CALCULATOR USE IN THE HIGH SCHOOL MATHEMATICS CLASSROOM

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I am submitting herewith a Field Study written by Stephanie Rasch entitled "*Calculator Use in the High School Mathematics Classroom.*" I have examined the final paper copy of this Field Study for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts in Education, Curriculum and Instruction, Mathematics Specialization.

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CALCULATOR USE IN THE HIGH SCHOOL MATHEMATICS CLASSROOM

A Field Study

Presented to the

Graduate and Research Council of

Austin Peay State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts in Education

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by

Stephanie Rasch

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ABSTRACT

This study examined the relationship between calculator use and performance of high school mathematics students. The review of literature explored a variety of studies about calculator use at different levels in many different areas. These studies revealed many common issues, opinions, and conclusions. The sources explored areas such as gender attitudes, calculation strategies, standardized testing, and equity among students when using calculators in settings involving mathematics. Student achievement was evaluated by using surveys, grades, and standardized test scores to determine whether calculators would have a positive or negative effect in various situations. Overall, the research indicated a positive effect on student achievement, attitude, and performance on standardized tests.

The corresponding action research investigated two areas of calculator use in a high-school mathematics classroom. The first area involved how the calculator affected performance on a mathematics assessment. The second area involved how the calculator was used for a variety of problems and how this affected the outcome. The results for the action research did support the positive findings from the studies cited in the literature review.

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CHAPTER 1

Introduction

Importance of the Problem

Technology has become a very important part of our society in recent years. In the mathematics classroom, calculators and computers are now used to increase student interest and to explore a variety of topics. However, over the years, debates have emerged about whether the extensive use of calculators is harming or helping students as they progress through their schooling. Many educators believe that calculators enable mathematics teachers to introduce topics that are far more complex, resulting in a deeper understanding for students. However, opponents of calculator usage believe that students rely too heavily on them, and therefore lack even basic skills. Misuse of calculators could eventually lead to greater difficulties with the more complex material covered in later years. In order to maximize student learning, we must correctly understand the effects of calculator use in the mathematics classroom. With this knowledge, teachers can appropriately choose how to implement this technology.

Statement of the Problem

Mathematics educators always need to be aware of what methods will help students reach a deeper level of understanding of mathematical concepts. Therefore, in this study, I examined the relationship between calculator use and student performance with various concepts. Even at the time of a 1996 survey conducted by the National Center for Educational Statistics, 80% of eighth grade students had access to some type of calculator in their mathematics classroom (Hanson, Brown, Levine & Garcia, 2001).

With this growing popularity of calculators, educators must be aware of exactly how this technology relates to the achievement of students.

Relationship to this Problem Area

Calculators and computers have been used by students and teachers for over 30 years (Barton, 2007). As of 2005, the position of the National Council of Teachers of Mathematics was that students "need an understanding of number and operations, including the use of computation procedures, estimation, mental mathematics, and the appropriate use of the calculator" (NCTM, 2002). Since this time, teachers and educational groups have continued to adapt and enhance the curriculum to meet these recommendations. As we change our methods, we need to be sure we are building a stronger foundation for our students' success. The results of this study can help mathematics educators decide whether and when to use calculators with their students.

Research Questions

1. Is there a relationship between calculator use and student achievement in the high school mathematics classroom?
2. What types of procedures are students using the calculator to complete?

Hypothesis

The use of calculators in the mathematics classroom increases students' ability to perform more complex problems and tasks along with more accurate calculations.

Assumptions

1. The sample used for the study was selected randomly.
2. All students have had experience with some type of calculator before beginning the study.

3. The sample used in the study contains students with a variety of mathematical abilities.
4. The instruments used to measure achievement in the study are valid and reliable.
5. The teacher received appropriate staff development training on the use and implementation of calculators.
6. The students participating in the study all had equal access to the calculators necessary for the instruments used for measurement.

Limitations

1. This study is limited to 66 Algebra 2 students, all from the same high school.
2. The sample is also limited to students from the same teacher.
3. The students were asked to answer the same questions two days in a row.

Definition of Terms

1. National Council of Teachers of Mathematics (NCTM): "a public voice of mathematics education, providing vision, leadership and professional development to support teachers in ensuring equitable mathematics learning of the highest quality for all students" (NCTM, 2008)
2. scientific calculator: a device that performs basic operations and algebraic functions
3. graphing calculator: a device that performs basic operations, algebraic functions, statistical functions, and multiple forms of graphing
4. computer algebra system (CAS): a calculator software program that performs manipulations on mathematical expressions

Preview

Over the past 30 years, studies have been conducted to assess the effects that calculators have on the mathematical achievement of students at all ages and levels. This literature review and corresponding action research will present the results of these studies within certain topic areas. These areas include achievement, standardized tests, attitudes, calculator type, availability, and age of introduction. The results in each of these areas will allow teachers to better understand the relationship between calculator use and performance.

CHAPTER 2

Review of Literature

Background of Conditions

For centuries, mathematicians have used calculators in various forms, including the abacus, Napier's Bones, slide rules, and adding machines. Calculators were introduced as a mathematical enhancement over 30 years ago. Since then, this technology has evolved from a basic four function calculator to scientific and graphing calculators. As calculators have evolved and become more popular, it has become increasingly important for educators and researchers to determine what changes are occurring in teaching methods and learning styles due to this technology.

The goal of all educators is to create environments for students that maximize their opportunities to gain a deeper understanding of material. For mathematics instruction, these environments include visual representations, explorations, and connections. Calculator and computer programs have been developed to perform calculations and manipulations that are otherwise impossible or too tedious for students to perform. Therefore, technology has not only changed how we teach mathematics, but what topics in mathematics are able to be taught. According to Thompson and Sproule (2000), mathematics lessons can now be taken further than ever possible in the past.

Achievement in Class

Throughout the years, many studies have been conducted about how student achievement in the classroom is affected by the use of calculators. In a paper written in 2007, Barton compiled the results of several of these studies. This review included studies ranging from kindergarten through high school from 1984 to 1995. The results

revealed that of the 46 studies, 29 showed higher achievement with the calculator group. Only one study showed higher achievement in the non-calculator group, and 13 studies found no difference between the two groups.

Another set of 32 studies in the Barton (2007) compilation investigated 88 different results on conceptual knowledge and understanding of visual representations of mathematical concepts, such a graphs and diagrams. These studies revealed that 66 of the results favored the calculator group and 22 showed no difference between the two groups. More specifically, the results of the studies revealed "significantly higher achievement for students who used calculators for problem solving, computation, and conceptual understanding" (Barton, 2007, p. 1). Overall, more than 65% of the studies showed that calculators were a benefit to student achievement.

Achievement on Standardized Tests

A number of studies have also been done to evaluate the relationship between calculator use and performance on standardized tests. One study conducted by Scheuneman et al. (2002) used an administration of the SAT I from 1996 and an administration from 1997. The tests from these two administrations included a section asking questions about calculator use on the test. From this survey, the researchers were able to conclude that about 95% of the students brought their own calculators to the test. The researchers also concluded that students with calculators generally performed better than those without a calculator, but those "who used the calculator on one third to one half" of the test performed best (Scheuneman et al., 2002, p. 102).

Student Attitudes

One issue of importance should be how this technology affects the attitudes of students in the mathematics classroom. Studies have been done to establish a relationship between calculator use and attitude. One set of studies found that a "significant difference also existed in the attitudes of students favoring those who used calculators in mathematics classes when compared to the attitudes of those who did not use calculators" (Barton, 2007, p. 1). These changes in attitude had the greatest effect on those students that were weak in mathematics by improving confidence in concepts and skills (Forgasz & Griffith, 2006)

One of the groups that had been a focus for attitude studies were female students. In the past, a gender gap favoring males existed in mathematics and science and "studies have shown that gender attitudes towards mathematics tend to influence students' performance in the subject" (Kaino & Salani, 2004, p. 113). Females have avoided these areas of study. However, according to a study conducted by Kaino and Salani (2004), the improved confidence and interaction related to the use of calculators encouraged more females to enter higher-level mathematics classes and choose careers in the fields of mathematics and technology.

Overall, students tend to have a positive attitude toward calculator use. Technology increases interest in all subjects and makes mathematical concepts interactive. However, there are students that view calculators negatively and avoid their use. Generally, these students have had very little exposure to this type of technology and therefore find it very difficult to use (Kaino & Salani, 2004). To avoid this problem,

teachers need to be sure students are exposed to a variety of technology though explorations, lessons, and activities.

Calculator Type

One area of controversy with calculators is what type of calculator should be used. Scientific and graphing calculators are the two most common types that are used in classrooms. Studies have been done to investigate whether one type of calculator gives students an advantage when completing mathematical problems. In the compilation of studies presented by Barton (2007), researchers found that three out of six studies did not show a significant difference between the group using the scientific calculator and the group using the graphing calculator. Of the three remaining studies, two of them revealed a higher level of performance with the graphing calculator.

Hanson et al. (2001) investigated whether the use of standard issued calculators as opposed to the use of the students' own calculators affected performance on standardized tests. The results of this study revealed that students were "just as accurate with the standard calculator as they were with their own calculator" (Hanson et al., 2001, p. 67). The type of calculator also had very little effect on how long it took the students to complete each test item. Therefore, the researchers were able to conclude that students should be able to use their own calculator on any standardized test.

Availability and Teacher Attitudes

Two major factors that influence the effectiveness of technology are availability and teacher attitudes. Students need to be comfortable with calculators in order to be able to use them successfully. Therefore, calculators need to be available to the students on a

regular basis and the teacher needs to model the correct usage and a positive attitude for exploration.

In a study conducted by Scheuneman et al. (2002), researchers examined whether calculator availability unfairly advantaged students that had their own calculator. Reports show "that 9 out of 10 college-bound students owned or had regular access to calculators" (Scheuneman et al., 2002, p. 96). In addition, this study revealed that more than 70% of schools allow calculator use and the majority of these schools had some type of calculator available for use in the classroom. A second study also revealed that "no performance advantages associated with calculator type were related to student background characteristics (e.g., socioeconomic status, ethnicity, sex, math ability)" (Hanson et al., 2001, p. 59).

In another study, Forgasz and Griffith (2006) gathered data on teachers' attitudes toward the introduction of new technology, specifically the calculators having a computer algebra system (CAS). Researchers feared that the complex nature of the CAS would cause some negative reactions. However, the results of this study showed that 68% of teachers surveyed believed that the CAS would have a positive effect on teaching and 70% believed the CAS would have a positive effect on the curriculum overall. This result was expected from the younger teachers, but it "seemed to fly in the face of conventional expectations that older professionals are unlikely to support change" (Forgasz & Griffith , 2006, p. 25).

When to Use Calculators

One final hurdle to overcome when implementing calculator use is deciding when calculator use is appropriate. Some lessons and activities may require technology, while

it may cause distractions in others. Therefore, each teacher needs to evaluate the goals of his or her lessons to make that decision. Thompson and Sproule (2000) describe characteristics of lessons that do require the use of a calculator and lessons that do not. The student-oriented dimension of this description considered the students' facility with computations. In this dimension, calculators would be necessary if the computational level of the students hinders their "successful participation in the activity" (Thompson & Sproule, 2000, p. 127). With calculators, these students can explore areas of mathematics that involve complex calculations. Thompson and Sproule (2000) provided several examples of topics that require a calculator. The first activity discussed was determining a pattern within fractions by examining repeating decimals. The calculations required for this activity would be far too involved and would interfere with the goal of the activity. Another example presented was completing statistical explorations with large data sets or data sets that contain large values. These computations would again interfere with the goal of the activity, exploration, or project.

Summary

The studies compiled in this literature review have revealed a number of patterns and common outcomes. In the classroom, calculators have been shown to improve student achievement and increase conceptual understanding. Therefore, teachers need to be aware of these advantages and plan lessons using this technology when appropriate. This includes topics such as statistical analysis, graphical manipulations, problem solving, and applications of mathematical concepts. These topics allow students to form a relationship with knowledge necessary outside of the classroom.

Calculators have also been shown to increase confidence in mathematical skills and improve students' overall attitude toward the subject. Students with weak skills in mathematics will often form a negative attitude toward the material, which will affect their performance. By allowing these students to use calculators on assignments and tests, teachers can set them up for success (Ellington, 2003).

As calculators are introduced into the classroom, teachers must decide which calculator is best. Studies have not revealed any major differences in the performance of students using the graphing calculator or the scientific calculator. Teachers need to decide what calculator is appropriate for the level of students being taught and the topic being covered. Scientific calculators allow for basic to complex calculations, while graphing calculators allow for statistical analysis and graphical exploration. Therefore, this technology can be used for activities ranging from the most basic knowledge to the most advanced theories.

Opponents of calculator use fear that students will become too dependent on the calculator and will not learn the basic mathematics skills necessary for the real world. However, studies have shown that even though most students will utilize technology to speed up the process, they are still able to use mental math strategies appropriately (Ruthven, 1998). Therefore, when calculators are introduced at the proper stage of development, teachers can avoid any negative effects on the students' mental mathematical abilities.

The overall outcome of these studies sheds a positive light on the use of calculators in the classroom in most situations. Regardless of the type, calculators have been shown to improve grades, scores, and conceptual understanding. Calculators have

also been shown to improve the environment of the classroom by increasing interaction with material and confidence in abilities. As is the case with any teaching method, calculator use is not appropriate for every topic or every student, but can be an overall positive addition to the mathematics classroom. However, as of 1998, only 26% of teachers surveyed stated that they were using a graphing calculator in the classroom (Laughbaum, 2003). As technology becomes more affordable and user-friendly, that number will continue to increase. Therefore, mathematics educators should be aware of the resources that are available to make the implementation of technology as effective as possible.

CHAPTER 3

Methodology

Subjects

The sample used for this study was selected from a total population of 125 Algebra 2 students at Rossview High School in Clarksville, Tennessee. The participants for the study were 66 of the students from the Algebra 2 population. The students were randomly assigned to each class. The sample included 35 males, 31 females, 28 sophomores, 32 juniors, and 6 seniors from a variety of mathematical backgrounds and ability levels. All students participating in the study were taught by the same teacher, the study author.

Instruments

The instruments used for this study, which are available in the Appendix, were two Algebra 2 assessments. One assessment was to be completed without a calculator, while the other was completed with a calculator. Each assessment contained 15 questions and both forms included the same problems. However, the calculator assessment asked students to also explain how they used the calculator to solve the problem.

The instruments included a variety of topics chosen from the Algebra 2 curriculum required by the Clarksville-Montgomery County School System. Topics included statistical and measurement word problems, equation solving, order of operations, substitution, fraction conversions, linear graphing, and systems of equations. The assessments contained both open response and multiple choice questions. The instruments were designed to measure the difference in performance when a calculator is used to complete various mathematical tasks.

Procedures

At the beginning of the 2008-2009 school year, 83 students were randomly assigned to four Algebra 2 class with the same teacher. These students were all given the opportunity to participate in the study through voluntary consent. Sixty six of the 83 students chose to participate in the study and were present for both assessments. Each of these students was assigned a number that would be used to match their assessments throughout the study. No student names were used on the assessments themselves.

Student responses on two assessments were collected and analyzed using both quantitative and qualitative methods. The first assessment was administered on October 9, 2008. For this test, students were instructed not to use a calculator and to show work for each question to support their solution. The second assessment was administered on October 10, 2008. For this test, students were instructed that they were able to use a calculator when necessary, but were still asked to show work for any steps done by hand. Students were also asked to provide an explanation of how the calculator was used to help solve each problem.

The participants were given 50 minutes to complete each test. At that point, the assessments were scored, with each correct answer worth one point. No partial credit was given for questions that were answered partially correct. The total scores for each assessment and the scores on each individual question were organized in a table. The first analysis that was performed was a comparison of the total scores on the calculator and non-calculator assessments. This was done by using both percentages and a chi-square independence test. The scores on each individual question were analyzed in the same way.

Next, four main topics were identified from the questions on the assessments. The questions were grouped by topic, and the number of students answering each question correctly was recorded. A chi-square independence test was performed for each topic to determine if an association existed between calculator use and performance.

Finally, the students' responses on calculator use were coded into six categories (no calculator, single operation calculations, multiple operation calculations, fraction conversions, answer checking, and plugging in multiple choice answers). The numbers of responses in each category were recorded. Analyses were then performed on the calculator use codes using percentages. The analyses were organized by total responses and by topic. One final chi-square independence test was performed comparing the accuracy of students' answers to whether the calculator was used or not.

CHAPTER 4

Results

Effects on Performance

The first set of results that was examined for the study was the variations in scores between the non-calculator and calculator assessment. The results were organized and analyzed in a variety of ways. Percentages and chi-square independence tests were used to identify any possible association between calculator use and performance on the assessment. The null hypothesis used for all chi-square independence tests is listed below:

> Null Hypothesis (H_0): Calculator use and student performance are not associated.

The first result involved the overall scoring for each assessment. The average score earned on the non-calculator assessment was 7.05 out of 15 points. The average score earned on the calculator assessment was 9.92 out of 15 points. This indicated that the average increase in score between the two assessments was approximately 2.88 points. The results also revealed that 92.4% of the students earned a higher score on the calculator assessment.

Using the overall score data from both assessments, a chi-square independence test was performed to determine if a significant difference existed between performance on the two tests. Five score ranges were created and the data for these ranges were compiled in Table 1 below:

Table 1

Total Earned Score Range	Observed: # of students in each score range for Non-Calc (Test 1)	Expected: # of students in each score range for Non-Calc (Test 1)	Observed: # of students in each score range for Calc (Test 2)	Expected: # of students in each score range for Calc (Test 2)	Total
1 pt to 7 pts	41	26	11	26	52
8 pts to 9 pts	10	11.5	13	11.5	23
10 pts to 11 pts	10	18	26	18	36
12 pts to 15 pts	5	10.5	16	10.5	21
Total	66		66		132
Chi-Square Test Statistic =	30.57201253		P = 1.05×10^{-6}		

At a 5% significance level, the test had a critical value of 7.815. The chi-square test statistic of 30.572 fell in the rejection region. Therefore, the null hypothesis of no association between calculator use and performance was rejected. The P-value of 1.05×10^{-6} also provided very strong evidence against the null hypothesis.

The questions were then grouped by topic and analyzed using the chi-square test for independence to determine if an association existed within each topic. The data for the questions within these topics were compiled in the tables below:

Table 2

Question Type: Order of Operations	Observed: # of students answering each question correctly	Expected: # of students answering each question correctly	Observed: # of students answering each question incorrectly	Expected: # of students answering each question incorrectly	Total
Test 1	110	113.50	22	18.50	132
Test 2	117	113.50	15	18.50	132
Total	227		37		264
Chi Square Test Statistic =	1.54018336		P = 0.215		

Table 3

Question Type: Solving Linear Equations	Observed: # of students answering each question correctly	Expected: # of students answering each question correctly	Observed: # of students answering each question incorrectly	Expected: # of students answering each question incorrectly	Total
Test 1	61	74.50	71	57.50	132
Test 2	88	74.50	44	57.50	132
Total	149		115		264
Chi Square Test Statistic =	11.2317479		$P = 8.04 \times 10^{-4}$		

Table 4

Question Type: Word Problems	Observed: # of students answering each question correctly	Expected: # of students answering each question correctly	Observed: # of students answering each question incorrectly	Expected: # of students answering each question incorrectly	Total
Test 1	161	181.00	103	83.00	264
Test 2	201	181.00	63	83.00	264
Total	362		166		528
Chi Square Test Statistic =	14.0584437		$P = 1.77 \times 10^{-4}$		

Table 5

Question Type: Simplifying Expressions Using Substitution	Observed: # of students answering each question correctly	Expected: # of students answering each question correctly	Observed: # of students answering each question incorrectly	Expected: # of students answering each question incorrectly	Total
Test 1	93	131.50	171	132.50	264
Test 2	170	131.50	94	132.50	264
Total	263		265		528
Chi Square Test Statistic =	44.9173111		$P = 2.06 \times 10^{-11}$		

At the 5% significance level, the tests had critical values of 3.841 for each. The chi-square test statistic of 1.540 for order of operations questions did not fall in the rejection region. Therefore, the null hypothesis was not rejected for this topic. However, the chi-

square test statistics of 11.232 for linear equations, 14.058 for word problems, and 44.917 for substitution questions fell in the rejection region. Therefore, the null hypothesis of no association between calculator use and performance was rejected for these topics.

The final analysis was done by examining performance by question. The data for the number of students correctly answering each question were listed in Table 6 below:

Table 6

Question #	# of students correctly answering for Test 1	# of students correctly answering for Test 2	Difference
1	46	54	8
2	56	64	8
3	15	34	19
4	54	53	-1
5	40	47	7
6	30	33	3
7	14	36	22
8	15	16	1
9	15	16	1
10	44	60	16
11	10	47	37
12	47	61	14
13	21	53	32
14	42	54	12
15	16	27	11
Chi-Square Test Statistic =	34.19834728	P = 0.0019	

This data revealed that 14 out of 15 questions (93.3%) showed a higher number of students answering correctly on the calculator assessment. A chi-square independence test was also completed for this set of data. At a 5% significance level, the test had a critical value of 23.685. The chi-square test statistic of 34.198 fell in the rejection region. Therefore, the null hypothesis of no association between calculator use and performance on the assessment was again rejected. The P-value of 0.0019 also provided very strong evidence against the null hypothesis.

Calculator Usage

The second set of results that was examined for the study was the way in which the calculator was used on the second assessment, and how often this occurred. The following codes were used to collect the data:

N = No Calculator

S = Single Operation Calculations

M = Multiple Operation Calculations (Order of Operations)

F = Fraction Conversions

C = Answer Check

P = Plug In Multiple Choice Answers

The data were organized as a whole, by question, and by topic. Percentages were then used to determine the frequency of calculator use, method of use, and success rate.

Student responses were first organized individually and recorded by question. Each of the 66 participants answers 15 questions on the assessment. Therefore, a total of 990 questions were answered. Of the total number of questions, 365 questions (36.9%) were answered without using the calculator and 625 questions (63.1%) were answered using the calculator. Of the questions completed using the calculator, the two most common uses were single operation calculations (45.0%) and multiple operation/order of operation calculations (46.2%). The other less common uses for the calculator included fraction conversions (6.2%), answer checking (1.3%), and working backwards by plugging in multiple choice answers (1.3%).

The students' responses were then organized by question type to examine what the most popular use of the calculator was for each topic. Table 7 below shows the results of the responses by topic:

Table 7

Topic:	No Calculator	Single Calculations	Multiple Calculations	Convert Fractions	Answer Check	Plug in Multiple Choice
Order of Operations	29.5%	17.4%	51.5%	0.0%	1.5%	0.0%
Equations	51.5%	40.9%	0.0%	0.0%	1.5%	6.1%
Word Problems	28.0%	52.7%	18.9%	0.0%	0.4%	0.0%
Substitution	22.0%	13.3%	64.8%	0.0%	0.0%	0.0%
Fractions	37.9%	1.5%	0.0%	59.1%	1.5%	0.0%
Linear Graphing	95.5%	4.5%	0.0%	0.0%	0.0%	0.0%
Systems of Equations	57.6%	39.4%	0.0%	0.0%	3.0%	0.0%

For order of operations and substitution questions, most students plugged the entire expression in the calculator to solve. For questions involving equation solving, linear graphing, and systems of equations, the majority of students chose not to use a calculator. Finally, the calculator was used most often to convert on the question involving fractions, and for individual operations on the word problems.

The final analysis conducted with the responses involved the success rate of the calculator use on the second assessment. The number of questions that were correctly and incorrectly answered are listed in Table 8 below:

Table 8

	Observed: # of questions answered without the calculator	Expected: # of questions answered without the calculator	Observed: # of questions answered with the calculator	Expected: # of questions answered with the calculator	Total
Correct	159	241.49	496	413.51	655
Incorrect	206	123.51	129	211.49	335
Total	365		625		990
Chi-Square Test Statistic =	131.9010153		$P = 1.57 \times 10^{-30}$		

Of the questions completed without using a calculator, 43.6% were answered correctly and 56.4% were answered incorrectly. Of the questions answered using the calculator, 79.4% were answered correctly and 20.6% were answered incorrectly. A chi-square independence test was also performed to determine if a significant difference existed between the number of questions answered correctly and incorrectly both with and without the calculator. At the 5% significance level, the test had a critical value of 3.841. The chi-square test statistic of 131.901 fell in the rejection region. Therefore, the null hypothesis of no association between calculator use and performance was rejected. The P-value of 1.57×10^{-30} also provided very strong evidence against the null hypothesis.

Research Questions

1. Is there a relationship between calculator use and student achievement in the high school mathematics classroom?

Based on the results of this action research, I concluded that there is strong evidence of a relationship between calculator use and student achievement in the high school mathematics classroom. The average score increased by almost three points on the calculator assessment. Students were also able to correctly answer 79.4% of the questions completed with the calculator compared to only 43.6% of the questions answered correctly without the calculator.

2. What types of procedures are students using the calculator to complete?

The results show that the majority of students will use the calculator to complete mathematical tasks when the technology is available. The most common use for the calculator in the high school mathematics classroom is

to complete calculations, both single and complex. Other less common uses include fraction conversions, answer checking, and working backwards using the answer.

CHAPTER 5

Summary, Discussion, and Recommendations

Summary

This study was conducted in order to investigate the relationship between calculator use and classroom performance of high school mathematics students. This was accomplished by having a sample of 66 mathematics students complete an assessment with and without a calculator. The score and calculator reasoning explanations were grouped and analyzed in a variety of ways.

Score results showed strong evidence that students performed better when able to use a calculator. Not only were total scores higher on the calculator test, but the number of students who answered each question correctly increased on the calculator assessment.

Discussion

The purpose of the analyses performed in this study was to investigate the association between calculator use and student performance. The results revealed that calculator use was positively related to how well students perform a variety of mathematical tasks. Several patterns in student thinking also emerged from the responses and work provided on the assessments.

The strongest pattern observed in the results was the number of times that students used the calculator to perform basic calculations. Students completed single operation calculations using the calculator 45.0% of the time. This resulted in more accurate solutions being reached when the calculator was used. However, this also demonstrates a reliance on the calculator to perform operations that should be easily done

using mental math. This suggests that students need to spend more time practicing mental math due to the everyday importance of this skill.

Another issue of importance that was observed on the calculator assessment was students' inability to use parenthesis properly with the calculator. This weakness was observed with two questions on the test. The first question asked students to simplify a fraction containing operations in the numerator and denominator. The second question required students to square a negative number to reach their answer. On both of these questions, students failed to put parentheses around the appropriate terms, resulting in an incorrect answer being reached more often with the calculator. This outcome indicates that students need to better understand the limitations of the calculator in order to avoid this problem.

The final surprising result was the fact that 95.5% of students chose not to use the calculator to complete the question involving linear equation graphing on the second assessment. The graphing calculator was available for use by all students during this test. The students' lack of comfort with the linear graphing function of the calculator was to blame for this result. Therefore, students should be provided with opportunities to explore the abilities of the graphing calculator throughout the Algebra curriculum.

Recommendations

With technology being more widely available, more students will be using calculators in the mathematics classroom. This allows teachers to use more in-depth activities without worrying about tedious calculations or operations that are too complex to be done by hand. However, if students are unable to input problems correctly or use the variety of functions the calculator is able to do, the full benefits of the calculator

cannot be experienced. Therefore, more emphasis needs to be placed on teaching students how to correctly use the calculator throughout middle and high school.

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APPENDIX

Field Study Assessment #1

Directions: Complete each of the following questions WITHOUT using a calculator. Show all work in the space provided below the problem. Place the answer on the answer line below the question.

1. Solve: $5(2x + 6) = 7x - 3$

   (A) -9 (B) No Solution (C) -11 (D) 9

   Work:

   Answer:_____

2. Simplify: $(35 + 5 \bullet 10 \div 5 - 10) \div 7$

   (A) 0 (B) 5 (C) 12 (D) 402

   Work:

   Answer:_____

3. Solve: $4x - 2(x + 7) = 4x + 5$

   Work:

   Answer:_____

4. Simplify: $\frac{15+60}{30-5}$

Work:

Answer:_____

5. The perimeter of a rectangle is 82 centimeters. What is the length of the longer side if the shorter side measures 8 centimeters?

(A) 33 cm (B) 30 cm (C) 16 cm (D) 25 cm

Work:

Answer:_____

6. During a Scrabble game, a player with 75 points can place a word on the gameboard and triple the value of the word. The player will then have a total of 99 points. How many points is the word worth?

(A) 24 pts (B) 15 pts (C) 6 pts (D) 8 pts

Work:

Answer:_____

7. Find $f(-2)$ given $f(x) = 2x^2 + x - 8$.

Work:

Answer:_____

8. What is the y-intercept of $4x + y = 4$?

Work:

Answer:_____

9. Solve the system of equations:

$$3x + 2y = -5$$
$$y = 3x - 7$$

Work:

Answer:_____

10. The number of patients treated at Dr. Jones' dentist office each day was recorded for eight days. Use the given data to find the mean.
Data: 19, 3, 6, 21, 8, 10, 19, 2

(A) 11 (B) 9 (C) 19 (D) 29.5

Work:

Answer:_____

11. Write 2.79 as a fraction in simplest form. (No mixed numbers!)

Work:

Answer:_____

12. The formula for the surface area of a rectangular prism is:

$$SA = 2(LH + LW + WH)$$

Find the surface area of a rectangular prism with a length of 7 inches, a width of 4 inches, and a height of 3 inches.

(A) 122 in^2 (B) 134 in^2 (C) 148 in^2 (D) 168 in^2

Work:

Answer:_____

13. Evaluate $2y^2(x + y)$ when $x = 2$ and $y = 4$.

Work:

Answer:_____

14. Find f(6) given $f(x) = x^2 + 3x - 2$.

Work:

Answer:_____

15. Evaluate $-x^2 + 3$ for $x = -4$.

Work:

Answer:_____

Field Study Assessment #2

rections: Complete each of the following questions using a calculator. Show all work in e space provided below the problem. Place the answer on the answer line below the estion.

1. Solve: $5(2x + 6) = 7x - 3$

(A) -9 (B) No Solution (C) -11 (D) 9

Answer:_____

Work:

How did you use the calculator to help you solve this problem?

2. Simplify: $(35 + 5 \bullet 10 \div 5 - 10) \div 7$

(A) 0 (B) 5 (C) 12 (D) 402

Answer:_____

Work:

How did you use the calculator to help you solve this problem?

3. Solve: $4x - 2(x + 7) = 4x + 5$

Work:

Answer:_____

How did you use the calculator to help you solve this problem?

4. Simplify: $\frac{15 + 60}{30 - 5}$

Answer:_____

Work:

How did you use the calculator to help you solve this problem?

5. The perimeter of a rectangle is 82 centimeters. What is the length of the longer side if the shorter side measures 8 centimeters?

(A) 33 cm (B) 30 cm (C) 16 cm (D) 25 cm

Work:

Answer:_____

How did you use the calculator to help you solve this problem?

6. During a Scrabble game, a player with 75 points can place a word on the gameboard and triple the value of the word. The player will then have a total of 99 points. How many points is the word worth?

(A) 24 pts (B) 15 pts (C) 6 pts (D) 8 pts

Work:

Answer:_____

How did you use the calculator to help you solve this problem?

7. Find $f(-2)$ given $f(x) = 2x^2 + x - 8$.

Work:

Answer:_____

How did you use the calculator to help you solve this problem?

8. What is the y-intercept of $4x + y = 4$?

Work:

Answer:_____

How did you use the calculator to help you solve this problem?

9. Solve the system of equations:

$$3x + 2y = -5$$
$$y = 3x - 7$$

Work:

Answer:_____

How did you use the calculator to help you solve this problem?

10. The number of patients treated at Dr. Jones' dentist office each day was recorded for eight days. Use the given data to find the mean.
Data: 19, 3, 6, 21, 8, 10, 19, 2

(A) 11 (B) 9 (C) 19 (D) 29.5

Work:

Answer:_____

How did you use the calculator to help you solve this problem?

11. Write 2.79 as a fraction in simplest form. (No mixed numbers!)

Work:

Answer:_____

How did you use the calculator to help you solve this problem?

12. The formula for the surface area of a rectangular prism is:

$$SA = 2(LH + LW + WH)$$

Find the surface area of a rectangular prism with a length of 7 inches, a width of 4 inche and a height of 3 inches.

(A) 122 in^2 (B) 134 in^2 (C) 148 in^2 (D) 168 in^2

Work:

Answer:_____

How did you use the calculator to help you solve this problem?

13. Evaluate $2y^2(x + y)$ when $x = 2$ and $y = 4$.

Work:

Answer:_____

How did you use the calculator to help you solve this problem?

14. Find f(6) given $f(x) = x^2 + 3x - 2$.

Work:

Answer:_____

How did you use the calculator to help you solve this problem?

15. Evaluate $-x^2 + 3$ for $x = -4$.

Work:

Answer:_____

How did you use the calculator to help you solve this problem?