The Effect of Graphing Calculators

on

Student Achievement

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Abstract

The purpose of this study is to examine the effect of graphing calculators on assessment performance. The measurement tool was the Unit 4A Curriculum Embedded Assessment created by the Baltimore County Public Schools, Office of Mathematics. The researcher hypothesized between two groups, those who used graphing calculators and those who did not, that there would be no difference on the unit assessment. At the conclusion of the study, the null hypothesis was confirmed. Research in the area of graphing calculator usage in mathematics classrooms for assessments should continue to be reviewed and improved upon in future studies. This research can then be applied to students in mathematics classrooms across the country.

CHAPTER I

INTRODUCTION

Overview

In the world of education, success looks different for each and every student. Many students look at their final grade as their measure of success while others have a more long-term view of assignments. Instead of focusing on their grade or score, some students focus on their progress as a measure of success (Zmuda, 2008). Students need to learn to embrace struggle, and realize that struggles are essential for growth. This lesson is crucial, not only for developing resiliency, but also for creativity, ingenuity, and entrepreneurship (Zmuda, 2008).

Due to the fact that success is different for each individual, success can be difficult to assess with a common measure. However, there are many tools and programs that have been developed to help a child achieve individual success. One of these tools is the calculator, which is invaluable in both math and science classrooms.

Calculators began by computing answers for basic functions such as addition, subtraction, multiplication, and division. Since invention, calculators have evolved to complete much more difficult tasks for their user; some which are impossible to complete by hand. Most classrooms are currently equipped with Ti-84 calculators that can complete a variety of tasks ranging from adding twenty numbers, to calculating regression equations from a data set. Despite what all these calculators can do, sometimes the old fashioned way of learning, by using pencil and paper, can be the best way.

This study focuses on the impact of graphing calculators in an Honors Algebra II classroom by comparing success rates of students with graphing calculators and those without. There have been studies done which show that calculators are beneficial to students with special

needs. Results from a previous study show that when given a calculator, special needs students can solve computation and word problems with greater accuracy (Yakubova & Bouck, 2014). This study was supported by a high increase in performance from low levels of baseline performance without a calculator to levels of performance with a calculator in both subtraction computation and word problem-solving questions. Despite these findings for the benefits of calculators for special needs students, there have not been many studies exploring their impact on the success of Honors students.

This research interest was triggered by the reliance of individuals on calculators, both in the classroom and out. In today's society, most individuals struggle with basic math because they constantly have a calculator at their fingertips in the form of a phone. The goal of this study is to show that students can successfully complete various mathematics tasks both with and without calculators.

This reliance on calculators begins at the elementary level when students are handed calculators each day for basic math. As students' progress, they begin to feel they cannot go through math class without a calculator because they have always had one. Many students feel that if they cannot complete basic math without a calculator, they cannot do other tasks such as graphing functions. In reality, they do not even know if they can do various mathematic tasks without a calculator since they have never actually tried. This study will determine whether students can be as successful without calculators as they are with calculators.

Statement of Problem

This study focuses on the impact of graphing calculators in two Honors Algebra II classrooms by comparing assessment success rates of students with graphing calculators and those without.

Hypothesis

The null hypothesis is that students using graphing calculators will perform at the same success rate as the class not using graphing calculators.

Operational Definitions

The independent variable is the use of graphing calculators on the Unit 4A Curriculum Embedded Assessment. The graphing calculator being used is the TI-84 Plus which allows students to complete tasks that range from basic computations to real-world data collection and analysis. This study will use the graphing calculators for the graphing functionality that will allow students to assess how various trigonometric functions transform under the specified conditions.

The dependent variable is the Baltimore County Public Schools Unit 4A: Curriculum Embedded Assessment (CEA) that will be given to each subject group at the end of this particular unit of study. This can be operationally defined by doing an item analysis for each question to see if there were specific aspects of the unit that are more beneficial to use a graphing calculator for. The percentage of correct answers from the item analysis will be compared for each class to determine whether the graphing calculator was beneficial for student success on those particular questions.

A ***trigonometric function*** is a function of a particular angle, which relates the angles of a triangle to the lengths of the triangle's sides. This unit began with students using trigonometric functions to find missing angles and sides of a right triangle before progressing to the unit circle. The unit circle was built upon student knowledge of special right triangles. Special right triangles are defined as a triangle with angles measuring 30°-60°-90° and a triangle with angles measuring 45°-45°-90°. The unit circle is a circle whose radius is one unit; trigonometric values are based upon measurements around the unit circle. Students then learned how to graph trigonometric functions, including various transformations. Transformations can be defined as a change in period, amplitude, and/or horizontal shift. Period is defined as the time frame in which one trigonometric function is graphed. Amplitude is how high and how low the function stretches from the midline. Horizontal shift is how much a function is moved to the left or right from the parent function.

CHAPTER II

REVIEW OF THE LITERATURE

There are many theories when it comes to enhancing student achievement. Each and every individual has a different sense of achievement, making success personalized. The path to achieving this individual success is also different for each individual based upon various life circumstances. Section one defines achievement and what achievement looks like in a mathematics classroom. Section two discusses the multiple barriers a student may face when working to achieve academic success in a classroom. Section three explores a few interventions that can be implemented to help overcome barriers discussed in section two.

Student Achievement

According to Merriam-Webster Dictionary (2017), achievement is the act of successfully carrying something out. The vague word of 'something' is used since there is a wide variety of acts that can be carried out and considered an achievement. Achievement looks differently for each and every individual based on their personal goals whether they are academic, work related, fitness, or other.

There are even further variations within these categories. For example, academic achievement in an English class looks different from achievement in a mathematics or science class. Achievement in a mathematics class can be a student's ability to quickly recall math facts or by earning a high grade on a major assessment, such as a unit exam or a state examination such as the Partnership for Assessment of Readiness for College and Careers (PARCC).

Not all students have the same goals for themselves since they all have different backgrounds. For example, a student who comes from a family of individuals with Master's Degrees may not feel a Bachelor's Degree is sufficient and may strive for a Doctorate Degree.

Whereas, a student who does not have any family members who attended college, may be proud of applying and being accepted. An individual's strengths and weaknesses also have an impact on one's sense of achievement. A student who consistently struggles in mathematics and has failed in the past, might be content in having a C average. However, there are other students who get straight A's in math and want the highest percentage possible and will do whatever it takes to get close to 100%.

Self-belief is a powerful motivator to push oneself towards successfully achieving a goal. Student expectations strongly predict achievement, followed by parental encouragement, self-motivation and self-confidence (Rubie-Davies, Peterson, Irving, Widdowson & Dixon, 2010). A positive teacher-student relationship is essential for learning in the classroom. Students invest academically in response to teachers they perceive as caring about their learning.

Similar statements can be made from a teacher's point of view. Unfortunately, there are many students who do not always have the self-confidence needed to accomplish a desired goal. When this is the case, another's belief in them is extremely valuable, which is why a positive relationship, such as the teacher-student relationship, is so crucial. When teachers expect their students to do well they interact with them in ways that lead to their expectations being fulfilled (Rubie-Davies et al., 2010). When a student sees a teacher believing in them and willing them to succeed, this encourages them and gives the student more confidence.

Challenges to Student Achievement

Unfortunately, there are many challenges to student achievement that include teacher, student, and parent expectations. In addition, to these barriers that every student faces, there are major stereotypes against girls in mathematics that is an added barrier for female achievement in this content area.

There are many different viewpoints from which to discuss expectations. Teacher and student expectations are negatively affected by the system of tracking. Tracking is the process in which students are placed in different academic levels based on their perceived abilities. These levels include Standard, Honors, Gifted and Talented/Advanced Placement; additional levels include Self-Contained and Inclusion classes, which are for students with various learning disabilities. Being placed in a low-track class has a serious impact on student's expectations for themselves. Students in these classes often have lower self-esteem and have said placement affects their ability to achieve their expectations (Rubie-Davies et al., 2010).

In addition to students having lower expectations for themselves, teachers often lower their expectations for low-track classes. Teachers of low-track classes often simplify the material and reduce the workload since there is a belief that students in these classes cannot achieve at the same level of success as those in higher-track classes. All students need the opportunity to struggle with a task that inspires their performance, that motivates them to do more than just go through the motions of learning and truly understand what the discipline requires (Zmuda, 2008). Students of every tracking level should be given material that challenges them and makes them appreciate their path of learning and success.

As previously stated, academic achievement differs based on the content area being discussed. The same can be said for barriers to academic achievement; barriers for mathematic success are vastly different than barriers to success in a history class. Barriers to mathematic success include the inability to recall basic math facts. Deficits in accuracy and speed of fact recall are characteristics common both to students with low mathematics achievement and those classified as learning disabled (Stickney, Sharp & Kenyon, 2012). Automatic recall must be developed over time with sufficient instruction, practice, and feedback. Mastering basic math

skills at the appropriate ages is important for laying the foundation for future math education. Students who do not lay this foundation are at risk for falling further and further behind their classmates, entering a cycle that gets harder to break out of as the student gets older.

A study was conducted in three New Zealand secondary schools in a large urban area in which students, parents, and teachers were divided into three focus groups (Peterson, Rubie-Davies, Elley-Brown, Widdowson, Dixon & Irving, 2011). The schools represented high, middle, and low socio-economic status. When the student focus group was asked who was responsible for their education, some students deflected the responsibility from themselves and onto their teachers, while others accepted the responsibility as their own. Despite these differences, all students saw their parents as playing some role in their education:

> The parents' role was largely to support, encourage, push and provide the right environment for studying. For some students, that support also meant helping them with their homework and '*reminding us if we got homework*,' arranging '*extra tuition*' if needed, providing the right motivation '*bribes*' or just offering guidance…Some students in the high socio-economic school indicated they wanted to do well by their parents: '*you want your parents to be proud of you*' (Peterson et al.,2011).

The role of parental involvement is instrumental to a student's academic achievement. However, are all parents as supportive as the ones involved in this study? Unfortunately, the answer is no. There are many students in the school system with no parental support and are essentially on their own; there is no parent to remind them to complete assignments or to help with homework. In some instances, students at the secondary level are the parental figure for

younger siblings since there is no adult presence at home. This is a barrier that is detrimental to a student's academic achievement.

Another barrier specific to academic achievement in mathematics, is the stereotype that boys are more dominant in mathematics than girls. Gender stereotypes can disrupt girls' math performance as early as five to seven years of age (Galdi, Cadinu & Tomasetto, 2014). Elementary girls show a weaker identification with math than boys on both implicit and self-report measures. Math gender stereotypes develop early and differently and influence boys' versus girls' self-identification with math prior to ages at which differences in math achievement emerge. These societal pressures may cause girls to have a weaker self-concept when completing tasks involving mathematics. When taking into account the self-fulfilling prophecy that was previously discussed, there is no wonder why girls underperform in mathematics or may avoid the content all together.

Interventions for Student Achievement

There are many interventions that can be implemented to help students achieve a high degree of academic success. These interventions include parental involvement, effective teachers, the integration of real world applications in the classroom, and calculators, specifically for mathematics classes.

Parental involvement in education is often a learned behavior. Parents whose parents were actively involved when they were students, are more likely to be involved in their own child's education. The same can be said for those parents who did not have involved parents when they were school-age. Effective parental support for a child's education is not a simple feat. It involves a shared understanding and negotiation among parents, teachers, and schools

regarding how children should be educated, the role of parents, and access to and mobilization of resources to support such efforts (Shiffman, 2011).

Researchers have argued that parents with higher educational and economic status tend to be proactive in relationships with schools and are able to garner needed resources and advocate for their children in ways that position them to receive the maximum benefits available (Shiffman, 2011). In contrast, parents with less education and fewer economic resources have greater difficulty maximizing these possibilities for their children. When parents possess high self-efficacy, they are expected to be more actively engaged in their children's education. High self-efficacy is also linked to setting high goals and committing to achieve them. Parents who demonstrate this positive mentality, are setting a good example for their students to do the same. Positive parental involvement whether it be for moral support, helping to allocate appropriate resources, or as a positive role model is a crucial intervention for student academic achievement.

Another intervention to aid in academic achievement is the presence of an effective teacher. There is much that goes into being an effective teacher. A few aspects that have been studied include student assessment, learning environment, and personal qualities. Effective teachers monitor student learning through the use of a variety of informal and formal assessments and offer meaningful feedback to students (Stronge, Ward & Grant, 2011). An effective classroom is one in which a teacher continuously checks for student understanding throughout the lesson and guides the course of the lesson based on the feedback from the students. Student assessment is forefront in the planning and implementation of a lesson for an effective teacher. An effective teacher uses the beginning of the school year to set clear expectations that are to be reinforced throughout the duration of the school year. Classroom management is based on respect, fairness, and trust, wherein a positive climate is cultivated and

maintained. Through this positive classroom climate and everyday interactions, teachers are able to establish connections with students. These connections are crucial to student academic achievement; students want to know they have a teacher who cares about them, not only academically but their overall well-being.

An additional intervention for student achievement would be to integrate cross-curricular topics such as literature into mathematics in order to help integrate more real world examples:

> The National Council of Teachers of Mathematics has called for changes in the problems that are typically posed to students, asserting that such problems should instead require students to reason, communicate, represent, problem solve, and make mathematical connections. Posing open-ended, extendable problems allows students to construct their own mathematical learning and understanding by building on previous experiences and making connections among topics and disciplines (Young, Marroquin, 2006).

These changes can be implemented through introducing more literature and real world examples in mathematics classrooms. For example, the book *Cook-a-Doodle-Doo* could be read in a mathematics classroom with a lesson on measurement and cooking built on the book. The book can lead to a rich discussion of different measurement tools and different units of measure all while using rich mathematics vocabulary. This book brings in the real world task of cooking which is an engaging topic for many students. There is a direct link between literature, mathematics, and real world tasks for many mathematics concepts if a teacher looks hard enough for one. This implementation of a cross-curricular task is a positive intervention for academic achievement.

A final intervention to be used, specifically in mathematics classrooms, are graphing calculators. As previously discussed, many students who cannot quickly recall math facts fall behind their peers in mathematics. This barrier can be counteracted through the use of even the most basic calculator. There are many different versions of calculators that serve various purposes. These devices allow students to accurately recall basic math facts in addition to completing much more complex tasks that are seemingly impossible by hand.

Calculators help bridge the gap for students who struggle with mathematics. A calculator can not only be seen as an intervention for struggling students but also one for students who achieve success in mathematics. Research has shown that they are commonly promoted as tools for checking or verifying work done by hand (Mcculloch, Kenney & Keene, 2012). Graphing calculators are popular and useful tools for students in mathematics classrooms of all academic levels.

Summary

This review of the literature has discussed what achievement is, barriers students face that prevent them from achieving, along with interventions that can be implemented in the classroom to aid students in reaching their fullest potential. Students are able to reach their greatest academic achievement when they are working on the same team as their teachers and parents. Academic success is truly a team effort in which all those involved need to be active participants. Research shows that while there are challenges to academic success, teachers and parents can work together to meet the needs of the student to help that student achieve their greatest potential.

CHAPTER III

METHODS

Design

This study was based on a pre-experimental design. The study required the comparison of two groups, one who received graphing calculators as a resource tool and one who did not. These groups were in effect for the duration of an Algebra II unit of study. The null hypothesis is that the class who uses graphing calculators will perform at the same success rate as the class not using graphing calculators on the unit exam.

Participants

The participants in this study were 60 Honors Algebra II students at a high school in Baltimore County. These students range from 9th to 12th grade, with the majority being 10th graders. Of the 60 participants, 28 were male and 32 were female. Participants were chosen based on convenience since they were at the same content and academic level that was vital for this study. Typically, both classes perform at the same success rate on unit exams so there was no advantage for either class.

Instrument

The unit exam, utilized as the measurement instrument in this study, was written by the Baltimore County Public Schools (BCPS), Office of Mathematics. This unit required twelve instructional days, spanning the course of four weeks. Students are on an 85-minute, four-period a day, A/B schedule which means they have Algebra II every other day.

All Honors Algebra II students across the county take the same unit exams throughout the course of the year. The school year 2016-2017 was the first time this series of exams were given. After the exams were implemented last year, teachers across Baltimore County and Resource Teachers from the Office of Mathematics got together over the summer and rewrote parts of the exams based on feedback through the county. This allowed corrections to be made and questions to be adjusted in difficulty based on the scores students received. This process improved the unit exams for the 2017-2018 school year, making them a more reliable and valid unit of measure.

Procedure

This study took place during Unit 4A of the BCPS Algebra II curriculum; the trigonometry unit. There were two classes that took part in this study, each containing 30 students of the same skill set and academic level, Honors. Both classes were taught the same content and experienced the same rigor of that content. To ensure this, all students were taught the same lessons but the experimental group was given graphing calculators as a modification for specific lessons. For example, the experimental class was taught how to complete graphs of sine and cosine with a graphing calculator while the control class learned how to do so by hand. Not all lessons in this unit required graphing calculators, so there is less room for error for those students who struggle with remembering the steps to do so.

Both classes took the same unit exam. The researcher then completed an item analysis for each question in which a graphing calculator could be used and compared the average scores of these questions for the two classes.

CHAPTER IV

RESULTS

The purpose of this study was to examine whether the use of a graphing calculator during an assessment improved the student's success rate on the unit assessment. The number of points earned out of the potential eight points on those particular questions determined the student's success rate.

This study used a pre-experimental design in order to compare the two groups. Each group's scores were recorded, based on an eight point maximum, at the conclusion of the Unit 4A CEA which came after the twelve instructional days which were required to complete Unit 4A. According to the findings, there was no significant difference between the calculator group and the non-calculator group.

The null hypothesis states that students using graphing calculators would perform at the same success rate as the class not using graphing calculators.

Table 1 shows the means and standard deviation for each group, the treatment group that used calculators, and the control group, which did not. An independent *t*-test was run to see if any differences existed after the administration of the post-test. Results showed no significant difference after the post-test, [$t(51) = 0.547$, $p > .05$]. Both groups performed similarly at post-test. The null hypothesis was supported. These results and their implications will be discussed in the following chapter.

Table I

Means and Standard Deviations of Math Performance for the Group

Group	Mean (Standard Deviation)
Treatment	3.04 (5.81)
Control	2.69 (4.78)

CHAPTER V

DISCUSSION

The purpose of this study was to determine the effect of graphing calculators on student performance on a unit assessment. The scores from the Unit 4A CEA were compared for each group of students at the conclusion of the twelve-day unit. The null hypothesis – there will be no difference in mean assessment scores for students using graphing calculators and those not using graphing calculators – was supported.

Implications of Results

The data collected shows no statistical differences between groups on the post-test. This unit of study was taught primarily without the graphing calculator; the content that could benefit from the use of a graphing calculator did not come until day nine of the twelve-day unit. Throughout the unit, both groups performed at the same success rate on minor assessments, showing the groups were academically equivalent.

The last three days of the unit were when students learned how to graph trigonometric functions. One class learned how to graph trigonometric functions by hand while the other group learned how to use the graphing calculator to complete the same task. The results showed that both groups performed at the same success rate, as they had throughout the duration of the unit. This showed that students who use a graphing calculator on assessments do not have an advantage over students who do not use a graphing calculator.

Threats to Validity

The largest internal threat to validity in this study was the duration of the study. Using only one unit of study from the curriculum limited the potential to see a statistical difference. There are some units in the BCPS Algebra II curriculum that have no use for a graphing calculator, while others require the use of a graphing calculator. Due to this, the units upon which this study could be conducted were extremely limited.

This particular unit of study was chosen since it did not require the use of a graphing calculator but the graphing calculator could be used as a resource to enhance one's learning throughout the unit. Due to the fact that this study was only completed over the course of one unit in the curriculum, there is a potential that for other Algebra II units, there would be a statistical difference between students who used graphing calculators on assessments and those who did not. The researcher could conduct the same study in a different class, such as Algebra I or College Algebra, which would allow for multiple units of study to be researched. The researcher was not able to conduct the study in this manner due to the classes that the researcher teaches.

An additional threat to internal validity is the sample used since it was a convenience sample and not a random sample. This is a threat to validity since the sample used is not representative of the entire population of Algebra II students. Due to the fact that the entire population is not represented, this study cannot be generalized for all students in Algebra II.

A student's attendance in the class is the greatest external threat to validity. There were a few students who missed three or more class periods throughout the course of this study. Due to these absences, these particular students missed out on learning key academic concepts that were

needed for the assessment, putting these students at a disadvantage. This is very likely to have a negative effect on the student's performance on the unit assessment, especially if they did not attend coach class.

Coach class is an hour-long period once a week, after school, in which students can ask questions to clarify their understanding and get the work that might have been missed from an absence. Students who attend coach class give themselves the advantage of more individual time with their teacher to gain a deeper understanding. The results have the potential to be skewed if several students from the same group were either absent for a few classes, or attended coach class a few times throughout the duration of the study.

Connections to Previous Studies

Prior to this study, a study was conducted demonstrating the positive effects of calculators on academic achievement for students with special needs. This particular study involved students with mild intellectual disabilities and examined the effectiveness of scientific and graphing calculators as instructional tools for them. From this study, three main results were found: (a) an increase in students' correct performance of subtraction computation and word problem-solving questions using both types of calculators, suggesting the effectiveness of scientific and graphing calculators, (b) use of calculators resulted in a decrease in the amount of time students spent on answering subtraction computation and word problem-solving questions, and (c) the effectiveness of the actual calculator varied by student, as some students improved in the percentage of correct answers more with the scientific calculator while others with the graphing calculator; students also held different perceptions towards the two calculator types (Yakubova, & Bouck, 2014).

The study just mentioned examines the same issue as the study carried out by the current researcher but was done in a different manner. The study looked at a different academic level of student and based the effectiveness of calculators upon the individual growth that each student made between the pre- and post-tests. This differs from the study that was conducted by the researcher since those groups were looked at as a whole and not each individual student. This study could not be conducted in the same manner since the groups had no prior knowledge of the content being taught, which would deem a pre-test as an invalid measure to compare the post-test results to.

Another big difference that could explain the varied results between the findings of the study, was the mathematics concepts being studied. Calculators are beneficial for mathematics facts, helping increase speed and accuracy, which is what the previous study examined. The current study used a graphing calculator to help graph trigonometric functions that required students to have some background knowledge in order to use the calculator as a resource. Further research on the impact of calculators in the classroom, whether for instructional purposes or assessments, is needed.

Implications for Future Research

In conducting this study, the researcher realized that the teaching that occurs in the classroom is more important than the use of the graphing calculator. If quality teaching occurs, students do not need the use of technology to enhance their assessment since they have a deep understanding of the content knowledge. Graphing calculators can be beneficial for a student to check their answers but having the knowledge to complete the assessment without technology is just as beneficial.

The researcher also found that attendance in the class was also essential to student success. This threat to external validity had an impact on student assessment success rates that in turn, affected the results of the study. In the future, the researcher would suggest weeding out students from the study who missed one-fourth or more of the class periods during the duration of the particular unit of study that can keep the results from being skewed.

Also, moving forward, the duration of the study needed to be longer. Students should have participated in this study for at least three units of study. This would make it easier to determine not only statistical significance, but also if the particular Algebra II unit of study made a difference in the results. If there were three different Algebra II units to be compared, the researcher could weed out whether any of the particular units of the Algebra II curriculum made a difference on the impact of graphing calculators on the assessment success rate.

A final suggestion to strengthen this study in the future would be the use of a random sample of students rather than a convenience sample. In order for this study to be generalizable, students should be chosen from various classes and even multiple schools. The students randomly chosen should then be randomly assigned to the two different groups, calculator and non-calculator. This randomization of students would strengthen the study and allow the study to be generalized for other populations.

Summary

The results of this study show that the null hypothesis was supported and that, even though the group with graphing calculators had an additional resource on their assessment, the findings were not statistically insignificant. However, this study had threats to validity, both internally and externally, which could have a significant impact on the results. Previous research

has shown that, students with special needs, benefit from the use of calculators, specifically addressing the areas of computation and word problems. Future research should address the impact of using graphing calculators on assessments for students who are in upper level mathematics courses to see if there is a similar impact on computation and word problems, as there were for special needs students. This research will hopefully give students a boost in confidence when they realize they do not need a graphing calculator as much as they might feel they do. Teachers should take from this research that a calculator will not solve mathematics problems if students do not know how to complete them without the calculator first.

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