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A study of secondary teachers' attitudes toward the use of the graphing calculator to prepare for and perform on the HSPA

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A STUDY OF SECONDARY TEACHERS' ATTITUDES TOWARD THE USE OF

THE GRAPHING CALCULATOR TO PREPARE FOR AND

PERFORM ON THE HSPA

by
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ABSTRACT

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A STUDY OF SECONDARY TEACHERS' ATTITUDES TOWARD THE USE OF
THE GRAPHING CALCULATOR TO PREPARE FOR AND
PERFORM ON THE HSPA
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The purpose of this research will be to identify the effectiveness of graphing calculators as instructional tools in building the skills needed to demonstrate proficiency on the New Jersey HSPA. To research this topic, teachers from South Jersey high schools were contacted and asked to respond to a survey regarding opinions and observations about the use of the graphing calculator. The survey was created by the researcher in order to investigate how teachers feel graphing calculators influence conceptual understanding of skills tested on the HSPA. The survey will use a likert scale to measure teacher attitudes about the effect of use of graphing calculators on students' conceptual understanding of skills that are tested on the HSPA. Because of previous research, and research contained here, it is clear that the appropriate use of the graphing calculator in mathematics classrooms will be of great benefit to the growth of students by enhancing conceptual understanding of HSPA skills. It is important that all teachers are properly trained in how to use the calculator appropriately to enhance these skills. Teachers should use the calculator often and include it as part of regular assessment.

Acknowledgements

I would like to thank my family and especially my wife Jamie for all of their encouragement and support. I would also like to that Dr. Eric Milou for his patience and encouragement throughout this process.

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CHAPTER 1

INTRODUCTION

Developing a fair, accurate, and worthwhile assessment is a challenge that all educators have faced and will continue to face. A report by Achieve Inc. (2004) cites the following:

> While some people question the use of tests as part of states' graduation requirements, the *need* for higher high school exit expectations should be clear because the *cost* of poor high school preparation to students and states is so clear. While roughly three-quarters of high school graduates pursue postsecondary education within two years of earning a diploma, fewer than half ever earn a degree. Twenty-eight percent of those entering two and four-year colleges immediately need a remedial English language arts or mathematics course, and half of all students take at least one remedial course during their college careers. For their part, more than 60 percent of employers rate high school graduates' grammar, spelling, writing and basic math skills as only fair or poor. The cost for one state's employers to offer remedial English language arts and math was estimated at about $40 million a year. High school exit exams allow states to set a floor of academic achievement for all students to ensure that they meet standards before earning a diploma. Such exams provide evidence of achievement that is more comparable and aligned with standards than Carnegie units or course grades alone (Achieve, 2004, 7).

As a result of the No Child Left Behind Act (NCLB) many schools and districts across the country are facing increasing pressure to perform well on standardized tests and mandatory high school exit exams. It is important to have some sort of measurement device that allows us to compare students statewide and even nationally. In New Jersey we have developed an assessment tool based on a compilation of state standards. These standards are extremely important and so is our tool for their assessment, the New Jersey High School Proficiency Assessment (HSPA). The HSPA serves as the state's graduation test. It tests student knowledge and skills aligned with the state's academic standards, known as the *Core Curriculum Content Standards*. These include the following:

1.) Geometry and measurement

2.) Patterns and algebra

3.) Data analysis, probability, and discrete mathematics

4.) Mathematical processes

According to the New Jersey Department of Education's State Report Card, the HSPA is one of the most important tools by which a district's success is judged (NJDOE).

In an age of unprecedented technological advances, the use of the graphing calculator in high school mathematics classrooms is becoming an increasingly important topic for teachers to address. Parker and Mills (2004) note that graphing calculators are being used more than ever to enrich math and science education. They point out that these tools allow students to visualize mathematics and make connections that might otherwise be missed. Beckmann, Senk, and Thompson (1999) are quick to point out that if graphing calculators are an integral part of instruction, then they should also be an

important feature of assessment. Smith (1998) points out that many educators believe that graphing calculators can be used as tools for conceptual understanding and catalysts for critical thinking.

Several experts have noted the importance of making connections between the appropriate use of graphing calculators and effective assessment. Dion, Harvey, Jackson, Klag, Liu, and Wright (2001) agree that there is an inconsistency between the uses of calculators and active test items. They also concur that mathematics educators, researchers, and test writers would benefit from further discussion of how to integrate calculator items into all aspects of curriculum, including assessments. Merriweather and Tharp (1999) conclude that graphing calculators need to be used more consistently over a prolonged period of time and that more research needs to be done to investigate if the graphing calculator has an effect on how students solve word problems. In addition to these experts, Waits and Demana (1998) concluded that investigating the proper use of calculators and their integration into curriculums is a worthy goal of research.

Connections between the use of the graphing calculator and its integration into HSPA preparations are already being made in some places. The College of New Jersey's college bound program is a program designed to prepare eligible students from New Jersey high schools for college. This program carefully integrates the use of the graphing calculator to prepare students for the HSPA (College Bound, 2004). On their school districts web page, the Southern Regional School district also describes the extensive use of the graphing calculator as a tool to help students connect mathematics to the real world. The Center for Mathematics, Science, and Computer Education at Rutgers University offers standards-based mathematics workshops for high school teachers to

help prepare students for the HSPA. One of the workshops presented by James Rahn on December 9, 2004, specifically addressed the topic of "Graphing Calculator Skills to prepare students for the HSPA". The workshop examined specific HSPA items and connected graphing calculator skills and investigations that would be beneficial in preparing students (Rahn, 2004).

The purpose of this research will be to identify the effectiveness of graphing calculators as instructional tools in building the skills needed to demonstrate proficiency on the New Jersey HSPA.

The research will answer the following questions:

1. Does the use of the graphing calculator in the classroom enhance students conceptual understanding of HSPA topics?

2. What HSPA skills/clusters in particular is the graphing calculator more or less beneficial in building?

3. Is one particular calculator more beneficial than another?

4. Does the use of a graphing calculator increase student performance on the HSPA?

5. Does the frequency of use of the graphing calculator have an effect on teacher opinions towards its benefits?

Limitations

The study will be limited to South Jersey high schools, specifically those in Gloucester and Camden Counties. A researcher designed survey of the attitudes and practices (regarding the use of graphing calculators) of the mathematics teachers and administrators in those schools will be conducted. The survey was limited to public school teachers and administrators. The calculators included in the research will be those manufactured by Texas Instruments, including the TI 82, 83, 83 Plus, 84, 86, and 89.

Definitions

HSPA - The High School Proficiency Assessment is used to determine student achievement in reading, writing, and mathematics as specified in the New Jersey Core Curriculum Content Standards. First-time eleventh grade students who fail the HSPA in March of their junior year will have an opportunity to retest in October and March of their senior year.

The HSPA is broken up into four major clusters of topics:
  I.   Number Sense, Concepts and Applications.
  II.   Spatial Sense and Geometry.
  III. Data Analysis, Probability, Statistics, and Discrete Mathematics.

  IV.   Patterns, Functions, and Algebra

Graphing Calculators – Specific models referred to for this research will include the following models manufactured by Texas Instruments: TI83, TI83 Plus, TI 84, TI 86, and TI89

NCLB – The No Child Left Behind Act was signed by President George W. Bush on January 8, 2002. Under the act's accountability provisions, states must describe how they will close the achievement gap and make sure all students, including those who are disadvantaged, achieve academic proficiency. They must produce annual and state school district report cards that inform parents and communities about state and school progress. Schools that do not make progress must provide supplemental services, such as free tutoring or after-school assistance; take corrective actions; and, if still not making adequate yearly progress after five years, make dramatic changes to the way the school is run.

AYP– Adequate Yearly Progress is one of the cornerstones of the federal No Child Left Behind Act (NCLB). It is a measure of year-to-year student achievement on statewide assessments.

CHAPTER 2

REVIEW OF LITERATURE AND RESEARCH

Since graphing calculators have been made available, a wide array of research has

been done to investigate the benefits of using such technology in secondary mathematics

classrooms. Those used in this study include the following: journal articles, opinion

papers, research reports, master's thesis and the ERIC digest. The review is divided into

two parts, first research and literature regarding the use of the graphing calculator, and

second, a review of the New Jersey HSPA.

Graphing Calculators

The review of the graphing calculator research will be divided into three specific

areas. It will address how the use of the graphing calculator enhances student

performance and achievement, the attitudes of teachers in regard to the use of the

graphing calculator as an instructional tool, and how the graphing calculator may serve as

a motivational tool for students and teachers.

Student Achievement and Performance

Hubbard's research (1998) reveals that increasing the use of the graphing

calculators strengthens students' understanding of mathematical concepts and improves

problem solving abilities. The first part of the graphing calculator research review will

focus on how the calculator is beneficial to student achievement and performance. Waits

and Demana (1998) examined the recent technological innovations with graphing

calculator technology and applications in the classroom. It appears that the use of the

graphing calculator is not just a good idea at this point, but is quickly becoming expected.

Waits and Demana acknowledge that most algebra and calculus textbooks today fully integrate the use of the graphing calculator, assuming use by the students. Waits and Demana also assert that if textbooks and curriculums are undergoing change, then eventually assessments will experience the same types of changes. Waits and Demana believe that if we want to see basic skills and problem solving skills improve, we must continue to develop appropriate methods. Appropriate use of the newest technologies may eventually not just be a good idea or a suggested strategy, but rather a necessity for demonstrating proficiency.

Waits and Demana concluded that using calculators for instruction and testing enhances learning and problem solving skills. They also assert that research on the proper use of calculators and their integration into curriculums is a worthy goal of research. They are careful to point out the concerns of some that calculators threaten basic skills. They note that research consistently shows that calculator use does not negatively affect basic skills when those skills have been developed in a calculator free environment.

Dick (1992) also points out that many concerns arise with the development of this new technology. Some teachers fear, as they did in the early days of scientific calculators, that some fundamental skills will be lost or at least underdeveloped. Dick explores the argument that many use against the use of the graphing calculators. Many believe that the overuse of the calculator will deprive students of the benefits of the mental exercise of computational skills and ultimately make the students' mastery of computational skills weaker. Dick provides evidence that extensive mathematics education research has dispelled that concern. Dick acknowledges the usefulness of the

graphing calculator in exploration and the initial stages of problem solving. He also points out that in most cases the proper use of the calculator requires a proper understanding of the problem being solved. Dunham and Dick's research (1994) reinforces this point. They found that calculators provide more time for instruction, supply more tools for problem solving, and allow students to perceive problems differently.

Mercer argues the following:

> Once we realize what is truly important in mathematics we will be less inclined to stick to our past prejudices about the necessity of training our students to do mechanical tasks....And even if such skills are necessary (to prepare for standardized tests) they can be much more effectively taught after the more important analytical skills have been developed and the students have gained an appreciation of what mathematics is really all about (Mercer, 1992, 417).

Through their research, Scariano and Calzada (1994) argue that proper use of the graphing calculator in a basic skills classroom will greatly enhance the learning of basic skills in ways consistent with NCTM (National Council of the Teachers of Mathematics) standards. Milou (1999) points out that the use of graphing calculators does not lead to a weakening of algebra skills. Rising (2003) notes that as test scores improve with the use of calculators, the depth of math instruction will grow and learning will accelerate. These authors all seem to agree that the calculator is an extremely beneficial tool, when used appropriately, for strengthening both problem solving and basic computational skills.

Next, it is important to also examine the effects of teacher attitudes toward the use of graphing calculators. Fleener's research (1995) explains that changes in calculator use in mathematics instruction are influenced by teacher experiences and opportunities to reflect upon beliefs about calculator use. Simonsen and Dick (1997) describe a large study of teacher's attitudes towards benefits of the graphing calculators in which sixty-seven percent believed that less time with computational detail was a major benefit. Sixty-three percent said that immediate feedback was also a major benefit. The largest disadvantages were believed to be lack of access, 59% and problems with security, 52%. Both of the major disadvantages are noticed to be non-academic. Smith (1998) points out that many educators agree that graphing calculators can be used as tools for conceptual understanding and catalysts for critical thinking.

Tharp, Fitzsimmons, and Brown (1997) suggest that teacher attitudes must change in order for teaching behavior to change. Their research reveals that more rule-based teachers were more reluctant to implement the use of and exploration with graphing calculators. In contrast, less rule based teachers were found to be more likely to adopt and implement the graphing calculator as an instrumental part of instruction. Vannatta and Fordham (2004) seem to be in agreement with these notions. Their research found that a combination of technology training, time spent beyond the contractual work week, and openness to change best predict a teacher's disposition to be willing to implement graphing calculator use (Vannetta & Fordham, 2004). Burke's (1993) Survey revealed that 93% of teachers surveyed believed that the graphing calculators enhance classroom instruction. Although Burke's survey revealed that the teachers believed that the use of

this technology enhanced classroom instruction, many of the teachers did not make adequate use of the technology. Burke's research attributed much of this disparity to a lack of training in the use of the calculator.

Motivational Tool

Lastly, it is important to examine the benefits of the graphing calculator as a motivational tool for both students and teachers. For example, Hubbard (1998) explains that the use of graphing calculators fosters positive attitudes in both students and teachers. Merriweather and Tharp (1999) conducted a study of the use of the TI82 graphing calculator for instruction of eighth-grade general math students. Half of the students received calculator based instruction, while the other half received non-calculator based instruction. Students were also classified as rule-based and non-rule based students. The rule-based students were more comfortable using an equation to solve a word problem rather than a numeric method. Merriweather and Tharp found that 4% of the non-calculator group felt that when doing mathematics it is only important to know how to do a process and not why it works, compared to 27% of the calculator group. Merriweather and Tharp believe that the use of the calculators encourage students to be more excited and involved in their learning. Merriweather and Tharp conclude that graphing calculators need to be used more consistently over a prolonged period of time and that more research needs to be done to investigate if the graphing calculator has an affect on how students solve word problems.

In addition, Van Dyke and White (2004) stress the importance of how visual approaches to mathematics make the content more meaningful. They found that graphical calculators make the visual representations more accessible and meaningful.

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As a result, students will have better comprehension of the content and enjoy mathematics more. Simmt (1997) observes that teachers find the graphing calculators beneficial in saving time and motivating students. *Media and Methods* (2001) reported that many students and teachers prefer the use of the graphing calculator because of the time that can be spent in exploring questions that may have gone unanswered in the past. The calculator allows the students' and teachers to explore more complex problems in practical ways ("Handheld Graphing," 2001). Dunham and Dick (1994) provide very strong points in support of the graphing calculator's use as a motivational tool. Their research points out that students' believed that the graphing calculator improved their ability to solve problems. The use of the calculator builds confidence in students, thereby motivating them to take on more difficult problems.

The above research concurs that the graphing calculator is very beneficial in enhancing classroom instruction if the appropriate strategies are implemented. It also reveals a clear increase in the conceptual understanding of students when used with an appropriate strategy. The calculator makes both the teacher and the student more effective by streamlining operations and affording the students and teachers greater time and opportunity to focus on conceptual understanding and mathematical meaning. It is clear that teacher attitudes are also instrumental in determining and implementing an appropriate strategy for the use of the graphing calculator. As teachers are better prepared and more confident in using the technology, they can better encourage and foster the same type of growth in their students. Finally, the reviewed research also points to the benefits of the calculator as a motivational tool for both students and teachers. The use of the calculator as a motivational tool is invaluable. It can be used to

build a confidence and excitement toward mathematics that otherwise may have been missed.

<div align="center">The New Jersey HSPA</div>

Achieve, Inc., an independent, bipartisan, non-profit organization created by the nation's governors and corporate leaders to help states raise academic standards and improve assessments has published a report (2000) chronicling how well New Jersey's assessments measure the knowledge and skills in the standards. The report also examines how New Jersey's standards compare with other high performing states and nations. The report was published in 2000. The HSPA was being field tested at the time. The report found the grade 11 math assessment to be substantially less rigorous than what the standards imply and often emphasized lower level content while omitting important concepts in algebra and geometry.

Another report by Achieve Inc. (2002) is careful to point out that NCLB will require grade-by-grade testing in reading and math for grades 3 through 8. It will be important that tests given in grades above and below each other are aligned with each other. New tests being added should be aligned with existing tests and state standards. If the existing tests, like the HSPA are only loosely connected as Achieve Inc.'s 2000 report suggests, this will be a great challenge. The report also acknowledges that many states, not just New Jersey should focus on making their standards clearer and more coherent from grade to grade.

Recently, Achieve Inc. published a report (2004) in which analysts examined mathematics and English language arts exams from Florida, Maryland, Massachusetts, New Jersey, Ohio and Texas. Three conclusions were reached:

<div align="center">12</div>

1. The expectations of the tests are reasonable. They are not overly demanding.

2. The exams need to be strengthened, to better measure knowledge and skills that graduates will need for post-high-school success.

3. States should not rely solely on these exams to measure a student's education. A more comprehensive set of measures should be developed.

If the conclusions that Achieve has reached are accurate, then changes in assessment will be a necessary step toward growth and progress. Researching strategies that could be potentially beneficial to that growth is vital. The following research will be concerned with how the use of the graphing calculator can be beneficial in fostering growth of the skills and standards measured by the HSPA.

CHAPTER 3

METHODOLOGY

Procedures

To research this topic, teachers from South Jersey high schools were contacted and asked to respond to a survey regarding opinions and observations about the use of the graphing calculator. All thirty five public high schools in Camden and Gloucester Counties were contacted by phone and asked to participate in the survey. The addresses and phone numbers for the schools were found via the internet. The researcher contacted each school by telephone first, before distributing the surveys through the mail. Only those agreeing to participate were sent surveys. The surveys were distributed to each respective school's mathematics department chairperson or supervisor. Each supervisor or chairperson distributed and collected the surveys for teachers in his/her mathematics department. The surveys were then returned to the researcher by mail.

In particular, the survey will explore the effectiveness of the graphing calculator as a teaching tool and resource to improve student performance on HSPA related skills. The results of the surveys will be analyzed and suggestions will be made as to what are the best ways to implement the use of the graphing calculator to enhance conceptual understanding of HSPA skills and increase student performance on the HSPA.

Measures

The survey was created by the researcher in order to investigate how teachers feel graphing calculators influence conceptual understanding of skills tested on the HSPA.

The survey will use a likert scale to measure teacher attitudes about the effect of use of graphing calculators on students' conceptual understanding of skills that are tested on the HSPA. The survey will ask the gender of the teacher, the courses the teacher instructs, how long the teacher has been teaching, the size of the school the teacher is teaching in, and how often the teacher has students use the graphing calculators. Likert scales will investigate teachers' feelings about students' conceptual understanding of skills on the HSPA. Each category of the Likert scale will be assigned a numeric value: Strongly Agree=5, Agree=4, Neither Agree/Disagree=3, Disagree=2, Strongly Disagree=1. The items will ask about how strongly the teachers surveyed felt about the impact of the use of the graphing calculator for increasing a student's conceptual understanding of HSPA topics. It will also ask how strong the surveyed teachers felt about how the appropriate use of the graphing calculator affects student performance on the HSPA. The survey will also ask teachers about what calculators are used in what courses and how often they use the graphing calculators in various courses. Each category of frequency will be assigned a numeric value; Daily = 5, 1-2 times/week = 4, monthly = 3, rarely =2, and never = 1.

Design and Analyses

Means will be calculated for each item on the Likert scale. Higher means are indicative of the use of the graphing calculator being beneficial in strengthening HSPA related skills. A t-test will assess whether teachers whose students' use the graphing calculator feel that the calculator is helpful in enhancing conceptual understanding of HSPA skills. Frequency tables will be used to determine which calculators were favored for use on the HSPA and for enhancing particular HSPA skills. Correlation analyses will

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be conducted to determine if there are significant relationships between teachers' feelings of the usefulness of calculators (for students) in grasping different mathematical concepts and the frequency of use of the calculator.

Research Questions

Each research question will be strongly connected to an element of the survey.

Question 1: Does the use of the graphing calculator in the classroom enhance students' conceptual understanding of HSPA topics? This will be answered by calculating the mean of the likert scale responses of survey items 1-4. A higher mean will indicate that the teachers surveyed believe that the use of the graphing calculator enhances conceptual understanding of each HSPA cluster. A t-test will compare the means to three to determine if the means differ significantly from a neutral response of three. Survey question one addresses number sense, survey question two addresses geometry and spatial sense, survey question three addresses data analysis, probability, statistics, and discrete math, and survey question four addresses patterns, functions, and algebra.

Question 2: What HSPA skills/clusters in particular is the graphing calculator more or less beneficial in building? This will be answered by comparing the means of the likert scale questions 1 thru 4 of the survey. Each question 1-4 is connected to a specific cluster, as stated previously. Each mean will be compared to each other using a paired samples test to determine if the differences in the values of the means are significant enough to conclude that the respondents believed the calculator was more beneficial to one cluster than another. The higher means will represent the skills that the teachers surveyed believed benefit the most from the appropriate use of the graphing calculator.

Question 3: Is one particular calculator more beneficial than another? This item will be answered in two ways using frequency tables. First, a bar graph and frequency table will display the results to survey question 6. It can be determined which calculator the teachers surveyed believed is most beneficial to students when actually taking the HSPA. Next, survey question 7 will determine which calculator is most beneficial for building specific HSPA skills. A bar graph and frequency table will identify which calculator was preferred for each particular skill cluster.

Question 4: Does the use of a graphing calculator increase student performance on the HSPA? The mean of the likert scale values for question 5 of the survey will be used to answer this question. A higher mean will indicate that the teachers surveyed believe that the appropriate use of the graphing calculator increases student performance on the HSPA. A t-test will be used to compare the mean to the neutral response of three and determine if it is statistically significant.

Question 5: Does the frequency of use of the graphing calculator have an effect on teacher opinions toward its benefits? Each survey respondant's likert scale values for questions 1 thru 5 of the survey will be averaged. This will result in a number between 1 and 5. Each of the frequency categories from survey item 8 will also be assigned a number. Daily = 5, 1-2 Times/Week = 4, Monthly = 3, Rarely = 2, Never =1. Each response will be separated according to subject groupings. Algebra 1, algebra 2, and advanced algebra 2 will be grouped together. Geometry and advanced geometry will be grouped together. Pre-calculus, advanced pre-calculus, calculus, and a.p. calculus will be grouped together. Statistics, a.p. statistics, probability and statistics, and discrete math will be grouped together. Integrated maths 1, 2, and 3 will be grouped together. HSPA

math will constitute its own group. Finally, there will be a separate group for any teacher who selected frequency of use for a course other than what was include on the survey. Correlation analyses will be conducted to compare the likert scale means to the frequency of use to determine if there is a significant relationship between teachers' feelings of the usefulness of calculators (for students) in enhancing performance and conceptual understanding of HSPA skills and the frequency of use of the calculator. A positive correlation will suggest a positive relationship between teacher attitudes and frequency of use.

CHAPTER 4

ANALYSIS OF DATA

Demographics

The purpose of this chapter is to describe the results of the survey according to the procedures described in the previous chapter. A total of 67 surveys were returned from 10 different South Jersey High Schools. Table 4-1 describes the respondents, their respective high schools, and demographic information.

Table 4-1:

Descriptive Statistics

School	Size	Males	Females	1-3 years	4-10 years	11-20 years	21-30 years	31 + years
Delsea	1001-1500	3	3	1 f	1 f	2 m, 1 f	1 m	0
Eastern	2001 +	4	5	1 m	1 m, 3 f	1 m	0	1 m, 2 f
Timber Creek	1001-1500	3	4	1 m, 1 f	2 m, 2 f	0	0	1 f
Triton	1501-2000	1	1	0	0	1 m, 1 f	0	0
West Deptford	1001-1500	0	3	0	0	1 f	2 f	0
Washington Township	2001 +	5	7	0	2 m, 2 f	1 m, 2 f	1 m, 3 f	1 m
Glassboro	501-1000	4	2	1 m, 1 f	1 m	1 m	1 f	1m
Lindenwold	501-1000	3	6	1 m, 1 f	1 m, 2 f	1 m, 1 f	2 f	0
Gateway	1001-1500	2	5	1 m, 3 f	0	1 f	1 f	1m
Clayton	501-1000	2	4	0	1 m, 1 f	2 f	1 m, 1 f	0
Totals		27	40	5 m, 7 f	8 m, 11 f	7 m, 9 f	3 m, 10 f	4 m, 3 f

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Descriptive Statistics

Table 4-2 describes the means, standard deviations, and standard errors for the 5 likert scale survey questions. All of the means were above a 3 with the lowest rating score a 3.76.

Table 4-2:

Mean Comparisons

	N	Mean	Std. Deviation	Std. Error Mean
Question 1: The appropriate use of the graphing calculator enhances a student's number sense.	67	3.7910	1.12192	.13706
Question 2: The appropriate use of the graphing calculator enhances a student's spatial sense.	67	3.9403	.86831	.10608
Question 3: The appropriate use of the graphing calculator enhances a student's conceptual understanding of data analysis, probability, statistics, and discrete math.	67	4.2239	.77501	.09468
Question 4: The appropriate use of the graphing calculator enhances a student's conceptual understanding of patterns, functions, and algebra.	67	4.2687	.84535	.10328
Question 5: The appropriate use of the graphing calculator increases student performance on the HSPA.	67	3.7612	.97062	.11858

Research Questions

Question 1: Does the use of the graphing calculator in the classroom enhance students' conceptual understanding of HSPA topics? T-tests were conducted to assess whether or not teachers found these calculators useful by comparing the means of each question to a 3 on the rating scale. A mean of 3 would signify that the respondents neither agreed nor disagreed with the statement. Since all of the means were greater than 3, a t-test was used to determine if the difference was statistically significant. As can be seen from table

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4-3, the means for each question were significantly higher than a 3 (p<.001), indicating

that the appropriate use of the graphing calculator does enhance conceptual

understanding of each HSPA related topic.

Table 4-3:

T-Tests

	Test Value = 3				95% Confidence Interval of the Difference	
	T	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Question 1: The appropriate use of the graphing calculator enhances a student's number sense	5.771	66	.000	.79104	.5174	1.0647
Question 2: The appropriate use of the graphing calculator enhances a student's spatial sense.	8.864	66	.000	.94030	.7285	1.1521
Question 3: The appropriate use of the graphing calculator enhances a student's conceptual understanding of data analysis, probability, statistics, and discrete math.	12.926	66	.000	1.22388	1.0348	1.4129
Question 4: The appropriate use of the graphing calculator enhances a student's conceptual understanding of patterns, functions, and algebra.	12.284	66	.000	1.26866	1.0625	1.4749
Question 5: The appropriate use of the graphing calculator increases student performance on the HSPA.	6.419	66	.000	.76119	.5244	.9979

Question 2: What HSPA skills/clusters in particular is the graphing calculator more or

less beneficial in building? Paired samples tests were conducted to determine if the

respondents felt stronger about one statement than another. Table 4-4 shows the results

of the paired samples tests. The mean of the teacher responses to the number sense

question was 3.791 and the mean for geometry and spatial sense was slightly higher at

3.9403. However, this difference was not statistically significant. When the number

sense mean of 3.791 was compared to the data analysis, probability and statistics mean of

4.2239, the difference was found to be statistically significant with $p = .002$. When the number sense mean of 3.791 is compared to the patterns, functions and algebra mean of 4.2687, the difference is also statistically significant. The mean of geometry and spatial sense question was 3.9403, when compared the mean of 4.2239 for the data analysis, probability and statistics question we find that the difference between the two means is not statistically significant at the .01 level. When comparing the geometry and spatial sense mean of 3.9403 to the patterns, functions, and algebra mean of 4.2687, we find that the patterns, functions, and algebra mean is significantly higher at the .01 level. Finally, when we compare the mean of 4.2239 for data analysis, probability and statistics to the mean of 4.2687 for patterns, functions, and algebra, we find that the difference is not statistically significant.

Question 3: Is one particular calculator more beneficial than another? This question was assessed by recording the frequencies of responses for each individual calculator included in the survey. As can be seen in figure 4-5, the TI 83 plus was the most favored calculator for all four skills clusters, and for use on the HSPA. When asked which calculator was most beneficial for enhancing number sense , thirty-one respondents preferred the TI83 plus, twenty-five selected the TI83, six selected the TI84, four selected the TI89, and one selected the TI86. Six respondents selected no calculator as being most beneficial for strengthening number sense. For the cluster of geometry and spatial sense, twenty-eight teachers selected the TI83 plus. Sixteen selected the TI83, nine selected the TI84, six chose the TI89, and one teacher selected the TI86. Six teachers surveyed responded that no calculator was most beneficial in strengthening geometry and spatial sense. For enhancing conceptual understanding of data analysis, probability, and

statistics, thirty-five teachers preferred the TI83 plus. Twenty-three selected the TI83, nine selected the TI84, three selected the TI86, and three preferred the TI89.

Table 4-4:

Paired Samples Test

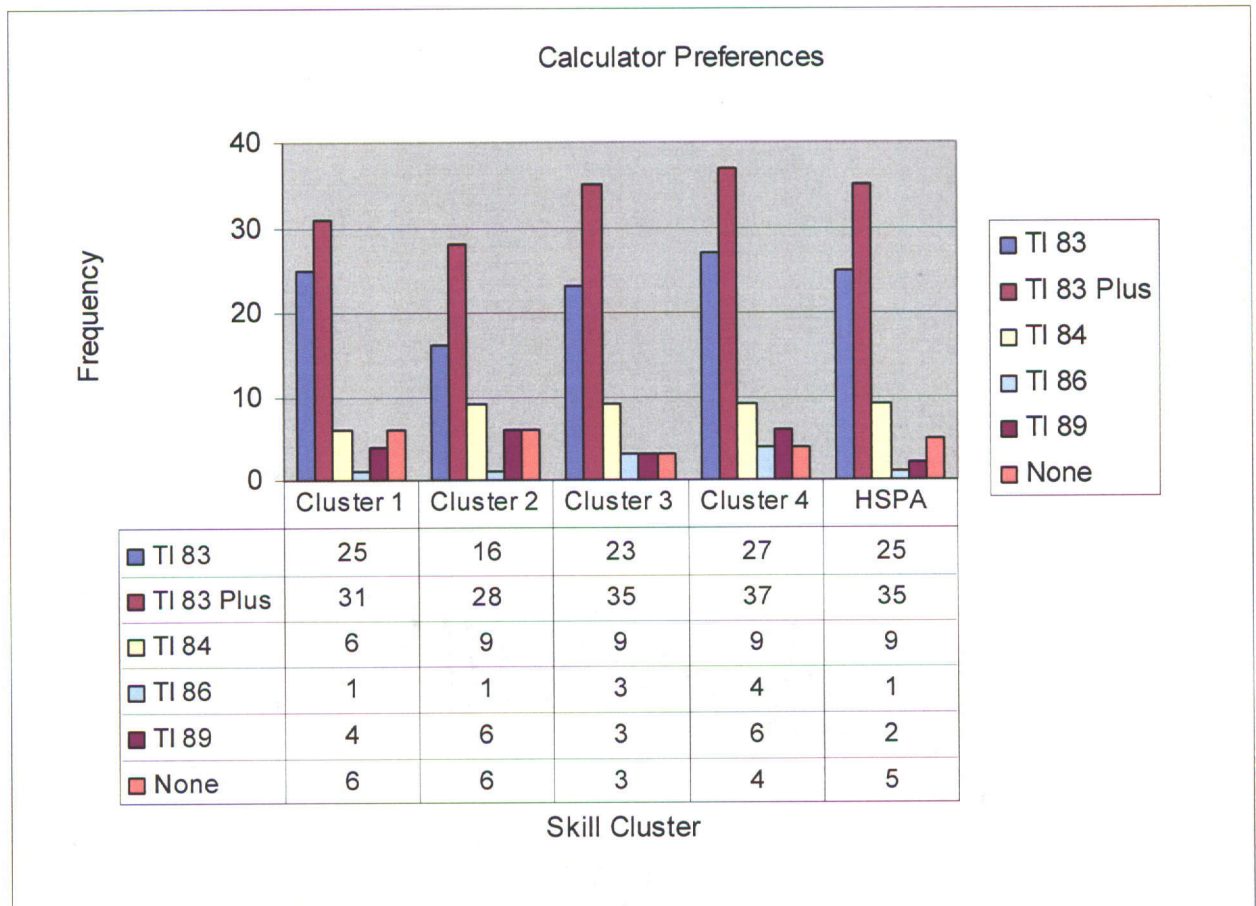|		Paired Differences					t	df	Sig. (2-tailed)
		Mean Difference	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Number sense compared to spatial sense.	-.14925	1.14487	.13987	-.42851	.13000	-1.067	66	.290
Pair 2	Number sense compared to probability and statistics.	-.43284	1.09023	.13319	-.69876	-.16691	-3.250*	66	.002
Pair 3	Number sense compared to patterns, functions, and algebra.	-.47761	1.09210	.13342	-.74400	-.21123	-3.580*	66	.001
Pair 4	Number sense compared to performance on the HSPA.	.02985	.88712	.10838	-.18653	.24624	.275	66	.784
Pair 5	Spatial sense compared to probability and statistics.	-.28358	.91794	.11214	-.50748	-.05968	-2.529	66	.014
Pair 6	Spatial sense compared to patterns, functions, and algebra.	-.32836	1.00586	.12289	-.57371	-.08301	-2.672*	66	.009
Pair 7	Spatial sense compared to performance on the HSPA.	.17910	.86909	.10618	-.03288	.39109	1.687	66	.096
Pair 8	Probability and statistics compared to patterns functions, and algebra.	-.04478	.72682	.08880	-.22206	.13251	-.504	66	.616
Pair 9	Probability and statistics compared to performance on the HSPA.	.46269	.80394	.09822	.26659	.65878	4.711*	66	< .001
Pair 10	Patterns, functions and algebra compared to performance on the HSPA.	.50746	1.02059	.12469	.25852	.75640	4.070*	66	< .001

*Indicates that the t-value is significant at the $\alpha = .01$ level.

Three of the teachers surveyed believed that no calculator was most beneficial in strengthening conceptual understanding of data analysis, probability, and statistics. When asked which calculator was most beneficial in strengthening conceptual

Figure 4-5:

Calculator Preferences

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	HSPA
■ TI 83	25	16	23	27	25
■ TI 83 Plus	31	28	35	37	35
□ TI 84	6	9	9	9	9
□ TI 86	1	1	3	4	1
■ TI 89	4	6	3	6	2
■ None	6	6	3	4	5

Skill Cluster

understanding of patterns, functions, and algebra, thirty-seven teachers preferred the TI83 plus. Twenty-seven chose the TI83, nine selected the TI84, four chose the TI86, and six selected the TI89. Four teachers believed that no calculator was most beneficial in strengthening conceptual understanding of patterns, functions, and algebra. Finally, teachers were asked what calculator was most beneficial in increasing student performance on the HSPA. Thirty-five found the TI83 plus to be most beneficial.

Twenty-five selected the TI83, nine chose the TI84, one selected the TI86, and two teachers chose the TI89. Five teachers believed that no calculator was most beneficial in increasing student performance on the HSPA.

Question 4: Does the use of a graphing calculator increase student performance on the HSPA? This question was assessed by conducting a one sample t-test, which determined if the mean of the responses to survey question number 5 were significantly higher than a 3. As can be seen in table 4-3, question 5, the mean of the responses to question number 5 was significantly higher than a 3, with $p < .001$, indicating that the teachers did feel that the use of the graphing calculator increases performance on the HSPA.

Question 5: Does the frequency of use of the graphing calculator have an effect on teacher opinions toward its benefits? In order to answer this question each respondent was given an overall calculator opinion score which was calculated by averaging the responses to survey questions 1 thru 5. This score was then paired with the frequency value that the respondent selected from survey item 8. These pairs were separated into groups according to subjects taught. For example algebra 1, algebra 2, and advanced algebra 2 all constitute one algebra group. A correlation analysis was done on the data pairs for each group. As can be seen from table 4-6, there is a significant positive correlation between teacher opinions and frequency of use for the algebra group.

Table 4-6

Correlations: Algebra Group
$n = 56$

Means of Likert Responses	Frequency of Use	Correlation	P Value
$\bar{x} = 4.046,\ s = 0.79$	$\bar{x} = 3.96,\ s = 1.026$	.701*	$p < .001$

The geometry group consists of responses for frequency of use in geometry and advanced geometry. Table 4-7 reveals a positive correlation between these responses.

Table 4-7

Correlations: Geometry Group

$n = 25$

Means of Likert Responses	Frequency of Use	Correlation	P-value
$\bar{x} = 4.008,\ s = 0.797$	$\bar{x} = 2.48,\ s = 1.447$	.430	$p = .032$

Pre-calculus, advanced pre-calculus, calculus, and a.p. calculus formed the calculus group. Table 4-8 shows that this correlation was also significant.

Table 4-8

Correlations: Calculus Group

$n = 56$

Means of Likert Responses	Frequency of Use	Correlation	P-value
$\bar{x} = 3.85,\ s = 0.691$	$\bar{x} = 3.468,\ s = 0.471$	.296	$p = .027$

Statistics, a.p. statistics, probability and statistics, and discrete math were grouped together as a probability and statistics group. The correlation for this group was found to be significant and is displayed in table 4-9.

Table 4-9

Correlations: Probability and Statistics Group

$n = 15$

Means of Likert Responses	Frequency of Use	Correlation	P-value
$\bar{x} = 3.92,\ s = 0.848$	$\bar{x} = 4.067,\ s = 1.033$	.659*	$p = .008$

The three integrated math courses included in the survey were grouped as one integrated math group. The results of this correlation analysis are displayed in table 4-10. The correlation was not significant.

Table 4-10

Correlations: Integrated Math Group

$n = 22$

Means of Likert Responses	Frequency of Use	Correlation	P-value
$\bar{x} = 3.739$, $s = 0.513$	$\bar{x} = 3.043$, $s = 1.397$	.315	$p = .153$

Twenty-six teachers responded as teaching a HSPA math course. The results of the HSPA math group correlation are displayed in table 4-11. The correlation was not found to be significant.

Table 4-11

Correlations: HSPA math group

$n = 26$

Means of Likert Responses	Frequency of Use	Correlation	P-value
$\bar{x} = 3.977$, $s = 0.762$	$\bar{x} = 2.885$, $s = 1.633$	.216	$p = .288$

The last group was those respondents that selected the option other as a class taught, but not included as a choice on the survey. The results of this correlation are displayed in table 4-12. The correlation was found to be significant.

Table 4-12

Correlations: Other Classes

$n = 15$

Means of Likert Responses	Frequency of Use	Correlation	P-value
$\bar{x} = 4.027$, $s = 0.465$	$\bar{x} = 2.80$, $s = 1.567$	.752*	$p = .001$

CHAPTER 5

SUMMARY, CONCLUSIONS, RECOMMENDATIONS

Summary

The New Jersey HSPA (High School Proficiency Assessment) is the major assessment tool for measuring success in New Jersey high school instruction. According to the New Jersey Department of Education's State Report Card, the HSPA is one of the most important tools by which a district's success is judged (NJDOE). The HSPA serves as the state's graduation test. It tests student knowledge and skills aligned with the state's academic standards, known as the *Core Curriculum Content Standards*. These include the following:

1.) Geometry and measurement

2.) Patterns and algebra

3.) Data analysis, probability, and discrete mathematics

4.) Mathematical processes

In an age of unprecedented technological advances, the use of the graphing calculator in high school mathematics classrooms is becoming an increasingly important topic for teachers to address. Parker and Mills (2004) note that graphing calculators are being used more than ever to enrich math and science education. They point out that these tools allow students to visualize mathematics and make connections that might otherwise be missed. Previous research has also shown that the use of the graphing calculator in high school instruction has several benefits. The graphing calculator

increases student performance, serves as a motivational tool, and allows teachers to be more efficient by streamlining instructional time. Previous research also indicated that teacher attitudes toward the benefits of the use of the graphing calculator were strongly influenced by the teacher's experiences and opportunities to reflect upon calculator use.

The purpose of this research was to identify the effectiveness of graphing calculator as an instructional tool in building the skills needed to demonstrate proficiency on the New Jersey HSPA.

The research was designed to answer the following questions:

1. Does the use of the graphing calculator in the classroom enhance students conceptual understanding of HSPA topics?

2. What HSPA skills/clusters in particular is the graphing calculator more or less beneficial in building?

3. Is one particular calculator more beneficial than another?

4. Does the use of a graphing calculator increase student performance on the HSPA?

5. Does the frequency of use of the graphing calculator have an effect on teacher opinions towards its benefits?

To research this topic, teachers from South Jersey high schools were contacted and asked to respond to a survey regarding opinions and observations about the use of the graphing calculator. A total of 67 teachers from ten different high schools in South Jersey participated in the survey.

Conclusions

The first research question asked whether or not the use of the graphing calculator in the classroom enhances students conceptual understanding of HSPA topics. There are four major clusters that HSPA topics can be divided into:

1. Number sense.

2. Geometry and spatial sense.

3. Data analysis, discrete math, probability and statistics.

4. Patterns, functions, and algebra

The survey instrument was designed to investigate teacher opinions toward the benefits of the use of the graphing calculator for each cluster. Teachers expressed their opinions using a likert scale and the means of the responses were compared to the neutral response of a three using a t-test. For all four clusters, the mean of the responses was significantly higher than a neutral response of 3, with $p < .001$. It can therefore be concluded that the appropriate use of the graphing calculator is beneficial for enhancing conceptual understanding of HSPA topics.

The second research question asked what HSPA skills/clusters in particular is the graphing calculator more or less beneficial in building. Paired samples tests were conducted to determine if the respondents felt stronger about one statement than another. The difference between the mean of the teacher responses to the number sense question and the mean for geometry and spatial sense was not statistically significant. When the number sense mean was compared to the data analysis, probability and statistics mean, data analysis, probability and statistics was significantly higher. When the number sense mean was compared to the patterns, functions and algebra mean, the patterns, functions, and algebra mean was significantly higher. When comparing the geometry and spatial

sense mean to the patterns, functions, and algebra mean, the patterns, functions, and algebra mean is significantly higher at the .01 level.

It can be concluded that the teachers surveyed believed that the appropriate use of the graphing calculator is more beneficial for enhancing conceptual understanding of data analysis, discrete math, and probability and statistics than it is for both number sense, and geometry and spatial sense. It can also be concluded that the teachers believed that the appropriate use of the graphing calculator is more beneficial for enhancing conceptual understanding of patterns, functions, and algebra than it is for both number sense, and geometry and spatial sense.

The third research question asked if one particular calculator is more beneficial than another. The teachers surveyed favored the TI83 and TI83 plus models above the TI84, TI86, and TI89 for enhancing conceptual understanding of all four skills clusters and for increasing performance on the HSPA. It is important to note that the TI83 and the TI83 plus have been on the market the longest and therefore may be the only calculator available to many of the respondents. The TI89 is considerably more expensive than the other models which could cause its availability to be limited. However, it seems that the TI83 and the TI83 plus would be valuable tools for any school district.

The fourth research question asked if the appropriate use of the graphing calculator increases student performance on the HSPA. The mean of the responses to this question was significantly higher than the neutral response of 3, with $p < .001$. It can be concluded that the teachers surveyed believed that the appropriate use of the graphing calculator increases student performance on the HSPA.

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The fifth and final research question asked if the frequency of use of the graphing calculator has an effect on teacher opinions towards its benefits. In order to answer this question each respondent was given an overall calculator opinion score which was calculated by averaging the responses to survey questions 1 thru 5. This score was then paired with the frequency value that the respondent selected from survey item 8. These pairs were separated into groups according to subjects taught. For example algebra 1, algebra 2, and advanced algebra 2 all constitute one algebra group. A correlation analysis was done on the data pairs for each group.

The first group was the algebra group. This consisted of teachers who used the graphing calculator in algebra 1, algebra 2, and advanced algebra 2. There was a strong positive correlation between the frequency of use of the calculator in these classes and the teachers' opinions towards the benefits of the use of the graphing calculator. The positive correlation for the algebra group was significant at the $\alpha = .01$ level. The geometry group consisted of geometry and advanced geometry. The calculus group consisted of teachers who used graphing calculators in pre-calculus, advanced pre-calculus, calculus, and a.p. calculus. Statistics, a.p. statistics, probability and statistics, and discrete math were grouped together as a probability and statistics group. The correlation for this group was very strong and was significant at the $\alpha = .01$ level. We can conclude that it is likely that teachers who believe the calculator is beneficial will use the calculator more frequently in their classes, with the exception of teachers who teach HSPA math and integrated math. It is also likely that teachers who use the calculator more frequently will have a more favorable view of the benefits of its uses.

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Only two groups were not found to have a significant positive correlation between the frequency of use of the calculator and the teachers' opinions towards the benefits of the calculator. These two groups were the integrated math group and the HSPA group. Integrated math consisted of teachers who used the graphing calculator in integrated math 1, integrated math 2, or integrated math 3. The HSPA group consisted of teachers who used the graphing calculator in HSPA math courses. One is left to speculate as to why teachers who believe the graphing calculator is beneficial for strengthening conceptual understanding of HSPA skills and increasing performance on the HSPA would not use the calculator more frequently in HSPA preparation classes. It is possible that these teachers are so focused on remediation of basic skills that they believe the calculator requires too much extra or perhaps unnecessary material to teach. They may also believe that a low level student who has failed the HSPA once or is considered at risk of failing might be intimidated by such technology.

Recommendations

Because of previous research, and research contained here, it is clear that the appropriate use of the graphing calculator in mathematics classrooms will be of great benefit to the growth of students by enhancing conceptual understanding of HSPA skills. It is important that all teachers are properly trained in how to use the calculator appropriately to enhance these skills. Teachers should use the calculator often and include it as part of regular assessments. School districts should provide a graphing calculator to students who are comfortable and familiar with it for use on the HSPA. The use of the graphing calculator should be an important part of teacher training programs at colleges and universities.

A comparison of years of teaching experience to opinions of the benefits of the graphing calculator would be useful for researching this topic in the future. Further research should be done to determine what methods for implementing the use of the graphing calculator are most beneficial in strengthening students' conceptual understanding of specific HSPA skills. The research should explore what HSPA skills are most benefited by the implementation of the appropriate use of the graphing calculator in instruction. Further research should also investigate if the appropriate use of the graphing calculator does increase student performance on the HSPA.

Future research should also investigate why there was not a positive correlation between teacher opinions toward the benefits of the use of the graphing calculator and frequency of use in HSPA mathematics classes. It would stand to reason that these to factors should have a strong positive correlation. The research presented here did not reveal that.

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