Spring 2016

Calculators in High School Classrooms

Adam P. Rohrabaugh
University of Akron, apr23@zips.uakron.edu

Clay M. Cooper
University of Akron, cmc178@zips.uakron.edu

Adam Rohrabaugh and Clay Cooper

Calculators in High School Classrooms

University of Akron

Calculators

Abstract

In today's mathematics classrooms, calculators are becoming incredibly well known and used almost daily. However, there has been a common question about the use of these calculators: Is too much exposure to calculators causing students to become dependent on them and consequently start to forget basic addition, subtraction, multiplication, and division, leading into confusion on other mathematics topics because the most basic foundation of mathematics is not there? The purpose of this paper is to discuss both sides of this question by looking at different studies as well as provide our own experiences with this subject while working in different classrooms.

Introduction

While both of us have been working in the field of mathematics education, such as during student teaching, some common questions or statements we hear from either students, parents, and co-workers are:

- Do you allow calculators in your classroom?
- Can we use a calculator on the test?
- I can't do this without a calculator!

This lead us to wonder are students putting too much emphasis on calculators in order to do mathematics? In today's schools, technology is being used in most classrooms and some schools are BYOD, bring your own device. Every student has access to a calculator either on their cell phone or one they purchased for classes. With such easy access to the calculators, students use them for all types of number operations such as addition, subtraction, multiplication, and division. Over the length of all my fieldwork, We have seen numerous students immediately go to the calculator to do simple multiplication of one digit numbers as well as adding negative numbers. When asked to do the multiplication problem without a calculator, students were unable to correctly answer the question because they would normally go directly to the calculator because they always had access to it. Examples such as these are what drove us to look into this topic of calculators in mathematics classrooms. The main question of focus is: "Is too much exposure to calculators causing students to become dependent on them and consequently start to forget basic addition, subtraction, multiplication, and division,

leading into confusion on other mathematics topics because the most basic foundation of mathematics is not there"? This paper will go over why this question is important to us as future math educators, the possible benefits and problems of calculators, what research has shown dealing with calculators and student learning, and lastly our own opinions from classroom observations.

Why this topic is important

In every type of mathematics classroom in grades 7 through 12 there will be calculators present at some point during the year. Depending on the classroom and the teacher, students will have access to these calculators about every single day during class. While working on problems that involve numbers, our student teaching has shown us that the initial reaction for students is to go directly to the calculator for the part of the computation that the calculator can do. The calculator can help speed up the process of the problem and get the students back on track to finish the remaining part of the problem. While this may be a benefit to using the calculator, there is no way of knowing if the student used the calculator to make the problem easier or if the student could even do the calculation if the calculator was not there. This is the main reason this question is important to us. By using the calculators, there is not a way to determine whether the students have fully mastered addition, subtraction, multiplication, or division of numbers up to positive and negative 12. Many different types of mathematics require full mastery of this subject because these four operations are the basic building blocks of mathematics. For an example, factoring requires knowledge of all four of these operations. In order to

factor, the knowledge of finding all possible pairs of numbers that multiply to variable c in the equation $ax^2 + bx + c$ is required. A calculator is of little use if these pairs of numbers are not memorized because in order to find the pairs, random guessing will be the only method while using the calculator. These two pairs of numbers will also have to add to the variable b. So ontop of finding the numbers that multiply to variable c, they also have to add to variable b. In order to find these pairs, an efficient method is to have memorized times tables that are learned in grade school. The alternative option is to use guess and check with the calculator. From working on factoring in our student teaching and experiencing this first hand, mathematics such as this will never be fully mastered by students who have lost the skill of these small computations because the calculator fails to be of value. As a mathematics educator, our goal is to teach all different topics in mathematics to the students. However, it cannot be done if the students lack the most basic foundation of mathematics. If this problem is due to the dependency on calculators many students develop, then are the calculators providing the support that they are supposed to?

Possible Problems

Over time, calculators can cause problems if used more than necessary. A few types of problems we have encountered in the field are:

- Reliance on calculators in order to do simple computations
- Over time, the skill of addition, subtraction, multiplication, and division of single digit numbers slowly decreases.

Calculators

- Student's confidence in their own mathematical abilities will be lower.

These problems can arise in some students, all students, or no students depending on the classrooms in which they were taught. However, let's get into why these problems can occur for students who depend on a calculator in mathematics classrooms. If a student always has access to a calculator to do any type of calculation, over time a reliance will start to develop. There is a possibility that in order to do any calculation, the student will think they need the calculator because that is the only way they are familiar with. The saying "You play like you practice" can be used here. If the students practice problems in class, then for tests or later in life, they will only know how to use the calculator and not know how to actually do the work.

This leads us to our next point, the mastery of addition, subtraction, multiplication, and division will slowly wither away without practice throughout high school. Around middle school years, the students are first introduced to calculators. Keep in mind, they just finished fully learning how to do these operations in their math classes in the previous years. The students are encouraged to buy a calculator, usually a TI- 30X IIS. This type of calculator is mainly used to do the small computations of the above four operations. Starting around the 6th grade, the students buy this calculator and use it until somewhere around 10th or 11th grade. By these high school years, graphing calculators come into play. Graphing calculators, such as the TI- 84, do the same as the previous calculator but now they have many more abilities such as graphing various functions. Students have access to these calculators during all these years and are

encouraged to use it. From working in the field, our students who have used calculators for many years have developed a reliance on the calculator because roughly half the students have trouble multiplying single digit numbers as eleventh and twelfth graders.

The last possible problem calculators can cause is that it can lower student's confidence in their mathematical abilities. During middle school years and some high school, the calculation can be used to check work easily and verify correct answers. However, once students get into upper level high school mathematics, the calculator can assist in checking the work, but it cannot fully verify the work. Our students are used to having the calculator as a crutch, but when it cannot possibly be used any longer and is taken away, they lose the confidence the calculator gave them and begin to question their work on every step. The phrases we usually hear students use are:

- There is no way this is correct.
- This looks wrong.
- Can I use my calculator to solve this?

Ultimately, these three problems are possible problems that can occur and are what we have personally seen in our fieldwork.

Possible Benefits

Even though calculators can have some negatives to them, there are some incredibly useful benefits that they bring into the classroom. These are the few benefits that calculators provided to our students during our student teaching:

Calculators

- Helps save time for the students/educator because it gets rid of tedious steps in certain problems, such as three digit multiplication.
- This type of technology can help student learning by showing students things such as how graphs look and change depending on how the function changes.
- Brings an engaging aspect into mathematics classrooms.

Let's first discuss why the calculators can save time during class and for students. Some types of math problems can involve large numbers, getting into two, three, or even four digits and multiplying them together. This is where the calculators can be used positively because it can save time doing that part of the problem and can save the time of working the tedious calculation and get the student back on track of actually doing the math part of the problem in question. By having the ability to continue to work on the new material and not be bothered to do lengthy calculations, the students can ultimately spend more time on the new material and increase mastery. (Also, by referring to "lengthy calculations", these include the four basic operations with two digit numbers or greater. Using a calculator for these calculations are fine. But if the calculations are single digit numbers, these should not be done with a calculator because they should have been mastered at a younger age.)

Secondly, when students are in late high school years, they will start to work with graphing calculators. Graphing calculators have all the normal function of a generic calculator plus many other functions. The biggest change of switching to graphing calculators is that they can graph any type of function. By having access to these graphs,

students can see different transformations of parent functions, find the intercepts, asymptotes, and are even provided with a table. These graphing calculators help students who are visual learners. They can take any function and plug it into the graphing calculator and see what each piece of the function did to change the graph. This way, students are able to study math. Such as observing how graphs change, the students will be able to discover the formulas for transformations of parent function graphs. There is no longer any need to draw up rough sketches of the graphs when an exact graph can be shown to you. By working with graphing calculators, students will be able to learn about graphs faster and easier than having to draw them.

Lastly, by introducing calculators into math classrooms, it makes the classroom more interesting for the students. Being able to work on a calculator and not on paper/pencil like in other classes gets the students engaged and involved in the lesson. The only way students are able to learn is if they are engaged and participating in class. Thus, by bringing calculators into the classroom, it will help promote student learning, which is the main goal of education.

What Research has Shown

Now that we have discussed the issue and some possible pros and cons of having students use calculators, we will get into a study dealing with calculators in the classroom. From a study done by Christina Sheets, an instructor from the University of Nebraska-Lincoln, she used her eighth grade classroom. She limited calculator use to her students and then compared their computational skills before and after to see if there was

a difference. This study concluded that the students, when exposed to unlimited calculator usage, the scores on the computational section of the achievement test were slightly lower (Sheets 12). Also, from the box and whisker plot, the data showed that when the calculator usage was limited, the students showed slight improvement in test scores. When the students were not permitted to use the calculators, they focused more on computations. Sheets also goes into talking about how with a calculator, the students spent more time on problem solving than on computations. This leads us into the question of: Where is the boundary between order of importance for students on computational skills and problem-solving skills? Problem-solving skills are the main concern when working with mathematics, however, in order to solve the problem, computational skills are also required.

A Survey of Current Teachers

In addition to research and use of other studies, we conducted our own survey with the intent of acquiring a professional opinion from current high school math teachers regarding appropriate calculator use within the classroom. The instrument used to survey can be located in the appendix of this paper (page 20). High schools around the country were randomly selected, and their math faculty was e-mailed, requesting their participation in this survey. In our study, 156 teachers were asked to participate, and 10 completed the survey. The survey consists of 11 statements for which participants are asked to rank their agreement with the statement. Following these, there was one question regarding programs at the participant's school, as well as a feedback portion for

questions, comments and further opinion. Statements contained in this survey were focused around calculator use and the fundamental mathematical skills of the participant's students, or lack thereof. Any data or quotes referred to regarding this survey come solely from the results of the surveys completed by these ten participants.

Limitations of the Survey

Of the 156 teachers who were asked to participate, only ten responded and completed the survey. Thus, the population included in this survey may not provide an accurate representation of the opinions of American high school math teachers regarding calculator usage. The amount of statements and the wording of the statements that the teachers were given could also be considered a limiting factor upon this survey. There is also a possibility of bias within the statements. There may be certain viewpoints regarding calculators that teachers are unable to express by only indicating that they agree or disagree with the given statements. Granted, teachers were given the opportunity to express further opinion within the feedback section of their survey. Additionally, of the ten teachers who participated in this survey, only four different states are represented in the survey data, Ohio, Colorado, Kansas, and Oregon.

A positive quality of this survey is the wide array of courses that the surveyed teachers instruct, so more than one course perspective is taken into account. Amongst others, some of the courses taught by these teachers are pre-algebra, Algebra I and II,

Geometry, Trigonometry, Probability, Statistics, and Calculus. On the contrary, this could also be a disadvantage because the way a calculator in each course is somewhat different, potentially changing the students' reliance on calculators with each change or course. Many of these courses are taught at various difficulty levels; remedial, intermediate, and advanced or honors. Also, outside of three teachers at one school and two teachers at another, the survey population is decentralized. They are dispersed at different locations, and are not likely to know each other or collaborate with each other regarding opinions related to this survey. Thus, several different perspectives are shared. Lastly, another positive attribute of the conducted survey is its recency. As of April of 2016, all participants completed the survey within the last year.

Results and Analysis of the Survey

The data taken from the responses of the participants is displayed below in two charts, each reporting the data of six of the twelve items contained in the survey. "S1" indicates the results from statement 1 of the survey, "S2" indicates the results from statement 2, on so on. The leftmost column represents each participant of the survey. In order to retain anonymity, participants are recognized by the abbreviation of the state they are from and the number of years they have been teaching. KS (Ø) did not indicate the number of years they have been teaching. Amongst the others, participants have spent an average of 16 years teaching, rounded to the nearest year. Each row represents the responses of one individual participant. Each column underneath a statement represents the responses for that specific statement. The bottom row of each chart displays the

Calculators

numerical average of the responses to the statement above it corresponds to. For statements 1-11, participants were asked to rate the statement in the following way with regards to themselves: 1 (Strongly Disagree), 2(Strongly Agree), 3 (Neutral), 4 (Agree), or 5 (Strongly Agree).

	S1	S2	S3	S4	S5	S6
OH (5)	4	4	5	4	4	3
KS (Ø)	2	5	5	2	2	2
OR (37)	5	5	5	1	1	4
OH (8A)	5	4	4	5	4	4
KS (21)	5	5	5	5	5	5
OH (20)	3	5	5	5	5	2
OH (8B)	5	5	5	5	5	5
CO (6)	4	5	5	5	5	3
OH (23)	4	5	5	4	4	4
OR (15)	1	1	1	1	1	1
avg.	3.8	4.4	4.5	3.7	3.6	3.3

	S7	S8	S9	S10	S11	S12

Calculators

OH (5)	3	4	2	2	3	no
KS (Ø)	5	2	1	1	5	yes
OR (37)	4	4	1	5	5	yes
OH (8A)	4	4	4	4	3	no
KS (21)	5	1	4	1	5	no
OH (20)	3	4	1	1	3	no
OH (8B)	5	3	1	4	5	no
CO (6)	4	1	1	1	5	no
OH (23)	5	2	2	2	5	no
OR (15)	1	1	1	1	3	no
avg.	3.9	2.6	1.8	2.5	4.2	

Participant OR(15) is an extreme outlier in the data compilation and skews the averages of many of the statements downward. Statements 1 and 2 elicited a “4” or “5” response from all participants except OR(15). The strongest agreement amongst the teachers was found in statements 2 and 3, which both suggest the notion that a lack in fundamental mathematical skill results in a lesser conceptual understanding of high school math topics. There was a less resounding agreement, but still an agreement, that the surveyed teachers attempt to limit the use of calculators by their students on both in-class assignments and on tests. There is also a general agreement amongst the surveyed teachers that calculators are overused in middle and high schools, and also that students are becoming dependent on these tools for mathematical processes that are not typically considered to require a calculator. As a whole, the participants do not deem the option of

taking tests without a calculator worthy of extra credit or bonus points on assessments. Three of the ten participants discovered that a student was using an information storing calculator to cheat. Finally, most teachers indicated that they would be supportive of an extracurricular program in their school that would focus on the strengthening of fundamental math skills. Only two of the ten participants indicated that there was already a program like this in place at their high school.

Five out of the ten participants provided further opinion in the feedback portion of the survey. Their individual responses are listed below.

OH(5): "Calculators are not necessarily a bad thing. Students must be taught to use them in the correct way and must be able to do certain calculations both with and without a calculator. For example, I typically have both a calculator and non-calculator section on my assessments. This enables me to assess students on their abilities to perform evaluation and calculations without the aid of a calculator. On the other hand, students may use the technology as a resource for more elaborate and extensive problems."

KS(Ø): "[W]e do have pre-algebra but many students do not know their multiplication tables and have no idea how mathematics works. The bigger problem is that the students lack critical thinking skills. Those need to be worked on from kindergarten on."

OH(8B): "I do think that technology in the classroom is important. Students need to be able to understand their graphing calculator for harder concepts/graphs etc but not

for basic math. The standardized tests including PARCC, ACT, SAT all allow for a calculator so they cannot be dismissed either."

CO(6): "I think it would be interesting to know the age of the teachers that you are surveying. Usually, people that are more old school (older) prefer to not let students use calculators, but I am only 28 and I think they are terrible. I never let me Algebra 2 students use them. EVER. We work with fractions, graph, multiply decimals…everything by hand."

OR(15): "I believe in using calculators as needed. I'm not going to limit what a student can explore in the way of mathematics because of weak arithmetic skills. I'd rather they have ample opportunity to look at how functions behave and we can work on the arithmetic of solving and evaluating as we go.

Our perspective may be skewed. We have always taught in high poverty schools. Our experience is that students struggle for a million different reasons and of course each student is different. Some students are so scared of math that if they don't have a calculator, we wouldn't make any progress at all. Others are skillful with arithmetic but struggle with how to use the different functions we study. Ultimately we would like students to be able to apply what they've been taught and that kind of thinking is challenging whether a student has a calculator or not. We want them to continually ask, "why do we care?" and "how will I use this to understand the world around me?" "

Both CO(6) and OR(15) appear to hold extreme opinions regarding this topic, but on opposite ends of the argument. The voices of the other three responses seem to support

the notion that the calculator has its time and place, but it is inappropriate for use at other times, times where students may display their lack of critical thinking skills. One participant even suggests that the lack of critical thinking skills is the root of students' problems, and that calculator dependence is just a reflection of that.

Based on both the data and the feedback from the survey, we conclude that our survey population believes that calculators in schools are generally overused and depended upon by students. They believe in limiting calculator use for the student, and agree that foundational math skills are crucial in order to comprehend high school mathematical concepts. However, the teachers do believe that there are specific occasions and settings where the use of a calculator is beneficial or necessary, that calculators have "their time and place."

Opinions/Classroom Observations

From student teaching this semester, we were both exposed to calculators in mathematics classrooms. There were ten graphing calculators and ten regular calculators in the classroom that could be lent out to the students if they needed one. Thus, the students always had a calculator when working in class or on tests. From the beginning of the semester all the way till the end, a common phrase the students said was "I need a calculator to do this". The students were accustomed to using a calculator and never asked to use a calculator because it was always implied they could use one. The main reason this topic is of concern is because when the students said they need a calculator, the question they needed it for was anything dealing with adding or subtracting negative

numbers as well as multiplying positive/negative number combinations. These operations are learned in grade school and negative numbers are introduced in middle school. Without fully understanding how negative numbers work, higher level mathematics will be impossible to learn since this basic foundation is always present. The students are using the calculator to do these problems since it's the only way they know how. From our student teaching experience, we concluded that either the students never fully understood how to do these calculations by hand or the students have lost the knowledge of how to do these calculations because they have always had access to the calculator. Therefore, we think the best way to approach calculators in mathematics classrooms is to limit its usage. By using a calculator for problems that require them, such as dealing with two or three digit numbers, a calculator can help save time and get the students back onto problem-solving. The calculator should not be used everyday, especially on problems where simple calculations are required because those need to be memorized, or can be computed easily. This will enable the students to keep their addition/subtraction/multiplication/division skills up to par for when they go into high level math classes in high school and college. These skills are the most basic foundation of mathematics and have to be mastered by high school. When math problems arise that require the calculator, then it can be used to keep students focused on the problem-solving part of the question. No reliance to the calculator will be formed and the students will still be exposed to them and have practiced using them.

Conclusions

To sum up, calculators are a tremendous help to mathematics classrooms because of their many capabilities. However, despite all the benefits they can bring into a classroom, they can also bring in some negatives. Many high school students are developing a dependency on the calculators in order to do simple computations such as addition, subtraction, multiplication, and division. From an overuse of the calculators during middle school and early high school, students will slowly develop this dependency. By limiting calculators in the classroom such as only using them on problems that require them or using them to help the students stay focused on problem solving would be a superb use of this technology. By using calculators correctly, they can help promote student learning and mastery of mathematics to the highest level.

Calculators

Appendix

Survey Used for Data Collection

Name:

School:

City & State:

Math Courses I Teach:

Number of years teaching:

Classroom Calculator Use Survey

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Please respond to the following statements (1-11) with one of the numbers above corresponding to your opinion.

1. In my experience, calculators are generally overused by students in high schools and middle schools.

2. Students who are struggling in my classroom are typically behind the rest of the class in fundamental math skills as well.

Calculators

3. I believe that having a firm grip on basic math skills leads to students being more likely to have a clear understanding of higher mathematical concepts (i.e. algebra and geometry).

4. I limit calculator use during in-class work.

5. I limit calculator use on tests.

6. With the increasing presence of 21st century technology in the classroom, I see students taking inappropriate short-cuts via those technologies.

7. I see students becoming dependent on these same technologies.

8. The majority of my students are at or above their current grade level in mathematics.

Calculators

9. I would award or have awarded extra credit to students who chose not to use their calculator on their math test.

10. I have witnessed students cheating on a test or assignment by storing information in their calculators.

11. I would embrace the idea of an extracurricular program at my school that focused on improving the basic arithmetic skills of the students.

12. Is there a program similar to the one described in statement 11 present at your district's middle or high school? If yes, please describe it.

Please share any additional feedback, questions or comments about this survey:

References

Sheets, C. (2007, July 1). Calculators in the Classroom: Help or Hindrance? Retrieved November 14, 2015.