
of the school or other system that they are working in. The most important facet,
according to NCTM (2000) is, “...like all teachers, mathematics teacher-leaders must
themselves engage in ongoing learning and professional development” (p. 376). Teachers
must also learn themselves in the way that their students will learn. According to the
National Research Council (NRC, 1996), “national professional development program
standards for both science and mathematics recommend that teachers increase their
content knowledge in the same inquiry and cooperative learning environment that the
standards recommend for their students” (p. 59).

**Professional Development**

According to Speck and Knipe (2001) successful professional development has
six elements. The professional development focuses on improving student learning,
assesses need and establishes goals, centers on the learner, sustains growth, requires
resources, and evaluates goals. Effective professional development should have all of
these elements throughout the planning and implementing phases.
The focus of professional development should always be that the educators have improved their students’ learning. According to Loucks-Horsley, Hewson, Love, and Stiles (1998), “effective professional development experiences are driven by a well-defined image of effective classroom learning and teaching” (p. 36). The image can be any aspect of what is going on in the classroom. Examples would be using the inquiry method or graphing calculator. According to Speck and Knipe (2001), “professional development work focused on how it will improve student learning will prevent a disconnect from occurring between the purpose of the professional development and the process” (p. 8). Teachers will be more apt to participate in the professional development if they know that the goal is to improve student learning and they know how they are going to try to change to increase their students’ understanding.

In order to establish the goal of the professional development, there needs to be a reason for the professional development. The need for professional development, according to Speck (2001), “can emerge from teachers’ expressed need, uses data to inform practice and make decisions, aligns plans systematically with school and district change efforts and goals, and bases professional development on a foundation of standards and accountability” (p. 10). Sometimes as changes are being implemented into classrooms, teachers might feel less prepared, and need to have professional development. According to Speck (2001), “because accountability for student learning is the focus, designers of professional development should use data about student achievement and needs as well as information on teachers’ abilities and needs to inform the design” (p. 10). The school or district wants to have goals that are tied to the standards or the school’s goals so that the professional development can be evaluated to
show if it really helped the students to learn. Professional development plans need to derive from data about the students’ achievement at the school. According to Speck (2001), “if the professional development is valuable, then it should be demonstrated through achievement of clear outcomes. Participants must know what has been accomplished and what must be done” (p. 11). This information will come from the evaluation of the goals of the professional development.

There should be two sets of goals for professional development: goals for the teachers and goals for the students. According to Loucks-Horsley (1998), “goals for teachers flow directly out of goals for students. If students are going to develop a set of understandings, skills, and predispositions, then what do teachers need to know and be able to do to realize those outcomes for the students” (p. 22). This is important if we are planning to keep student achievement as the goal for professional development.

Good professional development reflects the cognitive abilities of the participants and understands how the participants should implement what they learn. According to Loucks-Horsley (1998), “teachers benefit from experiences as students that are based on the same principles as the ones they are expected to implement with students” (p. 50). Teachers that go through a professional development that makes the teacher experience exactly what their students will experience in their classroom, will help the teacher to understand what their students will know and anticipate potential problems. However, teachers must still be challenged through the professional development and not learn the exact content that they will teach their students. According to Loucks-Horsley (1998), “teachers must be challenged at their own level of competence” (p. 50). By engaging in activities at a level appropriate for adults, the teachers will be able to investigate their
own content. Professional development must employ effective teaching and learning strategies. According to Speck (2001), “understanding the current developmental level of the participants allows a planner to challenge individuals to improve based on their current abilities within a focused area” (p. 12).

Professional development must be sustained if it is expected to affect student learning. Professional development cannot just be a one-time experience and then teachers are all set to implement. According to Speck (2001), “if teachers are condemned to onetime or fragmented workshops with little or no modeling, follow-up, coaching, analysis of problems, and adjustment of practice, there will be little change” (p. 15). Teachers are like most human beings and resist change. They need to have guidance, an opportunity to discuss and share their thoughts, and the safety of taking the risk. According to Loucks-Horsley (1998), “effective professional development experiences build a learning community—for example, continuous learning is part of the school culture, teachers are rewarded and encouraged to take risks and learn, and teachers learn and share together” (p. 37).

Professional development requires administrative support, leadership, and available resources. According to Speck (2001), “administrative support is a key element in successful professional development planning and implementation” (p. 16). Administration support of professional development work sends a message that professional development should be taken seriously and helps build a learning culture to the school. The principal can use resources, such as time or money, to help build the professional development. The administration should try to arrange a schedule so that all of the teachers in a department have some common time that they can use for
professional development. Administration can also try to allocate funds to pay the teachers for after school professional development or to bring outside expertise to help add fresh ideas to the department. According to Speck (2001), “outside expertise brings new knowledge and practices to the school setting” (p. 15). Outside expertise would be professional development from someone who is not a teacher in the department or school, whereas, inside expertise would be professional development from a teacher, teacher-leader, or administrator already in the particular system. Although using inside expertise is good to promote sharing of ideas amongst teachers and to help implement the new strategies, outside experts help bring in some new ideas to all and truly form a learning culture.

Last January, President Bush signed into law the No Child Left Behind Act (NCLB). This act puts pressure on the local and state governments on how to dispense the federal aid for education. According to Bailey (2002), “the $700 million state-administered technology grant, Enhancing Education Through Technology, provides opportunity for leaders to align the federal funds with their own priorities and initiatives” (p. 4). A key aspect in getting some of this money is to use it for professional development needs to train staff on current technology. According to Bailey (2002), “The Enhancing Education through Technology program also requires that applicants spend at least 25 percent of their technology funds on professional development. These programs help build the capacity of school leaders as they direct technology, reading, math, and accountability strategies” (p. 4).

The No Child Left Behind Act places more emphasis on teacher quality, which requires more professional development so that teachers are up to date on the current teaching
practices that will increase student achievement. The law increases the pressure on states to have "highly qualified" individuals in each subject they teach. According to Olson (2002),

"It defines 'highly qualified' educators as those who are fully certified through traditional or alternative routes and have demonstrated competency in the subjects they teach, either by having an academic major or its equivalent, or by passing a subject-matter test" (p. 27).

The law also requires professional development for teachers who are currently obtaining certification through an alternate route program. According to Olson (2002), "the final rules specify that teachers enrolled in alternative-route programs must receive high quality professional development both before and while they are teaching..." (p. 27).

Good professional development, like good teaching, must be evaluated to see if the goals were met. According to Speck (2001), "the evaluation process must analyze whether teachers improved in their practice and whether the changed practice affected student learning" (p. 17). This process of evaluating is not a one-shot deal at the end though. Assessment must be continuous. According to Loucks-Horsley (1998), "effective professional development experiences are continuously assessing themselves and making improvements to ensure positive impact on teacher effectiveness, student learning, leadership, and the school community" (p. 37). Effective professional development, like effective teaching, requires time for reflection, and if needed, revision. It is also important to evaluate the goals at the right time. According to Loucks-Horsley (1998), "it can take several years for teachers to become routine in their use of a new practice or
program; therefore, expecting student achievement to change in a short period is unrealistic” (p. 40).

Conclusion

Through the development of state and national standards mathematics education has started to change. With the knowledge of how children learn and through the changing technology, mathematics education is becoming more concept-based and student-centered. According to Anderson (2002), “teachers are relying on technology more than ever, but, as an increasing number of studies show, not necessarily more effectively” (p. 34). Teachers need to have the on-going professional development so that they may use this technology to its potential. This will lead to a learning culture in the school.

The professional development plan has to be implemented right. Schools need to set the goals for the professional development, plan, implement, and reflect. As they are planning, they must keep in mind the critical issues like the standards, strategies to teach adults and children, the knowledge that is to be learned and the context in which it should be learned. Reflection should be on going and changes in the plan made to accommodate the group.

Graphing calculators are great tools, but if the staff does not feel comfortable using them, they will not teach their students using them. In order to reform education, teachers must be properly trained. A teacher-leader role, therefore, from the school would be the best solution for their professional development needs.
Methodology

Setting
This study will be conducted at East High School in the Rochester City School District. East High School is an urban high school with 2400 students. East High School is on the New York State list of schools that are failing in mathematics. This means that there is a majority of students not passing the Math A exam by their junior year, and that the percentage of students meeting those requirements has not improved.

Participants
I will be providing graphing calculator workshops to the East High School Mathematics Department. This department consists of 15 teachers. Nine of the participants are male, and 6 are female. Three of the participants are African-American, two are Hispanic, and ten are Caucasian. Two of the participants have changed careers from the business sector to teaching. All of the participants attended a one-hour workshop that I provided in the beginning of the year. By participating in these workshops the teachers will be following the recommendations from the department head and principal to make an effort to show a change in their teaching methods, and subsequently the achievement of the students.

Goals
This project has two parts. The first part is to meet the goals of the East High School Math Department. From an interview (see appendix B) with the East High School Mathematics Department Head, Letresha Fuller, I learned that the goals of the East High School Mathematics Department "this year is to try to get as many students to pass the Math A exam as possible." Ms. Fuller said, "One way to help more students pass the Math A exam, is to have the math department use graphing calculators in their classes. This will hopefully inspire students to buy a graphing calculator to use on the Math A exam." This project ties along with the goals of East High School.

The second part of this project is to develop myself as an effective professional developer. This project will let me practice the professional development skills that I have learned from research. Ms. Fuller said, "I feel that an effective professional development meets the needs of the participants, and has the participants leaving with something that they can use in their classrooms."

Long-term Department Goals
1) To raise student achievement in math at East High School.
2) To have teachers using graphing calculators on a regular basis in their lessons.

Goals from the project
1) To make teachers feel more knowledgeable on the use of graphing calculators.
2) To make teachers feel more confident using the graphing calculator.
3) To have teachers develop and implement a lesson plan using graphing calculators.
4) To demonstrate how a graphing calculator could be used while taking the New York State Regents Math A Exam.
5) To develop my skills to become an effective professional developer on the use of graphing calculators.
Procedure

I begin by giving all participants a preliminary survey (see appendix C). I will gather information to see how many of the participants have used graphing calculators in their classrooms, and how often they have used graphing calculators since the first workshop in September. The survey will be questions regarding teacher confidence and knowledge of use of graphing calculators in the classroom. This will be my guide to see if my workshops have increased the use of graphing calculators. I will also give out a graphing calculator matrix for the participants to fill out before the workshops start, and then again to mark in a different color after the workshops (see appendix D).

There will be a series of five graphing calculator workshops. Each session will be one hour in length. Each session will concentrate on a certain concept of mathematics with certain features of the graphing calculator. The units of study will be coinciding with the Rochester City School District’s curriculum guide for Math I and Math II. The workshop will allow participants to see how the graphing calculators can fit in to their curriculum and lessons.

From the knowledge that I learned about effective professional development is that the workshops need to be relevant to the teachers that are participating in it. This will prove to be helpful in gaining the teachers’ comfort level with the graphing calculator, so that they will implement the graphing calculator into their lessons.

Apparatus

Every teacher participating in the workshop will be using a TI-83+ graphing calculator that the school will provide. I will use a TI-83+ graphing calculator along with the TI-Viewscreen. The TI-Viewscreen will be used in conjunction with an overhead machine to allow participants to look at my calculator screen as I work and type on it. This way teachers will see what I type onto my graphing calculator. This is also modeling good teaching strategies that the teachers will in turn use in their own classrooms. Modeling effective teaching is another aspect of effective professional development.

The following is the tentative itinerary for the series of workshops.

Feb. 6, 2003

The purpose of today’s workshop is to demonstrate to the mathematics teachers at East High School how to solve problems using the graphing features on the TI-83+ graphing calculator. Participants will be able to graph an equation, use the trace feature, calculate the intersection of graphs, calculate the maximum/minimum of a quadratic equation, adjust the window, change the look of the graph, and understand the “friendly-window”.

Starting off the series of workshops, participants will discover how the concept of graphing can be applied throughout various “topics” in the Math I curriculum. I will pose the following problem to the teachers and let them have a little time to try to figure out how they would use the calculator to solve the problem.

‘A cable company offers a pay-per-view club. To join the club you must pay an annual fee of $24 and then you will only pay $4 for each movie you order. If you are not a member of the pay-per-view club then you must pay $5.50 per movie that you order. Determine how many movies you must order so that you can justify joining the club.’

I will circulate to observe the methods that the teachers use. This day we will practice graphing equations, using the trace feature, making sure the calculator is in a “friendly-
window”, and using the calculations feature and have the calculator calculate the intersection of the two graphs. Then I will ask them how they can use their knowledge of graphing to solve the following problems:

1. \[3x + 4 = x + 18\]
2. \[5x + 3y = 1.5 / -8x - 2y = 20\]
3. \[y = x^2 - 6x + 9 / y = 2x + 3\]

Participants will fill out an evaluation about the workshop (see appendix E).

**Feb. 13, 2003**

The goal of today’s workshop is for the participants to learn how to use the TI-83+ graphing calculators to solve problems using a table of values. Participants will be able to develop a table of values from the graphing calculator, solve a system of equations from looking through the table of value, find the maximum/minimum value of a quadratic equation, and change the settings for the table of value.

I start off this week’s session with a problem, and we will see how the participants solve the problem. After discussing the problem, I will ask if anyone has anything they would like to share with the group about their experiences during the week. The concept of this week’s presentation will be “Tables of Values”. Participants will discover how the table of value might be a better way to solve problems, instead of graphing. Discussion will ensue on when it is better to graph and when to use a table of values. Participants will fill out an evaluation about the workshop (see appendix F).

**Feb. 27, 2003**

The goal of today’s workshop is for the participants to use the TI-83+ graphing calculator to solve equations and formulas using Solver. Participants will be able to solve equations and systems of equations using Solver, type any formula that they need to solve, as long as they only need to solve for one variable, into Solver.

I start off this week’s session with a problem, and we will see how the participants solve the problem. After discussion of the problem, I will ask if anyone has anything they would like to share with the group about their experiences from the past week. The concept of today’s workshop will be solving equations. This is similar to the two previous weeks’ workshops except this time the focus will be on how to use the calculator’s “Solver” feature. I give the participants the formula for calculating simple interest. We type the formula “\(O = PRT-I\)” into Solver and we answer problems. A discussion will be held to talk about the similarities and differences of the three styles, and when each might be more practical to use. Participants will fill out an evaluation about the workshop (see appendix G).

**March 6, 2003**

The goal of today’s workshop is for participants to become comfortable with the other menus and features on the TI-83+ graphing calculator. Participants will be able to store a given value for a variable and evaluate mathematical expressions.

I start off with a given problem to see how the different participants will solve the problem. We discuss how they solved the problem. I will ask if anyone has anything that they would like to share with the group about their experiences from the past week. This
week, I will show participants how they might be able to use the graphing calculator to evaluate equations. Time will be allotted for teachers to work together or by themselves to develop a lesson plan that they will implement in the coming week using the graphing calculators. Sample problems from today’s lesson are: Evaluate $x^2 + 3y$ when $x = -3$ and $y = 4$. I will show participants how they can store a value into the calculator for the different variables, and then have them type in the expression on the calculators and hit enter to find the answer.

**March 13, 2003**

The goal for today’s workshop is for participants to practice the strategies that they have learned on The TI-83+ graphing calculator and apply it to problems from the January 2003 Mathematics A Regents Exam.

Participants will share their experiences from the graphing calculator lesson that they implemented. Participants will make notes of their reactions, the students’ reactions and the lesson in general. Then, I will show them how the graphing calculator uses binary operations, also known as Boolean Logic, to solve multiple-choice questions. Then we will go through the New York State Math A Exam from January 27, 2003, and we will see how many questions could be done using the graphing calculator. We will also see how many ways we could use the graphing calculator on each problem. Participants will fill out an evaluation of the professional development series (see appendix H).

**Analysis**

I will give participants a survey before the workshops begin to see how many teachers use graphing calculators in their classrooms. I will conduct another survey at the end of each workshop to see if there was any change to the amount of class time that teachers are using graphing calculators. I will also have the teachers record in a journal how they feel while using the graphing calculators in their classrooms. This will allow me to analyze if the teachers are feeling more comfortable using the graphing calculators and if they also feel more knowledgeable on the graphing calculators. I will also keep a journal of my reflections and of field notes of how the teachers react during the workshops, as well as how I use the graphing calculators in my own classroom. From this analysis I hope to find that more of the East High School math teachers are using graphing calculators in their classes, and that the graphing calculators are used more often. This study may hopefully provide my school with some data to try to buy even more graphing calculators to be used in the classrooms, as well as more professional development. This will be a small stepping stone, to start changing the environment of the East High Math Department to a learning culture that will help raise student achievement.
Results and Analysis

I gave a questionnaire to all of the mathematics and special education teachers at East High School to conduct a preliminary basis of how comfortable and knowledgeable the teachers at East High School were with the use of graphing calculators (see appendix). Of the twenty questionnaires that I sent out, seven were returned to me. From these seven questionnaires I was able to determine that the average teacher in the East High School Mathematics Department has only been working 0-10 years. I assigned each option with a numerical value: 0-3 years worth 1, 4-10 years worth 2, and 11+ years worth 3, by doing this I calculated the average to be 1.57. This would be between the 0-3 range and the 4-10 year range. I also found out that 6 of the teachers have a provisional teaching certification and 1 teacher from those that replied has permanent teaching certification. I calculated how often the average math teacher at East High School uses graphing calculators into their lessons. I again assigned a numerical value with each option that the participants could have used: If they did not use graphing calculators at all I assigned a 0, 1-2 times a year worth 1, 1-2 times a month worth 2, and 1-2 times a week worth 3. The average use from these surveys was 1.7, so that suggests that the teachers incorporate graphing calculators into their lessons about 1-2 times per month.

The two most important parts from this questionnaire in regards to this study were asking the participants to rate on a scale from 1-5 how comfortable and knowledgeable they feel they are on the use of graphing calculators. With 1 being the least comfortable or knowledgeable and 5 being the most comfortable and knowledgeable I calculated that the average for these seven teachers 2.7 for how comfortable they feel using the graphing calculators in their classrooms. I also calculated an average of 2.4 for how knowledgeable
the 7 teachers feel that they are on the use of graphing calculators. These results suggest that my original hypothesis, teachers do not feel comfortable or knowledgeable enough to effectively implement graphing calculators into their lessons, is correct.

After each professional development session that I offered to the East High School teachers, the participants completed an evaluation (see appendix). These evaluations were designed to assess the participants’ knowledge as well as my skills as a presenter. The first three statements were the same on all of the evaluations. Statement 1) The professional development today provided an opportunity to build my knowledge and skills. Statement 2) The presenter used or modeled strategies that I will use with my students. Statement 3) The workshop allowed for time to collaborate with other teachers.

The averages for these statements for each date were as follows in the table:

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<tr>
<td>3</td>
<td>4.4</td>
<td>4.8</td>
<td>4.3</td>
<td>4.9</td>
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</table>

On Feb. 6, 2003 the first workshop was presented. Five of the twenty teachers that were invited participated in the workshop. For the statement “You know how to graph a function” the average of the five participants was 4.8. For the statement “You know how to use the ‘trace’ feature” the average was 5. The average for the statement “You know how to change the window settings” was 4.2. For the statement “You can solve problems requiring you to find the intersection of functions” was 4.4. The statement “You can solve roots of functions” earned an average of 3.6. For the statement “You can solve for
the maximum/minimum values of a quadratic function” the average was 4. For the statement “You feel more comfortable using graphing calculators” the average was 4.8.

On Feb. 13, 2003 the workshop was focusing on how to use tables of values to solve problems. Seven of the twenty teachers participated in this workshop. For the statement “I know how to change the table settings” the average was 4. For the statement “I can solve problems requiring me to find the intersection of functions” the average was 4.8. The average for the statement “I can solve for the roots of functions” was 4.5. The average was also 4.5 for the statement “I can solve for the maximum/minimum values of a quadratic function.” For the statement “I feel more comfortable using graphing calculators” the average was 4.8.

On Feb. 27, 2003 the workshop was focusing on how to use “Solver” to solve problems. Seven of the twenty teachers participated in this workshop. For the statement “I know how to use Solver” the average was 4.3. For the statement “I can solve problems requiring me to find the intersection of functions” the average was 4.4. The average for the statement “I can solve for the roots of functions” was 4.7. The average was 4.6 for the statement “I can type any formula I need to into the Solver.” For the statement “I feel more comfortable using graphing calculators” the average was 4.9.

On March 13, 2003 the focus of the workshop was how to apply the graphing calculator to the January 2003 Math A Regents Exam. Seven of the twenty teachers participated in this last session. For the statement “I know how to store numbers into variables on the TI-83+” the average was 4.3. The average for the statement “I know how to use the Logic Tests for multiple choice questions” was 4.1. For the statement “I know more strategies on how to use a graphing calculator on the Regents Mathematics A
exam” the average was 5. The average for the statement “I feel more comfortable using graphing calculators” was 4.7.
Discussion

From the preliminary questionnaire of my study the results showed that the average math teacher at East High School was 2.7 and 2.4 out of 5 for how comfortable and how knowledgeable, respectively, the teachers felt using graphing calculators. These results correlated with my hypothesis that the teachers were not incorporating graphing calculators into their lessons because of their confidence with their own use of the graphing calculators. One of the goals of the East High School Mathematics Department for the year was to increase the percentage of students passing the Regents’ Math A exam. As a result of the state allowing the use of graphing calculators on the Math A exam my department head deemed it important that the students learn how to use graphing calculators so they will have another tool to help them achieve higher scores on the Math A exam.

Initial discussions with the other math teachers at East High School seemed to show that most of the teachers were in agreement that we need to use graphing calculators more and that we needed to have more professional development. This project was part of the strategy to provide the professional development for the East High School math teachers. It was a little disheartening when only about 7 out of the 20 teachers attended these workshops after school. The response, however, from these individual teachers was exciting. All of the teachers that participated in the workshops feel more confident and have been using graphing calculators in their lessons more often. These teachers would come up to me excited to share how they used what they learned from my workshops and how the students were excited to learn new strategies to solve problems. Some students were saying how they need to go and buy a graphing calculator.
In the beginning of the study participants were asked to fill out a matrix on how they feel about graphing calculators. Participants were told that they would mark the matrix with a different colored pen or pencil at the end of the sessions to see their growth. Overall, the results seemed to have shown an increase by at least 1 box in the matrix for each skill (see appendix D).

Another strategy to help the East High School math teachers learn how to use graphing calculators in their classrooms was by having Texas Instruments come in to provide professional development. The department head, Letresha Fuller, received a grant to be used for professional development, and decided to hire Texas Instruments to come in for 5 days of professional development. The dates were for the Superintendent’s Conference Day on March 14, Saturday March 15, the Superintendent’s Conference Day on May 16 (which has to be rescheduled due to snow days), Saturday May 17, and June 30. The Superintendent’s Conference Days are required for all teachers to attend. Some of the teachers were complaining about having to give up a couple of Saturdays to come in for professional development. The department head said that all of the workshops were required, and since she was requiring the teachers to come on a Saturday the teachers were paid for their time. There were still a few teachers that did not show up for the Saturday workshop. The teachers that attended my workshops, however, were enthused about these other workshops. All of the participants from my sessions were glad that they came to mine first, because they said that they felt more comfortable with just knowing where the buttons are, since the presenter from Texas Instruments went through his presentation very quickly. The T-I presenter demonstrated a lot of material in a brief period of time. This caused a little frustration from some of the teachers, and they were
asking why I wasn’t just doing graphing calculator workshops on the Superintendent’s Conference Days. However, the outside professional development was a needed spark for me. I was able to learn some more features on the graphing calculator that I didn’t know of before. From my research I have learned that part of an effective professional development plan is to bring in some outside experts as well as using the inside experts.

My Department head is encouraging me to continue my pursuit of professional development with graphing calculators. She wants to set up dates in between the T-I presentations, and throughout next year, to help remind the other teachers how to use the graphing calculators. From the research that I have done on professional development I learned that in order to be effective the professional development has to be ongoing and not just a one-day workshop.

The Director of Mathematics for the Rochester City School District, Margaret Crawley, is impressed with the progress of the professional development that is taking place on graphing calculators at East High School. She has noticed that the mathematics teachers at East High School are more knowledgeable on graphing calculators and implement graphing calculators into their lessons more than the mathematics teachers at the other high schools. From this project there is a possibility to scale up my teacher-leader role of graphing calculators at East High School to offer graphing calculator workshops for the mathematics teacher of the entire Rochester City School District.

An area of future study that developed from this study is teacher motivation. Intrinsic motivation and an eagerness to learn new things is the main motivation from the 7 teachers that participated in this study. Money wasn’t enough of a motivation factor for the few teachers that didn’t even show up for the “required” Saturday workshop. Another
area of future study from this project will be how often and effective teachers use graphing calculators in their lessons in the future, and the impact on the knowledge and achievement of the students at East High School.
References


Appendix A
Interview with East High School Math Department Head

SC: How are the New York State Standards on Mathematics Education implemented at East High School?

DH: Well, each teacher is given the standards. They know the seven standards, and basically it’s not even the standards, but the 7 key ideals for the Math A so that curriculum is aligned to that, textbooks are aligned to that. So that’s pretty much how it’s done.

SC: How has the implementation of these standards changed the way that mathematics is being taught at East High School?

DH: Well, I don’t know if it’s truly changed how it’s taught, but that the alignment has changed since that we got written up. Because the standards are changing; the courses have to change. So what was normally taught for one course might not be taught in that course. Certain topics are really considered accelerated topics in Math B. Where normal tracked students typically get to that and now they are not. And truly technology has changed a implementation a lot. There is a need for graphing calculators.

SC: How have graphing calculators enhanced this change in mathematical pedagogy?

DH: Definitely another resource for teachers to work with. Also to give kids that “aha” moment in the classroom. Things that like permutations and combinations kids might not have to remember a formula. They have a hard time doing that, they can use the calculator now. It helps give them that extra edge. It has really been a tool to benefit and not hinder them like we used to think.

SC: What are the goals for the East High School Mathematics Department?

DH: Our number one goal is to get as many kids through the Math A exam as possible. Truly we want to see as many kids pass that Math A exam this year, so that is really our focus right now, but on top of that we just want to feel like we’re giving a solid math program.

SC: What are the professional development needs for the East High mathematics Department in order for this pedagogical change to occur?

DH: Number 1 is truly they need professional development on what is expected of them on that Math A exam. Really embracing that knowledge of this is what happens. So like teaching strategies, graphing calculator workshops is a major one. I think as math teachers we’re like that calculators are a crutch, and I think we’re coming to that age where we’re not seeing it as a crutch anymore, and more like a resource you know like you bring a pen and pencil to classroom you need to bring a graphing calculator as a tool for the classroom. They really need to buy in the change and be willing to change.
SC: From a Department Head’s point of view, what are the elements of an effective professional development program?

DH: One that addresses the needs of our students. What we think our students needs so that we can provide that professional development to the teachers. The needs of the teachers and what they feel they need professional development in and one that is truly giving them something new. Not something that is redundant, like over and over again. It needs to provide growth to a teacher. And it really needs to provide people really leaving with something that they can take back to their classrooms.
Opening Activity
TI-83 Plus Scavenger Hunt!

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<th>Calculations on the home screen</th>
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<td>(mark with X)</td>
<td>1. Press the <strong>ON</strong> button in the lower left corner.</td>
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<td>2. Press <strong>CLEAR</strong> to remove any entries from your TI-83 Plus.</td>
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Perform a Calculation:
Do the following calculation just as it is written below:

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4. Press **ENTER**. *(Note: Pressing ENTER evaluates the expression on your screen).*

What answer appears on the screen?

5. Now do the same calculation but include some parentheses as follows:

| Press | 1
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<tr>
<td>*<em>(8+4)<em>5</em></em></td>
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6. Press **ENTER**. What answer appears on the screen?

Why is it different from the one you got before?
Appendix B
Opening Activity
TI-83 Plus Scavenger Hunt!

Completed
(mark
with X)

Calculations on the home screen
1. Press the ON button in the lower left corner.
2. Press CLEAR to remove any entries from your TI-83 Plus.

Perform a Calculation:
Do the following calculation just as it is written below:
3. Press $3 + 4 \times 5$

4. Press ENTER. (Note: Pressing ENTER evaluates the expression on your screen.)
What answer appears on the screen?

5. Now do the same calculation but include some parentheses as follows:
Press $( (8 + 4) \times 5 )$

6. Press ENTER. What answer appears on the screen?

Why is it different from the one you got before?
Find the Square Root of 45:
7. Press the 2nd button. (Note: Pressing the 2nd button and releasing it allows you to access the yellow functions printed above many of the TI-83 Plus keys).
8. Press [√] (you actually press the x² button, but because you first pressed the 2nd button, you the square root function will be activated).

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<td>60</td>
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<tr>
<td>√45</td>
<td>6.708203932</td>
</tr>
</tbody>
</table>
10. Press ENTER. What is your answer?

Raise 7.5 to the 4th power:
11. Key in 7.5
12. Press x^n. (Note: The x^n button allows you to raise to a power)
13. Key in 4

<table>
<thead>
<tr>
<th>8+4*5</th>
<th>28</th>
</tr>
</thead>
<tbody>
<tr>
<td>(8+4)*5</td>
<td>60</td>
</tr>
<tr>
<td>7.5^4</td>
<td>6.708203932</td>
</tr>
</tbody>
</table>
14. Press ENTER.

Another example:
15. Key in (-2)^2. (Note: the negative symbol is near the ENTER key - see picture of TI-83 Plus)

<table>
<thead>
<tr>
<th>(8+4)*5</th>
<th>28</th>
</tr>
</thead>
<tbody>
<tr>
<td>(8+4)^2</td>
<td>60</td>
</tr>
<tr>
<td>7.5^4</td>
<td>6.708203932</td>
</tr>
</tbody>
</table>
| (-2)^2 | 3.16227766 
16. Press ENTER. What is your answer?

17. Now enter -2^2 (without the parenthesis) and press ENTER. What do you notice? Why is there a difference?
Mode Key: Change the number of decimal places

18. Press **MODE** to enter the Mode environment, and press **→3→** to highlight 3 and press **ENTER**. This will change the decimal to 3 places.

<table>
<thead>
<tr>
<th>Normal</th>
<th>Sci</th>
<th>Eng</th>
</tr>
</thead>
<tbody>
<tr>
<td>Float</td>
<td>0.12456789</td>
<td>Radian</td>
</tr>
<tr>
<td>Degree</td>
<td>Trace Pol Seq</td>
<td>Connected Dot</td>
</tr>
<tr>
<td>Sequential Simul</td>
<td>Real arbi re ^8i</td>
<td>Full Horiz G-T</td>
</tr>
</tbody>
</table>

19. Return to the Homescreen by pressing **2nd[QUIT]**. The **QUIT** key is the 2nd function of the **MODE** key. (Note: In general, when you want to start over "Quit and go Home" -- **2nd[QUIT]** will take you back to the homescreen.

20. Perform the following calculation:

\[ 25.6893^2 \]

What is your answer?

21. Press **MODE** and change your decimal to **FLOAT**. Press **=ENTER**. This will change the decimal places to Float mode.

22. Go back to the home screen and press **2nd[ENTER]**. What happens?

23. Press **ENTER**. Compare this number to the one you got in your calculation above. What happened?

---

Step 18:
Change the MODE

---

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---

3
Graphing and evaluating functions

24. Press \textcolor{red}{MODE} and have everything on the left highlighted.

25. Find the \textcolor{blue}{Y=\text{key}} and press it. Press \textcolor{green}{CLEAR}.

26. Key in $2x + 3$ in Y1= $\{2x+3\}$

27. Press the \textcolor{red}{WINDOW} key and change the settings to the following. Use the cursor arrows to navigate between choices:

\begin{verbatim}
<table>
<thead>
<tr>
<th>Step 25: Key in a Function</th>
</tr>
</thead>
</table>

28. Press \textcolor{red}{GRAPH}.

29. Press \textcolor{blue}{TRACE}. Use the arrow keys $\uparrow\downarrow\left\uparrow\downarrow$ to move the cursor along the function. What do you see?
Pre-Graphing Calculator Workshop Questionnaire

Name: (optional) Kyle Candall

1) Have you used graphing calculators in your math classes this year?  
Yes  No

2) If yes, how often do/did you use them? Indicate frequency.
   a) 1-2 times a week  
   b) 1-2 times a month  
   c) 1-2 times a year

3) On a scale from 1-5, 5 being most comfortable and 1 being the least comfortable, how comfortable do you feel using graphing calculators in your classrooms?
   5  4  3  2  1

4) On a scale from 1-5, 5 being the most and 1 being the least, how knowledgeable are you on the graphing calculator?
   5  4  3  2  1

5) How many years have you been teaching?
   a) 0-3 years  
   b) 4-10 years  
   c) 11+ years

6) What kind of teaching certification do you have?
   a) permanent  
   b) provisional

7) Place an “x” next to each topic you would like to receive professional development on.

<table>
<thead>
<tr>
<th>Graphing Calculator Skills</th>
<th>Math Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Graphing</td>
<td>1. Solving Equations</td>
</tr>
<tr>
<td>2. Tables of value</td>
<td>2. Systems of Equations</td>
</tr>
<tr>
<td>3. Solver</td>
<td>3. Quadratics</td>
</tr>
<tr>
<td>4. Boolean Algebra</td>
<td>4. Exponentials</td>
</tr>
<tr>
<td>5. Evaluations</td>
<td>5. Multiple Choice test skills</td>
</tr>
</tbody>
</table>

8) What would you like to learn from these series of graphing calculator workshops?
Appendix D
<table>
<thead>
<tr>
<th>Skill</th>
<th>Developing Awareness</th>
<th>Building Knowledge</th>
<th>Translating Into Practice</th>
<th>Practicing Teaching</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graphing Functions</td>
<td></td>
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<td></td>
<td>✓</td>
</tr>
<tr>
<td>Using trace</td>
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<tr>
<td>Changing window settings</td>
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<tr>
<td>Finding interceptions of functions</td>
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<tr>
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<tr>
<td>Find the max/min of parabolas</td>
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<tr>
<td>Create Tables of Values</td>
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<td>Use Tables of Values</td>
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<tr>
<td>Use Solver</td>
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<td>Evaluate Functions</td>
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<tr>
<td>Use Test Logic</td>
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</tbody>
</table>

Name: Latresha Fuller
Graphing Calculator Matrix

Place an X in the box that describes where you feel you are in regards to the skill.

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# Graphing Calculator Matrix

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</tbody>
</table>
Professional Development Evaluation for Feb. 6, 2003

Name: (optional)

For the following statements circle the number that best represents how you felt from today's workshop. 5 means strongly agree, 4 somewhat agree, 3 neutral, 2, somewhat disagree, and 1 strongly disagree.

1. The professional development today provided an opportunity to build your knowledge and skills.
   - [ ] 5
   - [ ] 4
   - [ ] 3
   - [ ] 2
   - [ ] 1

2. The presenter used or modeled strategies that you will use with your students.
   - [ ] 5
   - [ ] 4
   - [ ] 3
   - [ ] 2
   - [ ] 1

3. The workshop allowed for time to collaborate with other teachers.
   - [ ] 5
   - [ ] 4
   - [ ] 3
   - [ ] 2
   - [ ] 1

4. You know how to graph a function.
   - [ ] 5
   - [ ] 4
   - [ ] 3
   - [ ] 2
   - [ ] 1

5. You know how to use the "trace" feature.
   - [ ] 5
   - [ ] 4
   - [ ] 3
   - [ ] 2
   - [ ] 1

6. You know how to change the window settings.
   - [ ] 5
   - [ ] 4
   - [ ] 3
   - [ ] 2
   - [ ] 1

7. You can solve problems requiring you to find the intersection of functions.
   - [ ] 5
   - [ ] 4
   - [ ] 3
   - [ ] 2
   - [ ] 1

8. You can solve for the roots of functions.
   - [ ] 5
   - [ ] 4
   - [ ] 3
   - [ ] 2
   - [ ] 1

9. You can solve for the maximum/minimum values of a quadratic function.
   - [ ] 5
   - [ ] 4
   - [ ] 3
   - [ ] 2
   - [ ] 1

10. You feel more comfortable using graphing calculators.
    - [ ] 5
    - [ ] 4
    - [ ] 3
    - [ ] 2
    - [ ] 1

11. Do you have any comments on what could be improved from today's workshop?

12. Are there any concerns that you have with using the graphing calculator or teaching students how to use the graphing calculator?
Professional Development Evaluation for Feb. 6, 2003

Name: (optional) 

For the following statements circle the number that best represents how you felt from today's workshop. 5 means strongly agree, 4 somewhat agree, 3 neutral, 2, somewhat disagree, and 1 strongly disagree.

1. The professional development today provided an opportunity to build your knowledge and skills. 
   
2. The presenter used or modeled strategies that you will use with your students. 
   
3. The workshop allowed for time to collaborate with other teachers. 
   
4. You know how to graph a function. 
   
5. You know how to use the "trace" feature. 
   
6. You know how to change the window settings. 
   
7. You can solve problems requiring you to find the intersection of functions. 
   
8. You can solve for the roots of functions. 
   
9. You can solve for the maximum/minimum values of a quadratic function. 
   
10. You feel more comfortable using graphing calculators. 
    
11. Do you have any comments on what could be improved from today's workshop? 
    
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Professional Development Evaluation for Feb. 6, 2003

Name: (optional) ____________________________________________

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   5 4 3 2 1

2. The presenter used or modeled strategies that you will use with your students.
   5 4 3 2 1

3. The workshop allowed for time to collaborate with other teachers.
   5 4 3 2 1

4. You know how to graph a function.
   5 4 3 2 1

5. You know how to use the "trace" feature.
   5 4 3 2 1

6. You know how to change the window settings.
   5 4 3 2 1

7. You can solve problems requiring you to find the intersection of functions.
   5 4 3 2 1

8. You can solve for the roots of functions.
   5 4 3 2 1

9. You can solve for the maximum/minimum values of a quadratic function.
   5 4 3 2 1

10. You feel more comfortable using graphing calculators.
    5 4 3 2 1

11. Do you have any comments on what could be improved from today's workshop?

12. Are there any concerns that you have with using the graphing calculator or teaching students how to use the graphing calculator?
Appendix F

Name: (optional)

For the following statements circle the number that best represents how you felt from today's workshop. 5 means strongly agree, 4 somewhat agree, 3 neutral, 2, somewhat disagree, and 1 strongly disagree.

1. The professional development today provided an opportunity to build my knowledge and skills.
   5 4 3 2 1

2. The presenter used or modeled strategies that I will use with my students.
   5 4 3 2 1

3. The workshop allowed for time to collaborate with other teachers.
   5 4 3 2 1

4. I know how to change the Table settings.
   5 4 3 2 1

5. I can solve problems requiring me to find the intersection of functions.
   5 4 3 2 1

6. I can solve for the roots of functions.
   5 4 3 2 1

7. I can solve for the maximum/minimum values of a quadratic function.
   5 4 3 2 1

8. I feel more comfortable using graphing calculators.
   5 4 3 2 1

9. Do you have any comments on what could be improved from today's workshop?

10. Are there any concerns that you have with using the graphing calculator or teaching students how to use the graphing calculator?

Name: (optional) 

For the following statements circle the number that best represents how you felt from today's workshop. 5 means strongly agree, 4 somewhat agree, 3 neutral, 2 somewhat disagree, and 1 strongly disagree.

1. The professional development today provided an opportunity to build my knowledge and skills. 
   
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. The presenter used or modeled strategies that I will use with my students. 
   
<table>
<thead>
<tr>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. The workshop allowed for time to collaborate with other teachers. 
   
<table>
<thead>
<tr>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. I know how to change the Table settings. 
   
<table>
<thead>
<tr>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. I can solve problems requiring me to find the intersection of functions. 
   
<table>
<thead>
<tr>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6. I can solve for the roots of functions. 
   
<table>
<thead>
<tr>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7. I can solve for the maximum/minimum values of a quadratic function. 
   
<table>
<thead>
<tr>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8. I feel more comfortable using graphing calculators. 
   
<table>
<thead>
<tr>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

9. Do you have any comments on what could be improved from today's workshop?

10. Are there any concerns that you have with using the graphing calculator or teaching students how to use the graphing calculator?

Name: (optional)  

For the following statements circle the number that best represents how you felt from today's workshop. 5 means strongly agree, 4 somewhat agree, 3 neutral, 2, somewhat disagree, and 1 strongly disagree.

1. The professional development today provided an opportunity to build my knowledge and skills.  
   5  4  3  2  1

2. The presenter used or modeled strategies that I will use with my students.  
   5  4  3  2  1

3. The workshop allowed for time to collaborate with other teachers.  
   5  4  3  2  1

4. I know how to change the Table settings.  
   5  4  3  2  1

5. I can solve problems requiring me to find the intersection of functions.  
   5  4  3  2  1

6. I can solve for the roots of functions.  
   5  4  3  2  1

7. I can solve for the maximum/minimum values of a quadratic function.  
   5  4  3  2  1

8. I feel more comfortable using graphing calculators.  
   5  4  3  2  1

9. Do you have any comments on what could be improved from today's workshop?  
   Make sure you show them how to "hide" an equation in the Y= screen.  

10. Are there any concerns that you have with using the graphing calculator or teaching students how to use the graphing calculator?

Name: (optional) ________________________________________________________________

For the following statements circle the number that best represents how you felt from today's workshop. 5 means strongly agree, 4 somewhat agree, 3 neutral, 2, somewhat disagree, and 1 strongly disagree.

1. The professional development today provided an opportunity to build my knowledge and skills.
   5 4 3 2 1

2. The presenter used or modeled strategies that I will use with my students.
   5 4 3 2 1

3. The workshop allowed for time to collaborate with other teachers.
   5 4 3 2 1

4. I know how to change the Table settings.
   5 4 3 2 1

5. I can solve problems requiring me to find the intersection of functions.
   5 4 3 2 1

6. I can solve for the roots of functions.
   5 4 3 2 1

7. I can solve for the maximum/minimum values of a quadratic function.
   5 4 3 2 1

8. I feel more comfortable using graphing calculators.
   5 4 3 2 1

9. Do you have any comments on what could be improved from today's workshop?

10. Are there any concerns that you have with using the graphing calculator or teaching students how to use the graphing calculator?

Name: (optional)

For the following statements circle the number that best represents how you felt from today’s workshop. 5 means strongly agree, 4 somewhat agree, 3 neutral, 2, somewhat disagree, and 1 strongly disagree.

1. The professional development today provided an opportunity to build my knowledge and skills.  
   5 4 3 2 1

2. The presenter used or modeled strategies that I will use with my students.  
   5 4 3 2 1

3. The workshop allowed for time to collaborate with other teachers.  
   5 4 3 2 1

4. I know how to change the Table settings.  
   5 4 3 2 1

5. I can solve problems requiring me to find the intersection of functions.  
   5 4 3 2 1

6. I can solve for the roots of functions.  
   5 4 3 2 1

7. I can solve for the maximum/minimum values of a quadratic function  
   5 4 3 2 1

8. I feel more comfortable using graphing calculators.  
   5 4 3 2 1

9. Do you have any comments on what could be improved from today's workshop?

10. Are there any concerns that you have with using the graphing calculator or teaching students how to use the graphing calculator?

Name: (optional) **Kristen Frank**

For the following statements circle the number that best represents how you felt from today's workshop. 5 means strongly agree, 4 somewhat agree, 3 neutral, 2, somewhat disagree, and 1 strongly disagree.

1. The professional development today provided an opportunity to build my knowledge and skills.
   - 5 4 3 2 1

2. The presenter used or modeled strategies that I will use with my students.
   - 5 4 3 2 1

3. The workshop allowed for time to collaborate with other teachers.
   - 5 4 3 2 1

4. I know how to change the Table settings.
   - 5 4 3 2 1

5. I can solve problems requiring me to find the intersection of functions.
   - 5 4 3 2 1

6. I can solve for the roots of functions.
   - 5 4 3 2 1

7. I can solve for the maximum/minimum values of a quadratic function.
   - 5 4 3 2 1

8. I feel more comfortable using graphing calculators.
   - 5 4 3 2 1

9. Do you have any comments on what could be improved from today's workshop?

10. Are there any concerns that you have with using the graphing calculator or teaching students how to use the graphing calculator?
Professional Development Evaluation for Feb. 27, 2003

Name: (optional)  

For the following statements circle the number that best represents how you felt from today's workshop. 5 means strongly agree, 4 somewhat agree, 3 neutral, 2, somewhat disagree, and 1 strongly disagree.

1. The professional development today provided an opportunity to build my knowledge and skills.
   
   5 4 3 2 1

2. The presenter used or modeled strategies that I will use with my students.

   5 4 3 2 1

3. The workshop allowed for time to collaborate with other teachers.

   5 4 3 2 1

4. I know how to use Solver.

   5 4 3 2 1

5. I can solve problems requiring me to find the intersection of functions.

   5 4 3 2 1

6. I can solve for the roots of functions.

   5 4 3 2 1

7. I can type any formula I need to into the Solver

   5 4 3 2 1

8. I feel more comfortable using graphing calculators.

   5 4 3 2 1

9. Do you have any comments on what could be improved from today's workshop?

   Great!

10. Are there any concerns that you have with using the graphing calculator or teaching students how to use the graphing calculator?
Professional Development Evaluation for Feb. 27, 2003

Name: (optional)

For the following statements circle the number that best represents how you felt from today's workshop. 5 means strongly agree, 4 somewhat agree, 3 neutral, 2, somewhat disagree, and 1 strongly disagree.

1. The professional development today provided an opportunity to build my knowledge and skills.  
   ![Circle 5, 4, 3, 2, 1]

2. The presenter used or modeled strategies that I will use with my students.  
   ![Circle 5, 4, 3, 2, 1]

3. The workshop allowed for time to collaborate with other teachers.  
   ![Circle 5, 4, 3, 2, 1]

4. I know how to use Solver.  
   ![Circle 5, 4, 3, 2, 1]

5. I can solve problems requiring me to find the intersection of functions.  
   ![Circle 5, 4, 3, 2, 1]

6. I can solve for the roots of functions.  
   ![Circle 5, 4, 3, 2, 1]

7. I can type any formula I need to into the Solver.  
   ![Circle 5, 4, 3, 2, 1]

8. I feel more comfortable using graphing calculators.  
   ![Circle 5, 4, 3, 2, 1]

9. Do you have any comments on what could be improved from today's workshop?  

10. Are there any concerns that you have with using the graphing calculator or teaching students how to use the graphing calculator?
Professional Development Evaluation for Feb. 27, 2003

For the following statements circle the number that best represents how you felt from today’s workshop. 5 means strongly agree, 4 somewhat agree, 3 neutral, 2, somewhat disagree, and 1 strongly disagree.

1. The professional development today provided an opportunity to build my knowledge and skills.
   
   (5) 4 3 2 1

2. The presenter used or modeled strategies that I will use with my students.
   
   (5) 4 3 2 1

3. The workshop allowed for time to collaborate with other teachers.
   
   (5) 4 3 2 1

4. I know how to use Solver.
   
   (5) 4 3 2 1

5. I can solve problems requiring me to find the intersection of functions.
   
   (5) 4 3 2 1

6. I can solve for the roots of functions.
   
   (5) 4 3 2 1

7. I can type any formula I need to into the Solver.
   
   (5) 4 3 2 1

8. I feel more comfortable using graphing calculators.
   
   (5) 4 3 2 1

9. Do you have any comments on what could be improved from today’s workshop?

10. Are there any concerns that you have with using the graphing calculator or teaching students how to use the graphing calculator?
Name: (optional) 

For the following statements circle the number that best represents how you felt from today's workshop. 5 means strongly agree, 4 somewhat agree, 3 neutral, 2, somewhat disagree, and 1 strongly disagree.

1. The professional development today provided an opportunity to build my knowledge and skills.
   5 4 3 2 1

2. The presenter used or modeled strategies that I will use with my students.
   5 4 3 2 1

3. The workshop allowed for time to collaborate with other teachers.
   5 4 3 2 1

4. I know how to use Solver.
   5 4 3 2 1

5. I can solve problems requiring me to find the intersection of functions.
   5 4 3 2 1

6. I can solve for the roots of functions.
   5 4 3 2 1

7. I can type any formula I need to into the Solver.
   5 4 3 2 1

8. I feel more comfortable using graphing calculators.
   5 4 3 2 1

9. Do you have any comments on what could be improved from today's workshop?
   This is one I forgot from last summer.

10. Are there any concerns that you have with using the graphing calculator or teaching students how to use the graphing calculator?
**Professional Development Evaluation for Feb. 27, 2003**

**Name:** (optional) ____________________

For the following statements, circle the number that best represents how you felt from today's workshop. 5 means strongly agree, 4 somewhat agree, 3 neutral, 2, somewhat disagree, and 1 strongly disagree.

1. The professional development today provided an opportunity to build my knowledge and skills.
   - [ ] 5
   - [ ] 4
   - [ ] 3
   - [x] 2
   - [ ] 1

2. The presenter used or modeled strategies that I will use with my students.
   - [x] 5
   - [ ] 4
   - [ ] 3
   - [ ] 2
   - [ ] 1

3. The workshop allowed for time to collaborate with other teachers.
   - [ ] 5
   - [ ] 4
   - [x] 3
   - [ ] 2
   - [ ] 1

4. I know how to use Solver.
   - [x] 5
   - [ ] 4
   - [ ] 3
   - [ ] 2
   - [ ] 1

5. I can solve problems requiring me to find the intersection of functions.
   - [x] 5
   - [ ] 4
   - [ ] 3
   - [ ] 2
   - [ ] 1

6. I can solve for the roots of functions.
   - [x] 5
   - [ ] 4
   - [ ] 3
   - [ ] 2
   - [ ] 1

7. I can type any formula I need to into the Solver.
   - [x] 5
   - [ ] 4
   - [ ] 3
   - [ ] 2
   - [ ] 1

8. I feel more comfortable using graphing calculators.
   - [x] 5
   - [ ] 4
   - [ ] 3
   - [ ] 2
   - [ ] 1

9. Do you have any comments on what could be improved from today's workshop?
   ```
   You did a good job.
   ```

10. Are there any concerns that you have with using the graphing calculator or teaching students how to use the graphing calculator?
Professional Development Evaluation for Feb. 27, 2003

Name: (optional) G. Wiles

For the following statements circle the number that best represents how you felt from today's workshop. 5 means strongly agree, 4 somewhat agree, 3 neutral, 2, somewhat disagree, and 1 strongly disagree.

1. The professional development today provided an opportunity to build my knowledge and skills.
   5 4 3 2 1

2. The presenter used or modeled strategies that I will use with my students.
   5 4 3 2 1

3. The workshop allowed for time to collaborate with other teachers.
   5 4 3 2 1

4. I know how to use Solver.
   5 4 3 2 1

5. I can solve problems requiring me to find the intersection of functions.
   5 4 3 2 1

6. I can solve for the roots of functions.
   5 4 3 2 1

7. I can type any formula I need to into the Solver.
   5 4 3 2 1

8. I feel more comfortable using graphing calculators.
   5 4 3 2 1

9. Do you have any comments on what could be improved from today's workshop?
   Very good!

10. Are there any concerns that you have with using the graphing calculator or teaching students how to use the graphing calculator?
Professional Development Evaluation for Feb. 27, 2003

For the following statements circle the number that best represents how you felt from today's workshop. 5 means strongly agree, 4 somewhat agree, 3 neutral, 2, somewhat disagree, and 1 strongly disagree.

1. The professional development today provided an opportunity to build my knowledge and skills.  
   \[ \begin{array}{cccc} 5 & 4 & 3 & 2 & 1 \end{array} \]  
   \[4\] 

2. The presenter used or modeled strategies that I will use with my students.  
   \[ \begin{array}{cccc} 5 & 4 & 3 & 2 & 1 \end{array} \]  
   \[4\] 

3. The workshop allowed for time to collaborate with other teachers.  
   \[ \begin{array}{cccc} 5 & 4 & 3 & 2 & 1 \end{array} \]  
   \[4\] 

4. I know how to use Solver.  
   \[ \begin{array}{cccc} 5 & 4 & 3 & 2 & 1 \end{array} \]  
   \[4\] 

5. I can solve problems requiring me to find the intersection of functions.  
   \[ \begin{array}{cccc} 5 & 4 & 3 & 2 & 1 \end{array} \]  
   \[4\] 

6. I can solve for the roots of functions.  
   \[ \begin{array}{cccc} 5 & 4 & 3 & 2 & 1 \end{array} \]  
   \[4\] 

7. I can type any formula I need to into the Solver.  
   \[ \begin{array}{cccc} 5 & 4 & 3 & 2 & 1 \end{array} \]  
   \[4\] 

8. I feel more comfortable using graphing calculators.  
   \[ \begin{array}{cccc} 5 & 4 & 3 & 2 & 1 \end{array} \]  
   \[5\] 

9. Do you have any comments on what could be improved from today's workshop?

10. Are there any concerns that you have with using the graphing calculator or teaching students how to use the graphing calculator?
Appendix H
Professional Development Evaluation for March 13, 2003

Name: (optional) ________________________________________________  

For the following statements circle the number that best represents how you felt from today’s workshop. 5 means strongly agree, 4 somewhat agree, 3 neutral, 2 somewhat disagree, and 1 strongly disagree.

1. The professional development today provided an opportunity to build my knowledge and skills.  
   - 5  4  3  2  1

2. The presenter used or modeled strategies that I will use with my students.  
   - 5  4  3  2  1

3. The workshop allowed time for me to collaborate with other teachers.  
   - 5  4  3  2  1

4. I know how to store numbers into variables on the TI-83+.  
   - 5  4  3  2  1

5. I know how to use the Logic Tests for multiple choice questions.  
   - 5  4  3  2  1

6. I know more strategies on how to use a graphing calculator on the Regents Mathematics A exam.  
   - 5  4  3  2  1

7. I feel more comfortable using graphing calculators.  
   - 5  4  3  2  1

8) Do you have any comments on what could be improved from today’s workshop?

9) Are there any concerns that you have with using the graphing calculator or teaching students how to use the graphing calculator.
Professional Development Evaluation for March 13, 2003

Name: (optional)

For the following statements circle the number that best represents how you felt from today's workshop. 5 means strongly agree, 4 somewhat agree, 3 neutral, 2 somewhat disagree, and 1 strongly disagree.

1. The professional development today provided an opportunity to build my knowledge and skills.
   
   [ ] 5 [ ] 4 [ ] 3 [ ] 2 [ ] 1

2. The presenter used or modeled strategies that I will use with my students.
   
   [ ] 5 [ ] 4 [ ] 3 [ ] 2 [ ] 1

3. The workshop allowed time for me to collaborate with other teachers.
   
   [ ] 5 [ ] 4 [ ] 3 [ ] 2 [ ] 1

4. I know how to store numbers into variables on the TI-83+.
   
   [ ] 5 [ ] 4 [ ] 3 [ ] 2 [ ] 1

5. I know how to use the Logic Tests for multiple choice questions.
   
   [ ] 5 [ ] 4 [ ] 3 [ ] 2 [ ] 1

6. I know more strategies on how to use a graphing calculator on the Regents Mathematics A exam.
   
   [ ] 5 [ ] 4 [ ] 3 [ ] 2 [ ] 1

7. I feel more comfortable using graphing calculators.
   
   [ ] 5 [ ] 4 [ ] 3 [ ] 2 [ ] 1

8) Do you have any comments on what could be improved from today's workshop?

9) Are there any concerns that you have with using the graphing calculator or teaching students how to use the graphing calculator.
Professional Development Evaluation for March 13, 2003

Name: (optional)

For the following statements circle the number that best represents how you felt from today's workshop. 5 means strongly agree, 4 somewhat agree, 3 neutral, 2 somewhat disagree, and 1 strongly disagree.

1. The professional development today provided an opportunity to build my knowledge and skills.
   - 5
   - 4
   - 3
   - 2
   - 1

2. The presenter used or modeled strategies that I will use with my students.
   - 5
   - 4
   - 3
   - 2
   - 1

3. The workshop allowed time for me to collaborate with other teachers.
   - 5
   - 4
   - 3
   - 2
   - 1

4. I know how to store numbers into variables on the TI-83.
   - 5
   - 4
   - 3
   - 2
   - 1

5. I know how to use the Logic Tests for multiple choice questions.
   - 5
   - 4
   - 3
   - 2
   - 1

6. I know more strategies on how to use a graphing calculator on the Regents Mathematics A exam.
   - 5
   - 4
   - 3
   - 2
   - 1

7. I feel more comfortable using graphing calculators.
   - 5
   - 4
   - 3
   - 2
   - 1

8) Do you have any comments on what could be improved from today's workshop?

9) Are there any concerns that you have with using the graphing calculator or teaching students how to use the graphing calculator.
Professional Development Evaluation for March 13, 2003

Name: (optional) ____________________________

For the following statements circle the number that best represents how you felt from today's workshop. 5 means strongly agree, 4 somewhat agree, 3 neutral, 2 somewhat disagree, and 1 strongly disagree.

1. The professional development today provided an opportunity to build my knowledge and skills.
   5 4 3 2 1

2. The presenter used or modeled strategies that I will use with my students.
   5 4 3 2 1

3. The workshop allowed time for me to collaborate with other teachers.
   5 4 3 2 1

4. I know how to store numbers into variables on the TI-83+.
   5 4 3 2 1

5. I know how to use the Logic Tests for multiple choice questions.
   5 4 3 2 1

6. I know more strategies on how to use a graphing calculator on the Regents Mathematics A exam.
   5 4 3 2 1

7. I feel more comfortable using graphing calculators.
   5 4 3 2 1

8) Do you have any comments on what could be improved from today's workshop?

9) Are there any concerns that you have with using the graphing calculator or teaching students how to use the graphing calculator.
Professional Development Evaluation for March 13, 2003

Name: (optional) Jessica Snyder

For the following statements circle the number that best represents how you felt from today's workshop. 5 means strongly agree, 4 somewhat agree, 3 neutral, 2 somewhat disagree, and 1 strongly disagree.

1. The professional development today provided an opportunity to build my knowledge and skills.

2. The presenter used or modeled strategies that I will use with my students.

3. The workshop allowed time for me to collaborate with other teachers.

4. I know how to store numbers into variables on the TI-83+.

5. I know how to use the Logic Tests for multiple choice questions.

6. I know more strategies on how to use a graphing calculator on the Regents Mathematics A exam.

7. I feel more comfortable using graphing calculators.

8) Do you have any comments on what could be improved from today's workshop?

   No

9) Are there any concerns that you have with using the graphing calculator or teaching students how to use the graphing calculator.

   Just that I still remember when it is now for me to do so.
Professional Development Evaluation for March 13, 2003

Name: (optional) [Handwritten: Brian]

For the following statements circle the number that best represents how you felt from today's workshop. 5 means strongly agree, 4 somewhat agree, 3 neutral, 2 somewhat disagree, and 1 strongly disagree.

1. The professional development today provided an opportunity to build my knowledge and skills.  
   5  4  3  2  1

2. The presenter used or modeled strategies that I will use with my students.  
   5  4  3  2  1

3. The workshop allowed time for me to collaborate with other teachers.  
   5  4  3  2  1

4. I know how to store numbers into variables on the TI-83+.  
   5  4  3  2  1

5. I know how to use the Logic Tests for multiple choice questions.  
   5  4  3  2  1

6. I know more strategies on how to use a graphing calculator on the Regents Mathematics A exam.  
   5  4  3  2  1

7. I feel more comfortable using graphing calculators.  
   5  4  3  2  1

8) Do you have any comments on what could be improved from today's workshop?  
   [Handwritten: Show multiple strategies.]

9) Are there any concerns that you have with using the graphing calculator or teaching students how to use the graphing calculator.  
   [Handwritten: tape the calculator in]
Professional Development Evaluation for March 13, 2003

Name: (optional)  

G. Wilkes

For the following statements circle the number that best represents how you felt from today’s workshop. 5 means strongly agree, 4 somewhat agree, 3 neutral, 2 somewhat disagree, and 1 strongly disagree.

1. The professional development today provided an opportunity to build my knowledge and skills.        5 4 3 2 1

2. The presenter used or modeled strategies that I will use with my students.        5 4 3 2 1

3. The workshop allowed time for me to collaborate with other teachers.        5 4 3 2 1

4. I know how to store numbers into variables on the TI-83+.        5 4 3 2 1

5. I know how to use the Logic Tests for multiple choice questions.        5 4 3 2 1

6. I know more strategies on how to use a graphing calculator on the Regents Mathematics A exam.        5 4 3 2 1

7. I feel more comfortable using graphing calculators.        5 4 3 2 1

8) Do you have any comments on what could be improved from today’s workshop?

Very good! Very informative!

9) Are there any concerns that you have with using the graphing calculator or teaching students how to use the graphing calculator.

My concern is that I will not be able to answer some questions.
Create a Table of Values from a Function:

29. Press **2nd** [TABLE].

<table>
<thead>
<tr>
<th>X</th>
<th>Y₁</th>
</tr>
</thead>
<tbody>
<tr>
<td>-3</td>
<td>-1</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>X=1</td>
<td></td>
</tr>
</tbody>
</table>

What do these numbers represent?

Extension: See Graph and Values together.

30. Press **MODE** highlighted G-T and press **ENTER**.

31. Press **GRAPH** then press **TRACE**. Use the arrow keys △ □ to move the cursor along the function. What do you see now?
Appendix C
Pre-Graphing Calculator Workshop Questionnaire

Name: (optional)  

1) Have you used graphing calculators in your math classes this year?  
   Yes  No  

2) If yes, how often do/did you use them? Indicate frequency.  
   a) 1-2 times a week  
   b) 1-2 times a month  
   c) 1-2 times a year  

3) On a scale from 1-5, 5 being most comfortable and 1 being the least comfortable, how comfortable do you feel using graphing calculators in your classrooms?  
   5  4  3  2  1  

4) On a scale from 1-5, 5 being the most and 1 being the least, how knowledgeable are you on the graphing calculator?  
   5  (4)  3  2  1  

5) How many years have you been teaching?  
   a) 0-3 years  
   b) 4-10 years  
   c) 11+ years  

6) What kind of teaching certification do you have?  
   a) permanent  
   b) provisional  

7) Place an “x” next to each topic you would like to receive professional development on.  

<table>
<thead>
<tr>
<th>Graphing Calculator Skills</th>
<th>Math Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Graphing</td>
<td>1. Solving Equations</td>
</tr>
<tr>
<td>2. Tables of value</td>
<td>2. Systems of Equations</td>
</tr>
<tr>
<td>3. Solver</td>
<td>3. Quadratics</td>
</tr>
<tr>
<td>4. Boolean Algebra</td>
<td>4. Exponentials</td>
</tr>
<tr>
<td>5. Evaluations</td>
<td>5. Multiple Choice test skills</td>
</tr>
</tbody>
</table>

8) What would you like to learn from these series of graphing calculator workshops?
Pre-Graphing Calculator Workshop Questionnaire

Name: (optional) ____________________________

1) Have you used graphing calculators in your math classes this year?
   Yes [ ] No [x]
   In one out of two math classes I push in to
   (you're the one)

2) If yes, how often do/did you use them? Indicate frequency.
   a) 1-2 times a week [x]
   b) 1-2 times a month [ ]
   c) 1-2 times a year [ ]

3) On a scale from 1-5, 5 being most comfortable and 1 being the least comfortable, how comfortable do you feel using graphing calculators in your classrooms?
   5 4 3 2 1

4) On a scale from 1-5, 5 being the most and 1 being the least, how knowledgeable are you on the graphing calculator?
   5 4 3 2 1

5) How many years have you been teaching?
   a) 0-3 years [x]
   b) 4-10 years [ ]
   c) 11+ years [ ]

6) What kind of teaching certification do you have?
   a) permanent [x]
   b) provisional [ ]

7) Place an “X” next to each topic you would like to receive professional development on.

   **Graphing Calculator Skills**                               **Math Topics**
   2. Tables of value [x]                2. Systems of Equations [x]
   3. Solver [x]                        3. Quadratics [x]
   5. Evaluations [x]                   5. Multiple Choice test skills [x]

8) What would you like to learn from these series of graphing calculator workshops?
Pre-Graphing Calculator Workshop Questionnaire

Name: (optional) ________________________________

1) Have you used graphing calculators in your math classes this year?
   Yes ☑ No

2) If yes, how often do/did you use them? Indicate frequency.
   a) 1-2 times a week
   b) 1-2 times a month ☑
   c) 1-2 times a year

3) On a scale from 1-5, 5 being most comfortable and 1 being the least comfortable, how comfortable do you feel using graphing calculators in your classrooms?
   5 4 3 2 1

4) On a scale from 1-5, 5 being the most and 1 being the least, how knowledgeable are you on the graphing calculator?
   5 4 3 2 1

5) How many years have you been teaching?
   a) 0-3 years
   b) 4-10 years
   c) 11+ years

6) What kind of teaching certification do you have?
   a) permanent
   b) provisional

7) Place an “x” next to each topic you would like to receive professional development on.

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8) What would you like to learn from these series of graphing calculator workshops?
   How to use the calculator
Pre-Graphing Calculator Workshop Questionnaire

Name: (optional) [Redacted]

1) Have you used graphing calculators in your math classes this year?
   Yes _____ No _____ (not teaching yet)

2) If yes, how often do you use them? Indicate frequency.
   a) 1-2 times a week
   b) 1-2 times a month
   c) 1-2 times a year

3) On a scale from 1-5, 5 being most comfortable and 1 being the least comfortable, how comfortable do you feel using graphing calculators in your classrooms?
   5 4 3 2 1

4) On a scale from 1-5, 5 being the most and 1 being the least, how knowledgeable are you on the graphing calculator?
   5 4 3 2 1

5) How many years have you been teaching?
   a) 0-3 years
   b) 4-10 years
   c) 11+ years

6) What kind of teaching certification do you have?
   a) permanent
   b) provisional

7) Place an "x" next to each topic you would like to receive professional development on.

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8) What would you like to learn from these series of graphing calculator workshops?
Pre-Graphing Calculator Workshop Questionnaire

Name: (optional) Socorro M. Sanchez

1) Have you used graphing calculators in your math classes this year? 
   Yes X No

2) If yes, how often do/did you use them? Indicate frequency.
   a) 1-2 times a week 
   b) 1-2 times a month
   c) 1-2 times a year

3) On a scale from 1-5, 5 being most comfortable and 1 being the least comfortable, how comfortable do you feel using graphing calculators in your classrooms?
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6) What kind of teaching certification do you have?
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7) Place an “x” next to each topic you would like to receive professional development on.

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8) What would you like to learn from these series of graphing calculator workshops?
   I would like to learn how to use the solver function of this calculator in order to show it to my students.
Pre-Graphing Calculator Workshop Questionnaire

Name: (optional)

1) Have you used graphing calculators in your math classes this year?
   Yes _____ No _____

2) If yes, how often do/did you use them? Indicate frequency.
   a) 1-2 times a week ________________
   b) 1-2 times a month ________________
   c) 1-2 times a year ________________

3) On a scale from 1-5, 5 being most comfortable and 1 being the least comfortable, how comfortable do you feel using graphing calculators in your classrooms?
   5 4 3 2 1

4) On a scale from 1-5, 5 being the most and 1 being the least, how knowledgeable are you on the graphing calculator?
   5 4 3 2 1

5) How many years have you been teaching?
   (a) 0-3 years
   (b) 4-10 years
   (c) 11+ years

6) What kind of teaching certification do you have?
   (a) permanent
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7) Place an “X” next to each topic you would like to receive professional development on.

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8) What would you like to learn from these series of graphing calculator workshops?