Calculator Use in the Middle School Classroom

Julie Forman
St. John Fisher College

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Abstract
The use of technology in the classroom is a growing trend among many schools. Scientific calculators are appearing more frequently in middle school classrooms. The purpose of this study was to determine if calculators have a positive or negative effect on student performance. Fifty-one students completed two, thirty multiple-choice question assessments, the first without a calculator and the second with a calculator available if they chose to use it. The majority of students did increase their score when a calculator was available, however a small percent of the students saw a decrease in their performance. The benefits of calculators in the classroom are dependent on the students' ability to know when to use the calculator, what it can be used for, and how to actually perform the calculator functions.

Document Type
Thesis

Degree Name
MS in Mathematics, Science, and Technology Education
Calculator Use in the Middle School Classroom

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Abstract

The use of technology in the classroom is a growing trend among many schools. Scientific calculators are appearing more frequently in middle school classrooms. The purpose of this study was to determine if calculators have a positive or negative effect on student performance. Fifty-one students completed two, thirty multiple-choice question assessments, the first without a calculator and the second with a calculator available if they chose to use it. The majority of students did increase their score when a calculator was available, however a small percent of the students saw a decrease in their performance. The benefits of calculators in the classroom are dependent on the students’ ability to know when to use the calculator, what it can be used for, and how to actually perform the calculator functions.
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Calculator Use in the Middle School Classroom

The years are progressing and technology is advancing. However, the educational world is facing a growing debate about the use of technology in the classroom. Although many educators are in favor of classroom technology, a strong debate focuses on the idea of students using calculators. Questions that are arising in this debate include what will happen to pencil-and-paper computational skills, will students become calculator dependent, what effect will calculators have on number sense, and when does use become dependence.

Students have grown accustomed to using calculators at both home and school. They are knowledgeable on how to use them and look for opportunities when they can assist them in their mathematical tasks. Some teachers welcome calculator use in their classrooms while others shun students who reach for the tool. Both groups are vocal about their positions but neither will listen to the other's perspective. Valuable time with our youth is quickly passing and they deserve the best education teachers can provide, regardless of the calculator debate.

The conclusion of this research will bring a deeper understanding of the attitudes and perceptions of middle school students about calculator use in the classroom. The research will lead to a greater teacher understanding as to the benefits calculators hold for the students surrounding mathematics education.
Literature Review

Technology is an important piece to our growing society and therefore needs to be addressed in the educational classroom. It is inconsistent for people to use calculators daily in our adult lives for personal and business purposes yet deny students to opportunity to explore the power of this technology in the classroom (Kaiser, 1991, p. 39). The idea that calculators are important to teaching is not being disputed. However, the discrepancy occurs with what is considered acceptable calculator use for students of each educational level.

Monitoring Calculator Use

The literature states, “The real issue is not whether calculators should be used in mathematics classrooms; it is how calculators should be used in classrooms” (Kaiser, 1991, p. 4). This is important because children need to know how to apply calculator functions, not just know how to do them without mathematical context. In an effort to overcome this battle, Calculators and Common Sense, an article written by Jon L. Higgins (1990) supports the idea of using calculators to challenge students to real-world problems and to explore deeper mathematical ideas. The author goes as far as offering the following suggestion, “Perhaps the National Council of Teachers of Mathematics (NCTM) should issue licenses that would permit mathematics teachers to use calculators in classrooms; teachers who could not give examples of mathematical explorations with calculators should be forbidden to use them in teaching” (1990, p. 5). Higgins also offers an example of a contest between himself and ten fourth graders in which both groups had to solve twenty simple subtraction problems. The fourth graders were instructed to make paper-and-pencil calculations while Higgins had to use the calculator. The challenge
allowed the students to see that there are situations in which using a calculator may not be the best method to solve the problem.

In order to achieve such a high-level of application, the article *Calculators in the Classroom* (Kaiser, 1991) offers guidelines for teachers to consider when deciding to incorporate calculators into their mathematics curriculum. The literature specifies that the teacher should remain in control of which lessons are appropriate to permit students to use calculators, since the majority of students have difficulty with this concept. Other literature supports the idea of monitoring the lessons that allow calculators to be used. In the article *Deciding When to Use Calculators*, Sproule and Thompson (2000) offer an easy-to-follow framework for teachers. There are two main areas to consider before allowing students to use calculators on a lesson. First, ask yourself if individual students have the necessary skills to complete any computational work that is involved. If they cannot do the computation, a calculator is necessary. If the work can be completed but is tedious, a calculator may be a better option. Second, ask yourself what educational goals surround the lesson. If the purpose is strictly to compute a solution, it may be best to have students avoid using the calculator. However, if the problem has multiple steps or contains real-world data, it may be beneficial to allow students to use calculators in an effort to grasp the higher concept (Sproule, 2000).

Sproule and Thompson (2005) wrote a similar article suggesting the same framework for working with special needs students. *Calculators for Students with Special Needs* states that if a child is learning disabled in some way that impairs their ability to do mathematical computation, the child should be allowed to use a calculator to complete the computation in order to deepen their mathematical understanding. In fact
most of the teachers who use the framework have decided that when students with special needs would like to use a calculator, then all students are allowed to use a calculator. The literature (Sproule, 2005) reports that “none of the teachers have experienced a decline in students’ computational ability, and all have found that using the calculator increased the participation of all students in a wider variety of mathematical activities” (p. 394). The technology of the calculator allows for greater ownership of mathematics concepts. When calculators are available in the classroom all students are on an even playing field regardless of the previous mathematics background.

In the article Calculators in the Classroom, the author offers guidelines regarding a child’s need to learn how to perform calculations by hand as compared to a calculator. Gilliland presents the point that the students are the true power behind the calculator. “Calculators are the word processors of mathematics. A word processor cannot write a story by itself, and a calculator is useless unless it is in the hands of a person who has the problem-solving skills to know which buttons to push and when” (Gilliland, p. 151). Kaiser (1991) also states that estimation skills need to be constantly reinforced when students are using calculators. Students need to possess the ability to correctly judge if their calculated answer is reasonable.

The idea that students need to know mathematics in order to use a calculator also appears in Clearing Up the Confusion Over Calculator Use in Grades K-5 (Reys, 2001). There are many children who were never allowed to use calculators and therefore believe that using a calculator is considered cheating. This is a misconception that parents and teachers must try to correct. These students need to “understand that real mathematics is about thinking, applying strategies, reasoning and relating ideas. Computation is a
necessary tool in the process, but it is only one part of the whole process that makes up mathematics" (Reys, 2001, p. 93). Again Kaiser’s estimation claim is valid. Students must be able to recognize an unreasonable answer is due to human error using the calculator or incorrect application of calculator functions.

Also, the literature (Reys, 2001) states that calculator use should not be considered an all-or-nothing decision. The positive use of calculators in the classroom requires teachers to make good decisions and guide their students appropriately to become responsible technology users. Reys talks of a visionary classroom in which both students and teachers use many tools, such as counters, rulers, graph paper, scales, geometric shapes and solids, textbooks, instructional software. Calculators should be only one of the tools available for student use in a mathematics classroom.

Mathematics Misunderstanding

There are educators who believe that calculator use is a scapegoat for other mathematical dysfunctions. In Calculators: Have we moved forward since the ‘70’s? Janet Duffin (1999) explores the attitudes of mathematics educators and the general public throughout the decades of technology advancements. She states that both groups believe that calculator use makes students become lazy and that their mental math capabilities are lost. Duffin defends the technology movement in schools, but feels that they have been wrongfully blamed for such decline. Instead, she attributes this mental math decline to the implementation of calculators along with the paper-and-pencil methods without the accompanying proper mental math skills, primarily estimation. There is a lack of real-world estimation skills that is the true reason for the decline.
A Dependence on Technology and Algorithms or a Lack of Number Sense?

(Gordon, 1999) follows the same belief that calculators are being wrongfully accused for students' mathematical ability decline. Gordon correlates algorithms used with paper-and-pencil and calculator use. Both apply a process and arrive at an answer. She believes that the true culprit is that many children and adults lack an overall number sense. Gordon offers an example of a cashier where the total amount due was $3.28 and the customer gives the cashier a $5.00 bill. The register calculates $1.72 as the change but meanwhile the customer has found $0.03 that they would like to use. Now the cashier is at a loss for what to do. Gordon believes that algorithms offer people a variety of ways to recognize and practice relationships in and between numbers and number operations.

Much of the literature addresses the position of the National Council of Teachers of Mathematics (NCTM) on calculator use in the classroom. Calculators in the Classroom by Alain Jehlen (2001) offer examples of teachers who frequently use calculators with their students for investigation, enhancement or to give much more complex problems to younger students to expand their mathematical thinking. The same is true with NCTM Elaborates on Position on the Use of Calculators in the Classroom (Cavanagh, 2005). Cavanagh explains the NCTM idea of a balance between paper-and-pencil computations and calculators, as compared to an all-or-nothing approach. This relates back to the previous section, which discussed teachers and parents monitoring calculator use and teaching students when it is appropriate to use a calculator.

Computation, Calculators and Common Sense is the official NCTM position on the long-standing debate. NCTM states that the purpose of calculators is for teachers to
take advantage of the appropriate use of technology to expand students' mathematical understand, not to replace it. NCTM also follows the idea of two previous articles that it is essential for students to have estimation and mental math skills. This also includes a good rationale for each of the operations, which would allow students to be proficient at solving mathematical problems. NCTM stresses that the overall responsibility of student calculator use falls onto the shoulders of the teachers. It is their responsibility to teach students when it is appropriate to use each method of problem solving.

*International Comparisons*

Many of the recent mathematics curriculum series encourage students to use calculators. *Calculator in class: Freedom from scratch paper of 'crutch'?* (Clayton, 2000) offers contrasting opinions on the calculator debate. Clayton discusses the recent wave of "new new math" programs such as Mathland, Everyday Math, and Connected Math and their strong views on student calculator use. All three programs heavily use calculators yet were rated by the Education Department as "exemplary" or "promising" (p. 20). This statement shows Clayton references David Klein, a professor at California State University, for the counterargument. Klein states, "The highest-performing countries on international math tests used calculators less. At the eighth-grade level, students from three of the top five performing nations in math (Japan, Korea, Belgium) rarely or never used calculators. But in the United States and 10 of 11 nations with scores below the international average, many used calculators every day" (p. 21). This is important since all of the recent mathematics programs are incorporating more calculators and other technology into the classroom.
This view is also found in *Math Progress Hard to Figure: Calculator Benefit Varies with Grades* (Henry, 2001). The article references the views of the National Assessment of Educational Progress (NAEP). In 2000, NAEP found that fourth graders who frequently used calculators had significantly lower math scores than their peers who used them occasionally. However, this did not hold true at the eighth and twelfth grade levels where more frequent calculator use was associated with higher math scores. The NAEP states that this may focus on the need for fourth grade students to learn in depth about the operations, estimation and the base-ten number system. Calculators may hinder the process at such a young age but prove beneficial at the higher grades once the number sense base has been developed.

*Endless Ping-Pong Over Math Education* (Lewis, 2005) highlights the blame game that has surrounded the calculator debate. Lewis cites recent contrasting studies about the positive gains made in various grade levels compared to international counterparts. The literature attributes the decline in success to the misunderstanding of the NCTM and state standards by mathematics educators. The standards call for increased use of technology as well as a deep understanding of mathematical concepts. Lewis feels that mathematics educators have completed the first goal in place of the second. The two goals were meant to go hand in hand but most educators tend to conquer one goal or the other.

In an effort to compare the mathematical ability of eighth-graders from the United States with various nations, a study was done using calculator use data from the Third International Mathematics and Science Study (TIMSS). *A Comparison of Calculator Use in Eighth-Grade Mathematics Classrooms in the United States, Japan, and Portugal:*
Results from the Third International Mathematics and Science Study (Tarr, 2000) assesses the relationship, if any, between student performance and calculator use. Eighth grade students from the United States and Portugal both show frequent calculator use, whereas Japanese students rarely use calculators at the eighth grade level. Japan was selected for the study because they were one of twenty nations that scored significantly higher than the United States where Portugal was selected because they were one of the seven nations that scored significantly lower than the United States.

The literature also stated that there are only three specific standards for the Japanese eighth-grade year, as compared to the numerous standards for the United States.

A Survey of Calculator Usage in High Schools (Dion, 2001) reports data that the majority of high school classrooms in the United States allow students to use calculators during everyday lessons as well as tests. The literature states that the majority of assessments do not require the higher level of thinking that is expected with technology use and needs to be corrected. Also, the ability to use the calculator on assessments invites students to learn the process of finding the answer without learning the true concepts. Students who depend on calculators are moving toward computation skills rather than problem solving skills.

The article Classroom Technology: Tool for, or Focus of, Learning? (Day, 1996) offers a self-reflection for teachers who are in favor of incorporating technology into the mathematics curriculum. Day presents eight reflection questions that suggest technology remains the focus of learning for your students, rather than the tool that it is meant to be. It is the job of the teacher to create exploration activities and extensive problem situations to help students internalize the significance of a calculator and other technology devices.
Calculations About Calculators (Bracey, 1997) references an article published in Educational Assessment that reviews the literature available on student calculator use during assessments. The article states, “Students who use calculators have better attitudes toward assessments and feel empowered. Using a calculator frees students from having to devote a lot of time and energy to actual calculations” (p. 473). A similar belief was concluded in Technology in Support of Middle Grade Mathematics: What Have We Learned? (Guerrero, 2004). When technology is applied properly in the middle grades, there can be positive effects on the students’ attitudes about learning, confidence about mathematical concepts, and willingness to engage in mathematical problem solving.

A number of educators believe that student attitudes are related to calculator use but have difficulty overcoming their own beliefs. Research on Middle Grade Teachers’ Beliefs about Calculators attributes a lack of calculator use in the middle grades to the teachers allowing their personal views about mathematics and paper-and-pencil computations interfere with technology advancement. Calculators are suggested for use in a constructivist classroom environment, which is not the philosophy for the majority of middle grade classrooms. However, teachers did state that they would be more willing to use technology in the classroom if there were professional development opportunities to increase their knowledge of the technology available.
Methodology

This study was designed to compare the performance results of middle school students on a mathematical assessment with and without the availability of a calculator.

Participants

The study involved approximately seventy seventh-grade students that attend a suburban K-12 educational institution. The subjects are age-appropriate for the seventh-grade and have no history of failing a mathematics class throughout their educational career. Also, seven of the students are classified with Individualized Education Plan and one student has a 504 Accommodation Plan. Due to the subjects' ages and the nature of the study, subjects will remain anonymous and the researcher will be accountable for upholding the expectation granted with their participation. Each student was assigned a student number for further identification throughout the study.

Prior to the study the subjects were in a mathematics classroom environment where calculator use was encouraged. Students had a classroom calculator available to them at all times and were encouraged to use it whenever needed. There was one unit of study, operations with rational numbers, in which the teacher prohibited students from using the calculator. The reason for this was that the unit was testing the students' ability to compute each of the mathematical operations using whole numbers, fractions, decimals, and integers.

Instruments and Materials

The subjects completed a thirty question multiple-choice midterm twice, with and without the use of a calculator (see Appendix A). The midterm questions were taken from the previous units of study up to the time of the midterm. Concepts that appeared
on the midterm were multiples, factors, scientific notation, exponents, order of
operations, fraction operations, measures of central tendency, rational numbers, algebraic
expressions, coordinate pairs, area, and interpreting graphs.

All questions were taken from Book 1 of the 2005 New York State Mathematics
Sample Tests for grades six and seven. The New York State tests are published by
McGraw Hill and are tested for reliability and validity. Since the standard directions of
Book 1 do not allow for use of a calculator, all questions could be answered without the
use of a scientific calculator.

Subjects used a number two pencil to mark their answers on the scantron sheet.
The test booklet was available for students to complete calculations, if needed, during
both sessions.

Data Collection

Each of the of the assessments were collected immediately after it was
administered to document any differences in the quality of the students’ work. All
student responses were corrected by scantron; none of the work in the test booklet was
graded. During the second assessment, students marked a star next to any problem in
which they completed using a calculator. The second test booklet was then reviewed
only to analyze when each student used the assistance of a calculator when answering the
questions.

Procedures

The study began with a baseline assessment of the subjects’ knowledge. Students
took a thirty multiple-choice question midterm without access to a calculator. In the
eight weeks after the baseline assessment, students reviewed test-taking strategies, both
multiple choice and extended response, in preparation for the upcoming New York State Assessment. Multiple choice strategies discussed were reading questions and answers completely, highlighting key information, deciding what the question is really asking, eliminating unreasonable answers, working backwards, and drawing pictures. During this time calculator functions were also reviewed for the extended response portion of the exam. This included basic operations, fractions, roots and exponents.

At the end of the eight weeks and after the New York State Assessment, students were given the midterm for a second time with access to a scientific calculator. The students were told that they could use the calculator that was provided for them to answer any of the questions if they chose to do so. If they did use a calculator for part of any question, the students were directed to mark a star next to that specific problem on their test booklet (see Appendix B). They were told that they were not being judged on how many times they did or did not use the calculator, and that the results would not influence their quarterly average.
Results

Due to outside circumstances such as absences, fifty-one students from the original seventy were able to complete the second part of the study. Therefore only three of the students are classified with Individualized Education Plan and one student has a 504 Accommodation Plan.

The majority of students had a significant score increase when a scientific calculator was provided for student use. Of the fifty-one students that participated in the study, 53% increased their midterm score when allowed to use a scientific calculator on an “as needed” basis (see Appendix C). Of the students who raised their score, 26% increased their score by five or more points. This resulted in an overall score increase of at least 16%.

Approximately 29% of the participants scored worse when the assessment was presented with a scientific calculator (see Appendix C). 20% of this group missed five or more questions on the second assessment in comparison to the first.

The remaining 18% of the students did not have any change in their score when a calculator was provided (see Appendix C). These students scored produced identical scores on the assessment with and without the use of a scientific calculator. Although, the number of questions wrong may not have changed, the subject may have missed different questions on the second assessment.

When isolating students’ performance on individual questions, 69% answered at least one question incorrectly without the calculator but then answered the same question correctly using a calculator on the second assessment. However, 47% answered at least
one question correctly without the calculator and then answered the same exact question incorrectly using a calculator on the second assessment (see Appendix C).

The final portion of the research determined which questions the majority of students used the calculator to answer when given the opportunity. A minimum of 40% of the students used a calculator to determine their answer on the following mathematical concepts: calculating area of two-dimensional figures, executing the order of operations, measures of central tendency (specifically the mean), writing algebraic expressions and calculating exponents.

The mathematical concepts in which less than 2% of the students used a calculator to determine their answer were geometric and algebraic in nature. These topics included the following: identifying polygons, parts of a circle, measures of central tendency (specifically the median), interpreting graphs, writing algebraic expressions and identifying irrational numbers.

There were no adjustments that were made from the above methodology. The second assessment occurred a week later than planned due to a state assessment that was being administered during the original week. This was done to prevent any outside variables that may have occurred in conjunction with the state assessment.
Discussion and Conclusion

There is a definite effect on the performance of middle grade students when a calculator is available for them to use on a given assessment. These effects can be positive or negative, depending on the student.

Just over half of the students who participated in this research study increased their performance with the help of a scientific calculator. Most students used the calculator for computational questions, such as calculating the area of a two-dimensional figure or the mean of a data set. The majority of these types of computations could be completed without the calculator, but the students are aware of the technology that is available and know that they can avoid making small mathematical errors if they use the calculator.

Then there is the group of students who scored the same on the assessment with and without the addition of a calculator. It did not matter if the students were completing the work by hand or with a calculator, they were able to achieve the same score both ways. Unfortunately the results do not account for the fact that the questions that the student answered incorrectly on the first assessment are different from the questions that were incorrect on the second assessment. Out of the small percentage of students who did not see a difference in their overall performance between the two assessments, none of the students had the exact same questions wrong on the two assessments. This would be a good opportunity for further research in the area of calculator usage.

Although it is somewhat surprising, there are a variety of reasons why some of the students scored worse on the second assessment with the aid of a calculator. It is common for teachers to complain that students focus more on what to do with the
calculator than solving the actual problem. Many students feel that they have to use the calculator if it is available to them. This is a mindset that needs to be broken. If it is easier for the student to complete the problem without the assistance of a calculator, the student should be encouraged to do so without the technology.

The second research question compares students who can answer a question incorrectly without a calculator but correctly with a calculator. I believe that the 69% of the students who had this occur at least once during the study used the calculator for one of two things. First, the calculator was used for simple math to avoid any arithmetic errors (see Appendix D), or secondly, the calculator was used to guess and check the presented answers and then the student used the elimination method. It is comforting to see that the technology worked in favor of the majority of the students one way or another.

However, the other piece of this research segment is that 47% of the students experienced the opposite, where they answered a question incorrectly with a calculator after they answered it correctly on the first assessment. There are a variety of measures of error as to why this occurred. The simplest reason being that they incorrectly marked the wrong answer on their scantron sheet. This reason also holds true for the previous statistic where calculator use is favored.

A common misconception in the classroom is that students believe the calculator is always correct. It is difficult to distinguish the difference for students between the calculator being a piece of technology to eliminate pesky mathematical errors and the idea that if the wrong information is entered into the calculator or the wrong function is chosen, then the answer will be incorrect (see Appendix E). Many students have
difficulty believing that an answer, which was determined with a calculator, can be wrong. Students need to be taught that the calculator is always correct only if input the mathematics correctly.

This is where the literature discusses the idea that students do not have a strong number sense. Although the calculator should produce the correct answer, there is a chance for human error. It is up to the student to recognize an answer does not make sense for the question that they were asked. Students have a tendency to use the answer that appears on the calculator without questioning if the answer makes sense. If it does not make sense, students should be encouraged to reattempt the problem, checking their arithmetic and their mathematical process that was used.

The third and final question that was evaluated during this study was which types of questions are students frequently using the calculator to answer. The questions in which students used their calculators most frequently were computational-based, such as calculating area and mean. This is not surprising considering that those tasks are not difficult; they only require students to know a method of simple operations in order to solve the problem. Although these are the easiest types of questions, I believe that they are the most popular for calculators because completing the arithmetic by hand or mentally can be tedious and accentuates the possibility of errors. The most difficult types of questions, those that require mathematical reasoning or problem solving, did not prove to be calculator friendly to the students. I imagine a few used the guess and check strategy for an algebraic expression question, but otherwise did not choose to apply the calculator, which was available to them.
The most interesting part of conducting the research occurred when explaining the guidelines for the second assessment to each of the student groups. Each group was disappointed to hear that they had to complete thirty multiple-choice questions; some even made comments under their breath or groaned out loud. However, in the next sentence when I explained that a calculator would be available for them use on the assessment the students smiled and breathed a sigh of relief. It appeared that many of the students thought that they would do better or that they assessment would be easier because they had the opportunity to use a calculator. As the research shows, this did prove to be true for about half of the students, but had the opposite effect on others.

The idea that needs to be discussed is what are you assessing by asking a specific question. If you are trying to assess the students’ ability to perform basic operations then it may be inappropriate to have calculators available for students to use. However, if you are interested in a more complex problem or would like your students to calculate the mean, you should be focusing more on the process in which they use to get to the answer, not their ability to add and divide the numbers.

In comparison with the current literature, technology can have both a positive and negative effect on a group of students. It is the responsibility of the educator to make the important decision as to the type of access students should have to technology and how to incorporate it into the current classroom curriculum and environment. The majority of students continue their previous educator’s position on calculator technology. It is important for students to have the same level of understanding and acceptance as their current educator to prevent too little or too much dependence on a calculator.
Students at all levels are using calculator technology without understanding the basics of the device in front of them. For example, students become accustom to one specific type of calculator and do not know how to transfer their knowledge to another calculator of the same level. It is important for teachers to take the time to teach students about the calculator and give students multiple opportunities to explore the functions that are available on their calculator. Teachers should therefore use the correct mathematical terminology to describe each of the functions and show how they may appear depending on what brand or level of calculator you are using. An example that many upper elementary and middle school mathematics teachers fall victim to is referring to the exponent key as the “carrot” key. On the Texas Instrument scientific calculator the exponent key resembles the insert mark for editing writing, which is commonly called a carrot. Therefore the students that do not have this calculator are confused when the carrot key is not present. Instead, they need to use the \( y^x \) key, so the carrot reference does not carry the same weight as with the other calculator. If students were taught the true name key and it’s the function then it would not matter which calculator the student had in front of them.

A large benefit of learning the functions of a calculator comes in the area of fractions. Students of all ages struggle with fraction concepts and yet fraction functions are standard on all scientific calculators. Although it is important to teach the basics of why fractions exist and how the operations work, when students reach a certain level it is good for them to know that the applications appear on the calculator. Many students break down when they are faced with a problem dealing with fractions. If they were
aware of the fraction functions on their calculator and how to use them properly, the student may have a better chance to answer the problem correctly.

The idea of technology in the classroom is becoming more prevalent in our schools and needs to be addressed formally in a more in-depth manner. The technology is continuing to permeate our educational society and therefore we need to be willing to look more closely into the positive and negative effects it has on our educational system. One area that could benefit from more research is the long-term effect calculator use has on number sense. Many older adults tend to criticize younger generations on their inability to think mathematically in real-world situations. It would be extremely beneficial to educators to see if this is a growing trend and how it can be reversed.

Professional organizations (mathematics and education), state governments and educators who are in the classroom everyday need to come together to establish common goals for mathematics education, especially in this country. As a whole our mathematical abilities are declining and all involved seem to be heading in different directions. Research needs to be established to get all involved on one proven curriculum track, which will increase our overall mathematical instruction.

Another area for further research would be differences in incorporating mathematical technology among different countries of the same socioeconomic status. Do students in the United States depend more on calculators when compared to their counterparts in China, Japan, England or Canada? How does each country’s stance on technology affect the long-term mathematical thinking and ability of their youth?

When technology is used appropriately in the middle school classroom, it can have positive effects on students’ motivation and performance on a mathematical task.
Educators are responsible for instilling values of proper calculator use and educating their students about the functions that are available on calculators. This however, should not take the place of basic mathematical thinking that would decrease the students' number sense. The idea of calculator technology in the classroom needs to be explored more deeply by all parties involved in order to provide the best mathematics curriculum and better prepare our youth.
References


http://www.nctm.org/about/position_statements/computation.htm


Appendices

Appendix A: Midterm
Course 2 Midterm

Multiple Choice
Identify the letter of the choice that best completes the statement or answers the question.

1. What is the area of the rectangle drawn on the coordinate plane shown below?

![Coordinate Plane Diagram]

A. 21 square units  
B. 24 square units  
C. 28 square units  
D. 32 square units

2. Identify the base or bases of each figure.

![Pyramid Diagram]

F. pentagon  
G. square  
H. triangle  
I. circle

3. What line segment represents a diameter of the circle above?

A. \( \overline{KF} \)  
B. \( \overline{FH} \)  
C. \( \overline{KG} \)  
D. \( \overline{GH} \)
4. Ned wants to draw a pentagon on the grid below by plotting a fifth point and then connecting all points.

Which coordinates would **not** make a pentagon?

- F (5, 8)
- G (6, 7)
- H (7, 2)
- I (8, 4)

5. Willard has a stained glass window with one triangular piece shown below.

What is the area, in square inches, of the triangular piece?

- A 14
- B 24
- C 48
- D 96
Kevin designs a sprinkler system for his yard. One rotation of the sprinkler waters a circle with an area of 225π square feet. What is the radius, r, of the circle the rotating sprinkler waters.

\[ A = \pi r^2 \]

F 15 ft  
G 25 ft  
H 30 ft  
I 47 ft

7 What is the least common multiple of 3, 6, and 27?
A 3  
B 27  
C 54  
D 81

8 Last year 9.9 \times 10^5 people attended the New York State Fair. What is this number expressed in standard form?
F 9,900  
G 99,000  
H 990,000  
I 9,900,000

9 Simplify the expression below.
\[ 3^3 - 2^2 \]
A 1  
B 5  
C 23  
D 25

10 What is the greatest common factor of 12, 16, and 20?
F 2  
G 4  
H 6  
I 12

11 Which number has the greatest value?
A 6.7 \times 10^4  
B 7.6 \times 10^{-4}  
C 8.9 \times 10^3  
D 9.8 \times 10^{-3}
12. What is the least common multiple of 4, 5, and 6?
   F 30  
   G 60  
   H 90  
   I 120

13. Simplify the expression below.
   \((6^2 - 2^4) \cdot \sqrt{16}\)
   A 16  
   B 64  
   C 80  
   D 108

14. A.J.'s soccer team won \(\frac{4}{5}\) of its games. What is another way to write this number?
   F 0.2  
   G 0.4  
   H 0.5  
   I 0.8

15. A city council recorded the number of new trees planted at seven of the city's parks. The number of trees planted is recorded below.
   29, 11, 13, 29, 7, 21, 16

   What is the median number of trees?
   A 16  
   B 18  
   C 21  
   D 29

16. Jacob received the following scores on his last five science tests.
   81, 73, 80, 94, 97

   What is the range of Jacob's scores for these five science tests?
   F 16  
   G 24  
   H 81  
   I 85
The graph below shows the number of animals on Glenda's farm.

What is the total number of animals on Glenda's farm?

A 15
B 27
C 37
D 38

The U.S. Basketball team has the following shoe sizes.

8, 6, 7, 9, 8, 17, 8, 9

What is the mean shoe size for the team?

F 8
G 9
H 8 and 9
I 10
The pictograph below records Vista sunglass sales for 2004.

**VISTA SUNGLASS SALE FOR 2004**

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<tr>
<th>Color of Lens</th>
<th>Pairs Sold</th>
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<tr>
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<tr>
<td>Green</td>
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<td>Gray</td>
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</table>

**Key:**

![Image of sunglasses] = 10,000 pairs

Which color of lens had sales three times greater than one of the other color of lens?

A. brown  
B. gray  
C. green  
D. yellow

20. Cathleen planned to walk her dog for \( \frac{3}{4} \) of a mile. After it started to rain, she decided to walk only \( \frac{1}{2} \) of that distance. What fraction of a mile did Cathleen walk her dog?

F. \( \frac{1}{4} \)  
H. \( \frac{4}{6} \)  
G. \( \frac{3}{8} \)  
I. \( \frac{4}{8} \)

21. There are 30 pencils left at a school store after Shilo buys a certain number of pencils, \( p \). Delia buys 4 times as many pencils as Shilo. The expression below shows the number of pencils remaining at the store after Delia buys her pencils.

\[ 30 - 4 \times p \]

How many pencils remain at the store if Shilo bought 3 pencils?

A. 14  
B. 18  
C. 78  
D. 104
22. Mr. Bryant writes the expression below.

\[9^2 + 3n\]

What is the value of the expression when \(n = 3\)?

F 27  
G 9  
H 3  
I 2

23. Pat threw a football 5 more than twice a number of yards, \(y\), that Gary threw. Which expression can be used to find the number of yards Pat threw the football?

A \(2y - 5\)  
B \(2y + 5\)  
C \(5y - 2\)  
D \(5y + 2\)

24. On Friday, Extreme View Helicopter Tours flew 34 times. They flew the same number of times on Saturday as they did on Sunday. The total number of times they flew for the three days was 118. How many times did Extreme View Helicopter Tours fly on Saturday?

F 34  
G 42  
H 59  
I 84

25. What is "two more than the quotient of six and a number, \(n\)," written as an algebraic expression?

A \(6n + 2\)  
B \(6n - 2\)  
C \(\frac{6}{n} + 2\)  
D \(\frac{6}{n} - 2\)

26. Tyree’s solution for a division equation is 18. Which equation could Tyree have solved?

F \(\frac{720}{2} = w\)  
G \(\frac{425}{5} = x\)  
H \(\frac{600}{6} = y\)  
I \(\frac{162}{9} = z\)

27. Carmen put new tile on \(\frac{1}{4}\) of her bathroom floor. She put new carpet on \(\frac{5}{8}\) of another section of the same floor. What fraction of the bathroom floor is covered with new tile and new carpet?

A \(\frac{5}{8}\)  
B \(\frac{4}{12}\)  
C \(\frac{7}{8}\)  
D \(\frac{6}{12}\)
38. Jordan went swimming each day of his vacation. On Monday he swam for $\frac{3}{4}$ of an hour, on Tuesday he swam for $2\frac{1}{4}$ hours, on Wednesday he swam for $\frac{1}{2}$ of an hour, on Thursday he swam for $\frac{3}{4}$ of an hour, and on Friday he swam for $\frac{1}{4}$ of an hour. Which list shows the times in order from shortest to longest?

F $\frac{1}{4}, \frac{3}{4}, \frac{1}{2}, \frac{3}{4}, \frac{1}{4}$

G $\frac{3}{4}, \frac{1}{4}, \frac{3}{4}, \frac{1}{2}, \frac{3}{4}$

H $\frac{1}{4}, \frac{3}{4}, \frac{1}{2}, \frac{3}{4}, \frac{1}{4}$

I $\frac{1}{4}, \frac{3}{4}, \frac{1}{2}, \frac{3}{4}, \frac{1}{4}$

29. Which number is an irrational number?

A $\sqrt{5}$

B $-13.5$

C $\frac{7}{11}$

D $\frac{1}{\sqrt{9}}$

30. The expression $\frac{1}{15} + \left( \frac{4}{15} + \frac{1}{3} \right)$ is equivalent to.

F $\frac{1}{9}$

G $9$

H $\frac{1}{5}$

I $5$
Appendix B: Assessment Markings

13. Simplify the expression below.

\[(6^2 - 2^2) \cdot \sqrt{16}\]

A  16
B  64
C  80
D  108

14. AJ's soccer team won \(\frac{4}{5}\) of its games. What is another way to write this number?

F  0.2
G  0.4
H  0.5
D  0.8

15. A city council recorded the number of new trees planted at seven of the city's parks. The number of trees planted is recorded below.

29, 14, 10, 29, 7, 21, 16

What is the median number of trees?

A  16
B  18
C  21
D  29

16. Jacob received the following scores on his last five science tests.

81, 73, 80, 94, 97

What is the range of Jacob's scores for these five science tests?

F  16
G  24
H  81
I  95
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black - incorrect answers on assessment 1
red - incorrect answers on assessment 2
green - questions that a calculator was used
|   | Area | Polygons | Circles | Polygons | Area | LCM | Scientific Not | Exponents | GCF | Scientific Not | LCM | Order of Ops | Dec | Median | Bar Graphs | Mean | Pictographs | Fractions | Ops | Algebraic Exp | Exp | Algebraic Exp | Exp | Algebraic Exp | Exp | Solving Equations | Algebraic Exp | Exp | Algebraic Exp | Exp | Ordering Fractions | Fraction | Ops | Irational # | Totals | Change in score |
|---|------|----------|---------|----------|------|-----|---------------|----------|-----|---------------|-----|-------------|-----|--------|-----------|------|-------------|----------|-----|--------------|------|---------------|------|----------------|------|----------------|------|----------------|------|----------------|------|-----------------|--------|
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| student 14 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 11 | 11 |
| student 15 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 8 | 2 |
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| student 17 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 17 | 0 |
| student 18 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 5 | 2 |
| student 19 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 4 | 3 |
| student 20 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 4 | 0 |

- **black**: Incorrect answers on assessment 1
- **red**: Incorrect answers on assessment 2
- **green**: Questions that a calculator was used
| Student | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | Totals | Change in score |
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| Student 23 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 0 |
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| Student 25 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 13 | 3 |
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| Student 27 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 18 | 4 |
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| Student 30 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 | 3 |

*black - incorrect answers on assessment 1*
*red - incorrect answers on assessment 2*
*green - questions that a calculator was used*
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- **Black** - Incorrect answers on assessment 1
- **Red** - Incorrect answers on assessment 2
- **Green** - Questions that a calculator was used
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black - incorrect answers on assessment 1
red - incorrect answers on assessment 2
green - questions that a calculator was used
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- **Black**: Incorrect answers on assessment 1
- **Red**: Incorrect answers on assessment 2
- **Green**: Questions that a calculator was used
Appendix D1: Incorrect response followed by correct

Incorrect response without a calculator

9. Simplify the expression below.

\[ 3^2 - 2^2 \quad 3 \times 3 \times 3 - 2 \times 2 \]

A 1
B 5
C 23
D 25

Correct response with a calculator

9. Simplify the expression below.

\[ 3^2 - 2^2 \]

A 1
B 5
C 23
D 25
Appendix D2: Correct response followed by incorrect

**Correct response without a calculator**

21. There are 30 pencils left at a school store after Shilo buys a certain number of pencils, \( p \). Delia buys 4 times as many pencils as Shilo. The expression below shows the number of pencils remaining at the store after Delia buys her pencils.

\[
30 - 4 \times p
\]

How many pencils remain at the store if Shilo bought 3 pencils?

A. 14  
B. 18  
C. 78  
D. 104

**Incorrect response with a calculator**

21. There are 30 pencils left at a school store after Shilo buys a certain number of pencils, \( p \). Delia buys 4 times as many pencils as Shilo. The expression below shows the number of pencils remaining at the store after Delia buys her pencils.

\[
30 - 4 \times p
\]

How many pencils remain at the store if Shilo bought 3 pencils?

A. 14  
B. 18  
C. 78  
D. 104