

Integrating Calculators in the Secondary Mathematics Classroom: Teachers' Attitudes and Perspectives

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6/28/2010

Abstract

The purpose of this study was to analyze secondary mathematics teachers' experiences, attitudes, beliefs, and practices in teaching and learning mathematics using the calculator. The study also focused on the role of the calculator in the mathematics classroom. A high number of students lack simple math skills and many use the calculator at all times. This led to the question, is the calculator a substitute for learning and authentic understanding? Data was collected through questionnaires, observations, and interviews. Results show that (1) teachers believe students can successfully learn mathematics using calculators, however (2) teachers believe that the calculator can contribute to a lack of mathematical understanding and threaten basic skill development and (3) the role and use of the calculator in the middle and high school differ significantly. These results demonstrate that integrating the calculator in the secondary mathematics classroom is a complicated, deliberated task and teachers need to be prepared to do so with as much support and knowledge as possible.

Introduction

Calculators provide teachers with the ability to explore, compare, and discover concepts with their students in the mathematics classroom. However, deciding when and how to integrate the calculator in the secondary mathematics classroom is difficult and debated. The purpose of this research was to explore teachers' experiences, attitudes, beliefs, and practices in teaching and learning mathematics using the calculator. Examination of the body of knowledge about integrating the calculator in the secondary mathematics classroom has identified that most professionals and scholars believe that the calculator is a very useful tool in learning. When used appropriately, the freedom a calculator provides can allow students to focus on more challenging concepts rather than

painstaking or lengthy calculations. This study describes mathematics teachers' beliefs and practices regarding calculator use and how they differ in grades 6-12, as well as the role of the calculator in mathematics classroom.

From my personal experience as a prospective mathematics teacher, I have seen a high number of students lacking simple math skills such as basic multiplication and addition facts. Most students seem to use calculators at all times, leading me to wonder if this is because they realize the calculator supported their learning or because it was a substitute for learning and authentic understanding.

Literature Review

In reviewing the body of literature related to calculator use for this study, a few themes emerged.

- a) Students and the calculator
- b) Teacher beliefs and practice concerning the calculator and
- c) Professional development regarding the calculator.

Students and the calculator

Reznichenko (2007) conducted a study about students' experiences, perceptions, and attitudes toward graphing calculator use. Data was collected through interviews with two high school mathematics students. The study concluded that "when calculators are used in instruction and assessment, the operational skills, computational skills, skills necessary to understand mathematical concepts, and problem-solving skills are improved" (2007, p. 6). Student responses indicated that using a graphing calculator makes mathematics easier by removing demanding tasks like lengthy calculations and it takes less time. Students said it was easier to visualize concepts with the calculator's displays and they were more likely to try different methods and approaches. One student

responded that with constant use of the graphing calculator some math skills were unused and then forgotten. She said certain things are hard to remember, “like multiplying, cause you’re so used to plugging it in, and doing multiple things, you can lose the basic skills of what you’ve learned in the past” (Reznichenko, 2007, p. 15). Another student indicated that students were not able to think enough using a calculator, and she associated understanding with doing tasks manually.

Margaritis (2003) points out that graphing calculators give students and teachers the ability to investigate and explore concepts in a much more comprehensive way than when calculators are not utilized. They also serve to stimulate and inspire students to realize their potential and learn important mathematical ideas and skills without feeling frustrated or miserable. Calculators incorporate a portable environment and foster learning and thinking by providing immediate feedback. Some teachers argue that calculators threaten basic skill development. As a result some teachers do not incorporate calculators into the curriculum or limit their use to the point where they are rarely used in ways which promote higher thinking and a meaningful understanding. According to the study, if students are allowed to develop algorithms using exploratory materials without a calculator at a young age, the use of calculators in the middle school is not harmful (Margaritis, 2003). This study highlights benefits of calculators, however it is also important to draw attention to and be aware of the detriments of calculator use, such as students not fully understanding the mathematics behind button pushing on the calculator.

Teacher beliefs and practice concerning the calculator

Milou (1999) conducted a survey about classroom usage of the graphing calculator. She surveyed 146 teachers from different schools and 108 or 74% responded their school was currently using graphing calculators (Milou, 1999). Out of the 108

teachers whose schools use graphing calculators, 73 teachers responded that they use them in their classroom several times a week, 21 teachers use the calculator once a week, and 14 teachers hardly use it at all (Milou, 1999). Milou posed another question to the teachers participating in her study; “Should graphing calculators be permitted to be used on all tests?” 14.6% of teachers strongly agreed, 21.5% agreed, 13.9% neither agreed or disagreed, 36.1% disagreed, and 13.9% strongly disagreed (Milou, 1999). Findings suggest use of the graphing calculator is widely accepted by high school Algebra II teachers and debated by middle school and Algebra I teachers. “Many teachers feel Algebra I students become too dependent on the graphing calculator and are thus unable to master algebraic manipulations so crucial to the algebra course of study” (Milou, 1999, p. 137).

A study of calculator use by Doerr and Zangor (2000) examined the relationship and interactions between the teacher’s role, knowledge, and beliefs, and the students’ use of the graphing calculator in learning. Doerr and Zangor performed the qualitative classroom-based study in two pre-calculus high school math classes with the population of 2 teachers and 31 students in these classes. Data suggests that the role, knowledge, and beliefs of the teacher influenced the emergence of rich usage of the graphing calculator. The observed teacher’s confidence and flexibility using the graphing calculator encouraged students to freely use the calculator in the classroom to calculate, explore, confirm or check their ideas. The teacher emphasized the calculator presents limitations because is not the “mathematical authority” and needs to be checked with mathematical reasoning. This data supports the idea that a teacher’s knowledge and beliefs regarding the graphing calculator has a direct influence on student learning and is therefore important to study.

Professional development regarding the calculator

Professional development informs teachers of the latest research and successful technology innovations including calculator use in the classroom. Professional development is not judged by the number of hours of training but by the impact it has on student learning, achievement, attitudes, skills, and actions (Beswick et al., 2007).

In a study on professional development by Chamblee, Slough and Wunsch (2008), teachers stated they had attended professional development regarding the graphing calculator but had attended few, if any, which focused on teaching specific topics using graphing calculators. The instruments used in the study were questionnaires and classroom observations. Chamblee et al 2008, reported that professional development had increased knowledge on how to best use graphing calculators to teach mathematics and made teachers want to explore additional applications of graphing calculators in the curriculum. However, participants in the professional development still continued to “have high levels of personal concerns about using graphing calculators to teach mathematics” (Chamblee et al, 2008, p. 192).

Laumakis and Herman (2008) studied the effect of a calculator training workshop for high school teachers on their students’ performance on state-wide assessment in Florida. The research concluded that training programs are an effective way for teachers to better prepare their students for statewide assessment. Overall students of trained teachers had higher scores on testing. Geometry taught by teachers who attended the training workshop “increased their scores, on average, 13.2 points more than students taking Geometry taught by non-trained teachers” (Laumakis & Herman, 2008, p. 92). The authors inferred that students taught by a calculator-trained teacher most likely gained a larger repertoire of techniques for solving problems and were therefore better

able to solve the problems on the test (Laumakis & Herman, 2008). This study demonstrated that calculator training workshops are imperative to successful teaching in mathematics.

After examining the body of knowledge about calculators in the secondary classroom I determined that much of the existing studies focus on the benefits of calculators, but little attention has been drawn to the detriments of calculator use. Several existing studies focus on students' beliefs, attitudes, and experiences regarding the calculator but few focus on teachers'. This led to my research questions: What is the role of the calculator in mathematics classroom?, What are the advantages and disadvantages of calculator use?, and What are mathematics teachers' beliefs and practices regarding calculator use and how do they differ in grades 6-12?

Methodology

Convenience sampling was used, targeting grades 6-12 mathematics teachers. There were 16 participants from one suburban school district in Central New York. All the teachers were white, tenured, in their mid-thirties to early fifties, and of middle class in socioeconomic background. Distribution of math teacher participants is shown in *Figure 1* on the following page. All mathematics teachers in the particular school district were invited to participate in the study by responding to a questionnaire. Three out of the 16 who responded to the questionnaire participated in an individual interview and classroom observations.

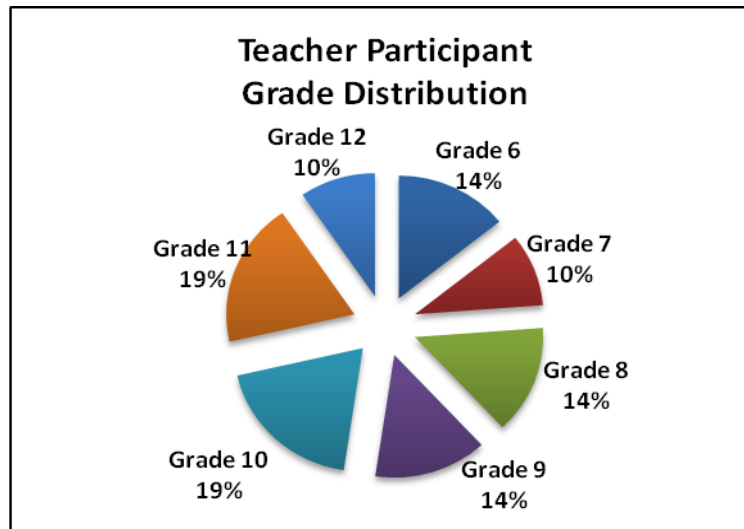


Figure 1

I distributed questionnaires as soon as I was granted entry to conduct research in my targeted school district and my research was approved by the Human Subjects Committee of my institution (Appendix A). The questionnaire included a cover letter explaining the purpose of the study and the questionnaire. Participants were assured that all information would be kept anonymous and confidential and that they could refuse to participate without penalty. The first part of the questionnaire included 23 statements to be rated using a five point Likert scale (5 strongly agree, 4 agree, 3 neutral, 2 disagree, 1 strongly agree). The statements were about calculator use, experiences, attitudes, and beliefs that the teachers have about calculators. The second part of the questionnaire consisted of mostly open-ended questions. These questions were on topics such as disadvantages/advantages of the calculator, student use, and challenges students encounter when using a calculator. Sixteen of a total 34 math teachers that received a questionnaire responded resulting with a return rate of 47%.

The second instrument used was individual interviews. Prior to each interview I presented teachers with an informed consent for their signature and answered any questions they had. I interviewed three teachers. The first teacher taught 11th grade Algebra II and Trigonometry, the second taught 10th grade Geometry and 10-12th grade Algebra II and

Trigonometry, and the third taught 9th grade Integrated Algebra. Teacher interviews were conducted using ten questions and the response-guided strategy (Appendix B). The questions were about frequency of calculator use in their classroom, students and calculator use, professional development, and other questions about their beliefs concerning calculators. The interviews served as an informative follow-up to the questionnaires and validated responses because similar questions were asked with both instruments.

The third and final instrument used was observations. I observed three classes two times each. The three classes/grade levels I observed were: 8th grade Pre-Algebra, 9th grade Integrated Algebra, and 11th grade Algebra II and Trigonometry. The Pre-Algebra observations were two days apart, the Algebra II and Trigonometry observations were five days apart, and the Integrated Algebra observations were consecutive days. In these observations, I focused on what the teacher used the calculator for in their classroom, if all students had access to calculators, and if calculator emulator software was used. I took notes during the observations and used a checklist of the following items to keep track of what the calculator was used for: graphing/graphic representation, computation/basic operations, multiple representations of a problem, problem solving, investigation/ exploration/discovery learning, checking answers, data collection, on tests, or on homework.

Findings

Data from the questionnaire was both qualitative and quantitative as teachers answered Likert scale and open-ended questions. Qualitative data from the questionnaires, interviews and observations was used to compare teacher's responses at each level. Responses were categorized in themes such as practice, teacher beliefs, students, frequency, and professional development. Quantitative data was compiled using Microsoft Excel. This

allowed the creation of graphs and tables and computation of mean scores for each Likert statement for easy comparison.

The first part of the teacher questionnaire asked, “What type of calculator is used by your students? (4-function, scientific, graphing)” and “How many days on average do you use the calculator in math class each week?” The data for all teachers’ responses grades 6-12 is displayed in *Figure 2* and *Figure 3* below.

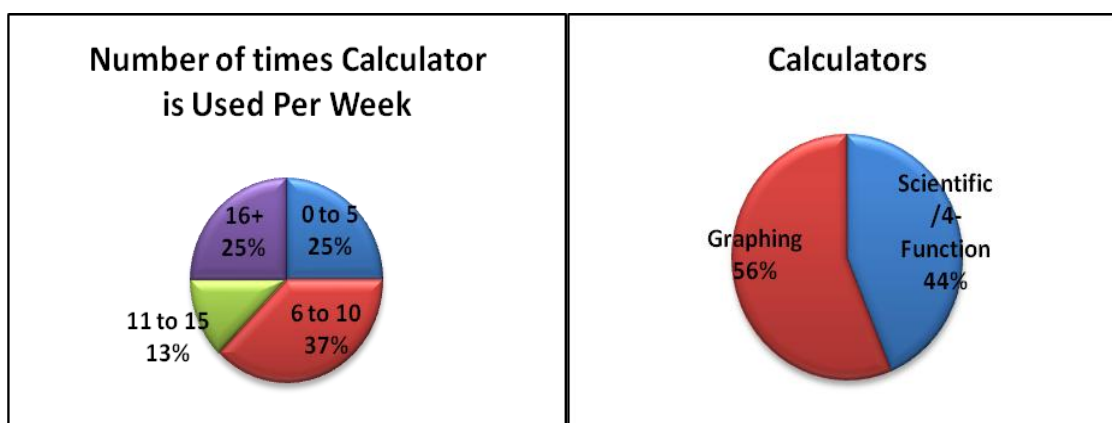


Figure 2

Figure 3

In grades 6-12, 56% of mathematics teachers use the graphing calculator in their classroom as compared to 44% who use a scientific/4-function calculator. The majority of teachers, 37%, use the calculator 6 to 10 times per week, while only 13% use the calculator 11 to 15 times per week. Breaking this data down into middle school and high school, 57% of middle school teachers reported using a calculator 0 to 5 times per week. In contrast, 78% of high school teachers reported using a calculator 11 or more (11 to 15 or 16+) times a week.

Information obtained from interviews regarding the calculator has been organized in *Table 1* on the following page. The three teachers interviewed are referred to as “Alice,” “Betty,” and “Cara” (pseudonyms). All teachers taught high school level math classes, and predictably use graphing calculators in their classrooms as well as calculator

emulator software. Each teacher uses the calculator in the classroom almost every day. Access to calculators is not an issue in this district, as there are classroom sets of calculators available in most rooms. If there is not a classroom set, then the school loans calculators for the year.

Interviewee	“Alice”	“Betty”	“Cara”
Grade/Class	<ul style="list-style-type: none"> • 9th grade Integrated Algebra • 11th grade Algebra II and Trigonometry 	<ul style="list-style-type: none"> • 10th grade Geometry • 10-12th grade Algebra II and Trig 	<ul style="list-style-type: none"> • 9th grade Integrated Algebra
Calculator	<ul style="list-style-type: none"> • TI 30X Algebra • TI-83 AlgII Trig 	<ul style="list-style-type: none"> • TI 83 • TI 84 Plus 	TI 84 Plus
Calculator Emulator Software	TI Smartview	TI Smartview	Uses calculator emulator software for TI 84 Plus
Classroom Set of Calculators	Does not have a classroom set of calculators, every student has to buy their own calculator or the school will loan them one.	Has a classroom set of calculators, most class sets are 25-30 calculators “There are many loaner calculators for the year that students can sign up and be liable for through the year”	Has a classroom set of calculators available for students. “Each student has a calculator number and uses that calculator whenever needed. Calculators are returned at the end of class.”
Frequency	Uses the calculator in class every day, with both classes.	Calculator used in classroom approximately 4 days a week.	Students use the calculator in class every day.

Table 1

*See Appendix C for a complete description of calculators and emulator software.

The second part of the questionnaire had a checklist that included the following items: graphing/graphic representation, computation/basic operations, multiple representations of a problem, problem solving, investigation/ exploration/discovery learning, checking answers, data collection, tests, and homework. Teachers were asked to check all that applied to their use of a calculator in their classroom for the previous month (see *Figure 4* and *Figure 5*). These pie charts display the breakdown of the

percentage of calculator use for grades 6-8 and grades 9-12 teachers for each item on the checklist. From the graphs we can see middle school teachers use the calculator mainly for computation and checking answers, while high school teachers use the calculator for graphing/graphic representation, computation, and multiple representations of a problem. At the high school level calculators are used much more for multiple representations of a problem and graphing.

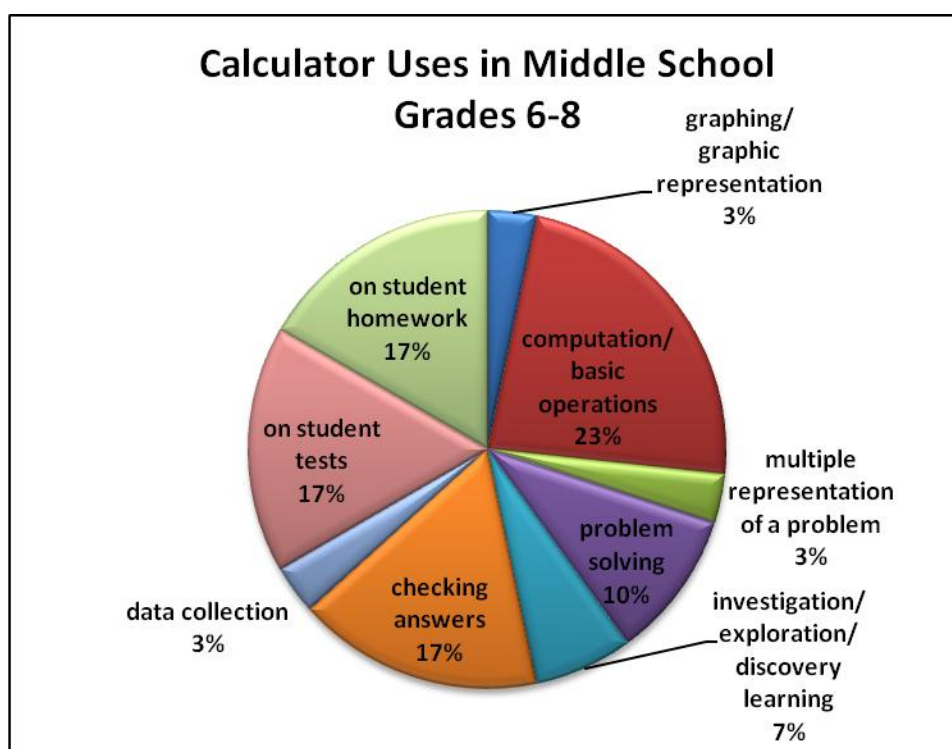


Figure 4

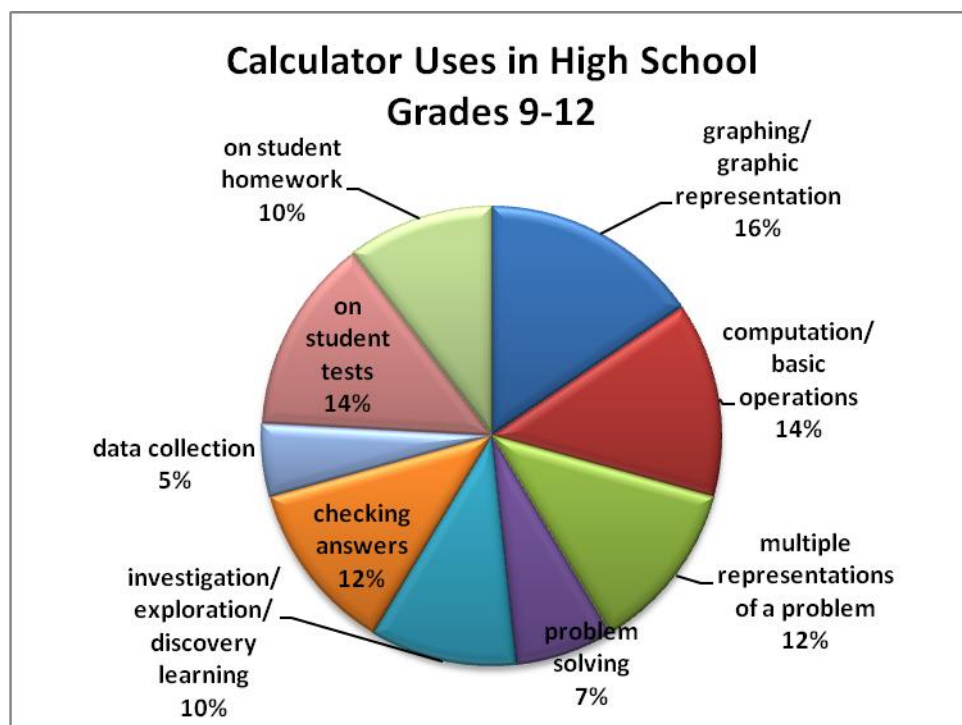


Figure 5

The three classes observed were 8th grade Pre-Algebra, 9th grade Integrated Algebra, and 11th grade Algebra II and Trigonometry. Each of these classes was observed two times each. One of the areas I focused on during observations was what the calculator was used for in each class. *Table 2* summarizes information about what the calculator was used for, and what it possibly could have been used for.

Class & Grade	Calculator Uses	Calculator NOT used, when it possibly could have been
8 th Grade Pre-Algebra	<ul style="list-style-type: none"> On student homework 	<ul style="list-style-type: none"> Graphing/graphic representation
11 th Grade Algebra II and Trigonometry	<ul style="list-style-type: none"> Computation/Basic Operations On student homework Checking answers 	
9 th Grade Integrated Algebra	<ul style="list-style-type: none"> Checking answers On student tests Graphing/graphic representation 	<ul style="list-style-type: none"> Computation/Basic Operations

Table 2

The topics of the lessons I observed in the 8th grade classroom were writing linear equations and solving systems of equations graphically. When graphing or determining the slope of a line, students did not use the graphing calculator but did the graphs and computation by pen and pencil calculation. In the 11th grade classroom students were learning right angle trigonometry. Students used the graphing calculator for computation of the sine, cosine, and tangent of angles as well as computations with pi. The calculator was available to them at any time when needed, and it was allowed on homework. In the 9th grade classroom students were learning how to solve linear-quadratic systems algebraically. The calculator was not used in class as students were learning how to solve the systems by hand using algebraic manipulation. The lesson involved factoring, solving for a variable, and substitution for variables. The calculator was not allowed on the assigned homework but was allowed on a quiz taken during my second observation. The topic of the quiz was solving linear and quadratic equations graphically.

Teachers were asked what in their opinion the advantages of using a calculator are. Many teachers responded that one advantage of calculator use was time (see *Table 3*). In addition, Alice emphasized that calculators are time efficient for students. With calculators, as a class Alice gets “more done in a 40 minute period and can focus on new learning.” Betty said that using a graphing calculator helps students to “understand applications faster, quicker, and deeper than they could without it.”

<i>Response</i>	<i>Advantages of Calculator Use - Time</i>
1	<ul style="list-style-type: none"> • It puts the fears of calculation and the frustration that comes with the extra time out of the process.
2	<ul style="list-style-type: none"> • To minimize time spent on computation
3	<ul style="list-style-type: none"> • Less time
4	<ul style="list-style-type: none"> • Time
5	<ul style="list-style-type: none"> • Able to cover much more
6	<ul style="list-style-type: none"> • Time efficiency, especially with the Integrated Algebra Curriculum
7	<ul style="list-style-type: none"> • Quicker, can do more
8	<ul style="list-style-type: none"> • They save time and eliminate many calculation errors
9	<ul style="list-style-type: none"> • The calculators can quickly give students various representations (graph, equation, table, etc.)
10	<ul style="list-style-type: none"> • Calculation time savers
11	<ul style="list-style-type: none"> • Allows them to see visually many different graphic representations quickly

Table 3

Two other advantages of the calculator that emerged were increased student engagement and the calculator as a visual tool (see Table 4). Betty also highlighted that calculators increase student interest and focus. Cara had observed that using the graphing calculator increases student confidence. She said that using the graphing calculator also allows students to better visualize and understand mathematical concepts.

<i>Response</i>	<i>Advantages Calculator Use – Engagement & Visual Tool</i>
1	<ul style="list-style-type: none"> • It puts the fears of calculation and the frustration that comes with the extra time out of the process.
2	<ul style="list-style-type: none"> • To increase accuracy when applying formulas
3	<ul style="list-style-type: none"> • Students get to see multiple ways to solve a problem
4	<ul style="list-style-type: none"> • Good way to compare graphs, tables, and equations
5	<ul style="list-style-type: none"> • Students get to see multiple ways to solve a problem
6	<ul style="list-style-type: none"> • Deeper understanding
7	<ul style="list-style-type: none"> • Great for displaying and exploring graphic concepts
8	<ul style="list-style-type: none"> • Allows them to see visually many different graphic representations quickly
9	<ul style="list-style-type: none"> • The calculators can quickly give students various representations (graph, equation, table, etc.)
10	<ul style="list-style-type: none"> • With advanced topics students don't get "hung up" on arithmetic errors and can focus on material

Table 4

Teachers were also asked what in their opinion the disadvantages of calculator use were. Many teachers responded that the calculator contributes to a lack of understanding and threatens skill development (see *Table 5*). Alice believes that one disadvantage of calculator use is students will “come to rely on it to make simple mathematical calculations.” She does not limit calculator use in her classroom or have any “calculator inactive portions” on tests. However, in Pre-Calculus and Calculus classes in Alice’s school there are calculator inactive portions. Betty believes that a disadvantage of the calculator is it allows some students to do less mental math. As a result they “can’t do it in their lives for example, making change or calculating tips without a calculator.” Cara believes that a disadvantage of using a calculator is that some students rely on it too much for basic computations.

<i>Response</i>	<i>Disadvantage Calculator Use– Understanding & Skill Development</i>
1	• Students forget basic facts, rely too much on displayed answers
2	• Students rely on the answer and not think through
3	• Forgetting math facts
4	• Trusting the calculator as always correct
5	• Some students use the results “blindly” without making connections to the problem
6	• When used at a young age some students can become reliant on the calculator and not understand the basics needed for higher level math.
7	• Lack of understanding
8	• Kids rely on them too much for computational skills which has hurt some of their basic skills such as adding 2 fractions together, multiplication facts etc...
9	• We produce some students who are so calculator dependent that they cannot get through daily life without it. (ex: making change, estimating discounts, tips, etc.)
10	• Students are calculator dependent, lose basic skills due to lack of use
11	• Some students never do basic computing on their own
12	• When students use them without understanding what they do/are looking at they have no idea if they’ve made errors
13	• Students rely on their calculators for even the most basic math skills. They don’t want to think for themselves.
14	• Students too dependent and stop using minds for basic calculations

Table 5

Teachers were then asked to state approximately how many professional development seminars they had attended regarding calculator use and if they consider them to be beneficial or how they could be improved (see *Figure 6*) On average, middle school teachers have each attended 1.57 seminars in comparison to 4.125 seminars attended on average by each high school teacher. *Table 6* displays some suggestions teachers had for improvement of seminars they attended.

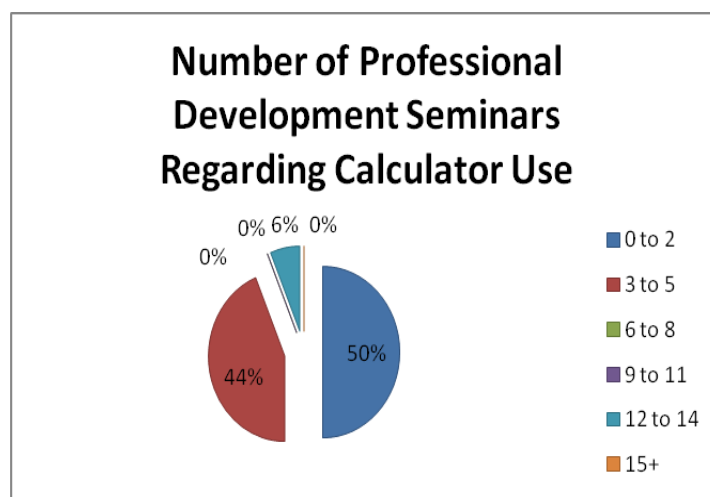


Figure 6

<i>Response</i>	<i>Suggestions for Professional Development Improvement</i>
1	<ul style="list-style-type: none"> By offering refresher workshops to accommodate current features
2	<ul style="list-style-type: none"> They could be course specific
3	<ul style="list-style-type: none"> The ones that were beneficial were very “hands-on” and allowed us to practice with the calculator systems (TI Nav)
4	<ul style="list-style-type: none"> Showing more advanced techniques on calculator and their capabilities by providing better examples!
5	<ul style="list-style-type: none"> More problem solving such as when students come across certain errors on when settings get messed up
6	<ul style="list-style-type: none"> Time to play/use concepts

Table 6

Alice had not attended professional development seminars on calculator use, but said she would like to. She feels like she has “adequate training for calculator use in her upper level classes because she can separate the new learning from the calculator skills.”

However, Alice would like some more training in the special education context. Betty also had not attended professional development seminars regarding calculator use. She would like to attend seminars “if it is applicable to what she is teaching.” Currently, Betty feels like she has adequate training/professional development for calculator use and instruction with calculators. Cara had attended professional development seminars regarding calculator use. The topics of these seminars were the graphing calculator and TI Navigator workshops. She “found the seminars beneficial, especially when they were ‘hands on’ presentations.” Cara felt she had adequate training for calculator use, but would always like more.

Interpretation & Outcomes

From this analysis, it is clear that mathematics teachers believe students can successfully learn mathematics using calculators because they are time efficient, result in active engagement with students, and increase interest and motivation.

Limitations

As with any study utilizing self-report, caution must be taken when interpreting the data. I do not have access to a classroom of my own and therefore was not able to include students’ opinions in the study or firsthand accounts or experiences from my own teaching. Another limitation is my sample of convenience. My sample population was small and only from one suburban district. It would have been more desirable to have a larger sample of teachers from several districts of rural, suburban and urban settings. Additionally I would like to include special education teachers and special education students. I think the use of the calculator with these populations opens up many different issues. However, even with these limitations, the study has yielded significant results and may not have altered the conclusion.

Student engagement, motivation, & interest

The use of calculators may lead to active engagement and increased interest in students because they have grown up in the digital age surrounded by technology. Students are constantly text messaging, watching television, surfing the Internet, playing video games and engaging in other activities involving technology. For this reason using the calculator as a tool for learning may appeal to students and increase engagement and interest in math lessons. This finding concurs with research done by Margaritis, who concluded that graphing calculators give students and teachers the ability to investigate, explore, compare, and discover concepts in a much more comprehensive way than no calculators at all (2003). She also concluded that calculators serve to stimulate and inspire students to realize their potential and learn important mathematical ideas and skills without feeling frustrated or miserable. When students use the calculator, they are removing some of the more tedious math computations that sometimes discourage students. When a student is struggling with a math problem and can turn to the calculator for help, this can replace feelings of frustration with a confidence and renewed interest in the subject.

Calculators may also increase student engagement, motivation, and interest because it appeals to a more diverse body of learners. The graphing calculator has capabilities to visually display data, which would appeal to visual learners. Calculators, especially the graphing calculator, allow students to have a more hands-on approach to learning math. This hands-on exploration and investigation of different concepts and representations would appeal to tactile/kinesthetic learners. Margaritis had a similar conclusion from her 2003 study. She concluded that graphing calculators allow students to approach the solution of a problem through the use of multiple intelligences, which communicates with learners of a variety of learning styles.

Efficient use of time

When I surveyed math teachers asking about the advantages of calculator use, 82% indicated that the calculator is time efficient. I believe time is an important factor for teachers especially at the high school level because of the rigorous, demanding NYS math curriculum. With the recent changes in the mathematics curriculum, I know teachers are feeling pressured to get through the material in classes like Integrated Algebra, AlgebraII/Trigonometry, and Geometry. With the calculator, teachers are able to cover much more material as it minimizes time spent on computation and other processes. As one teacher stated, she gets “more done in a 40 minute period and can focus on new learning.”

Mathematical understanding & basic skill development

My study reveals that teachers believe the calculator can contribute to a lack of mathematical understanding and threaten basic skill development. It is debatable that calculators become a crutch for students. When surveyed, middle and high school teachers both agreed that students should use calculators only after they know their basic facts. I think some students may become reliant on the calculator because the curriculum progresses so quickly they are unable to keep up. It may seem easier for students to blindly push buttons than put forth the effort to understand the process and what it means when using the calculator. As long as a student can get the right answer, they may not care about understanding the process and deeper meaning of what they're doing. Other students may not feel confident learning new math, and turn to the calculator for answers and computations they cannot work out by pen and pencil calculation. As a result, the calculator permits students to rely on the calculator and not truly think for themselves or make connections to math problems so they do not understand what they are actually doing. My results were similar to Doerr and Zangor (2000) which concluded that the graphing calculator emerged as

a constraint because students tended to use the calculator without attaching meaningful interpretations or strategies to the problem situation.

Role of calculator in middle and high school

My research revealed that the role and use of the calculator in the middle and high school differ significantly. The different roles of the calculator could be explained by the different curriculum and requirements of students. In middle school, students learn the basic building blocks necessary for the more complex math in high school math courses. The typical track for mathematics is in 8th grade students take Pre-Algebra, in 9th grade Algebra, in 10th grade Geometry, 11th grade AlgebraII/Trigonometry, then 12th grade Pre-Calculus. Middle school teachers reported using the calculator mainly for computation and checking answers, while high school teachers use the calculator for graphing/graphic representation, computation, and multiple representations of a problem. In classes like AlgebraII/Trigonometry and Pre-Calculus students are doing a lot more graphing and the graphing calculator allows students to see graphic representations quickly, so this makes sense. Fifty-seven percent of middle school teachers reported using a calculator 0-5 times per week, and 78% of high school teachers reported using a calculator 11 or more times a week. This finding concurs with research done by Milou (1999) which stated the use of the calculators is widely accepted by high school Algebra II teachers and debated by middle school and Algebra I teachers. He stated, “Many teachers feel Algebra I students become too dependent on the calculator and are thus unable to master algebraic manipulations so crucial to the algebra course of study” (Milou, 1999, p.137). As a result teachers use the calculator less at this level.

My data also revealed an interesting fact that may contribute to the different uses of the calculator by middle and high school teachers. Middle school teachers may be less comfortable integrating the calculator in the classroom when compared to high school

teachers, and as a result of this feeling integrate the calculator less often. When asked the question, “I feel competent to teach students how to use calculators”, the majority of middle school teachers answered “undecided” or “agreed” to this statement while the majority high school teachers “highly agreed”. This could be related to the number of professional development seminars attended. On average, middle school teachers have each attended 1.57 seminars in comparison to 4.125 seminars attended on average by each high school teacher. This could explain why high school teachers are more confident, and middle school teachers have more reservations teaching math to students.

Professional development

Many teachers that participated in my study stated that the most beneficial professional development seminars they attended were hands-on and allowed them to practice with different calculator systems. This finding is similar to the study by Chamblee, Slough and Wunsch (2008), which reported that teachers had attended professional development regarding getting to know the graphing calculator but had attended few, if any, professional development opportunities that focused on teaching specific topics using graphing calculators. This is similar to the data obtained from my study. Many teachers that participated in my study stated that the most beneficial professional development seminars they attended were hand-on and allowed them to practice with different calculator systems. Teachers also stated that they would like seminars to be more course specific, as reported by participants in Chamblee, Slough and Wunsch’s study in 2008. This emphasizes the need for professional development. I feel that the majority of teachers are familiar with calculators, so it would be most beneficial if professional development workshops focused on specific topics and situations where calculators can be appropriately integrated.

Implications

Results from this study reveal important implications for mathematics teacher's practices and pre-service teacher preparation. My study presents a source of information to help teachers develop an action plan for appropriately integrating the calculator in their classroom. Data from these experienced teachers will help prepare pre-service mathematics teachers by making them aware of issues and common uses of the calculator at each grade level. Analyzing data about teacher's beliefs will allow teachers to learn about how other teachers use the calculator. In turn, teachers will be encouraged to reflect and modify their own methods to enhance student learning.

Another implication of this research is that it would be beneficial for all mathematics teachers, but especially middle school teachers, to get more professional development for integrating the calculator into their classrooms. Middle school teachers reported attending few, if any, professional development seminars regarding calculator use and this may be reflected in their teaching with the calculator.

Recommendation for future research

A future study should focus on calculator use from the student perspective. Special education students and those with learning disabilities should be included. It would be interesting to compare a study concentrating on students to my study focusing on teachers. The data obtained from students about their experiences, attitudes, and beliefs about using calculators in mathematics may or may not correlate with the data I obtained from teachers in this study.

As the population of my study was small, I would also recommend replicating the study with a larger sample, over a longer period of time. A larger sample would integrate a more diverse perspective and create a deeper understanding. For these reasons, more research on calculator use is necessary.

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Appendix A**Teacher Questionnaire Part II**

24. How many times on average do you use a calculator in a week?

- A) 0-5 B) 6-10 C) 11-15 D) 16+

25. Which of the following have you used a calculator for in the last month?

(Check all that apply)

- A) graphing/graphic representation
 B) computation/basic operations
 C) multiple representations of a problem
 D) problem solving
 E) investigation/exploration/ discovery learning
 F) checking answers
 G) data collection
 H) on student tests
 I) on student homework

26. What in your opinion are the advantages of using a calculator?

27. What in your opinion are the disadvantages of using a calculator?

28. What challenges do students encounter when using a calculator?

29. Approximately how many professional development seminars have you attended regarding calculator use? _____

- Would you consider them beneficial?

- How could they be improved?

Appendix B

Teacher Interview Questions

Basics

Grade/Class taught: _____

What calculator do you use in your classroom?

Do you use calculator emulator software?

Do you have a classroom set of calculators?

- If yes, can you estimate how many calculators are in the room?

Frequency

1. How often do you use a calculator in your classroom?

Students

2. How do you think the calculator effects student attitude and development of mathematical skills?

3. Do you feel students who own a calculator have an unfair advantage compared to those students who don't?

Teacher Beliefs

4. Is calculator use limited in your classroom?

5. In your teaching experience, what are the disadvantages of using a calculator?

6. In your teaching experience, what are the disadvantages of using a calculator?

7. Do you teach any special education classes?

- If yes, do you make modifications when using the calculator with special education students?

8. Have you attended professional development seminars regarding calculator use?

- If yes, what was the topic?
- Did you find it beneficial?
- If no, would you like to?
- Do you feel you have adequate training and/or professional development for calculator use?

Appendix C Calculator Terms

Information from Texas Instruments Website

http://education.ti.com/educationportal/sites/US/productHome/us_product.html

1. Texas Instruments (TI)

- A company that works with educators throughout the world in designing and developing classroom technology.

2. TI Math Explorer

- The two-line display scientific calculator with fraction capability is a durable and affordable calculator for the classroom. The two-line display helps students explore math and science concepts in the classroom.
- **2 Constant keys with counter:** Help build tables and develop concepts of multiplication, division, and unit-of-measure conversions.
- **Integer division key:** Expresses results as quotients and remainders.
- **Symbolic value of π :** Recognizes π as a symbol in radian mode.
- **Basic scientific and trigonometric functions**



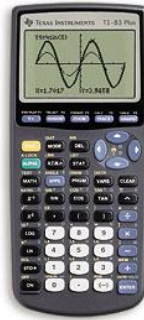
3. TI 30X

- The two-line display scientific calculator combines statistics and advanced scientific functions and is a durable and affordable calculator for the classroom. The two-line display helps students explore math and science concepts in the classroom.
- **Fraction features** Allows operations with fractions and mixed numbers.
- **2-Variable statistics** Enter/delete/insert/edit individual data elements.
- **Conversions**
Fractions/Decimals, Degrees/Radians/Grads, DMS/Decimal/Degrees
- **Symbolic value of π** Recognizes π as a symbol in radian mode.
- **Basic scientific and trigonometric functions**



4. TI-83 & TI-84 Calculators

- Easy-to-use graphing calculators for math and science that lets students graph and compare functions, as well as perform data plotting and analysis. Memory allows students to update and add software applications.



5. TI Smartview

- Software that complements the TI-83 Plus and TI-84 Plus families of graphing calculators, letting the educator project an interactive representation of the calculator's display to the entire class. It is an ideal demonstration tool for leading classroom instruction of math and science concepts.
- Easy operation with the educator's computer or calculator as a remote keypad
- Easily integrates with existing projection systems and interactive whiteboards

6. TI-Nspire Calculator –

- Texas Instrument's newest graphing calculator. Multiple representations let you manipulate and view up to four representations of a math problem at once. Grab and Move features give you the ability to navigate seamlessly between lines, parabolas and more. Ability to interchange keypads When you snap on the TI-84 Plus Keypad, you get all the features of the TI-84 Plus - a great added value.

