Enhancing Student Performance by Incorporating the TI-Nspire™ into Advanced Algebra

A Capstone Project Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Arts in Teaching: Mathematics

Jonathan Nels Fugleberg

Department of Mathematics and Computer Science College of Arts and Sciences

Graduate School
Minot State University Minot, North Dakota

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This capstone project was submitted by

Jonathan Nels Fugleberg

Graduate Committee:

__________________________________________
Dr. Laurie Geller, Chairperson

__________________________________________
Dr. Cheryl Nilsen

__________________________________________
Dr. Ernst Pijning

Dean of Graduate School

__________________________________________
Dr. Linda Cresap

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Abstract

The purpose of this action research study was to determine whether a more frequent integration of the TI-Nspire™ into the pedagogy for my Advanced Algebra class would enhance the students’ achievement and increase their comfort with, usage of, and knowledge of graphing calculators in general and the TI-Nspire™ in particular. I also wanted to determine students’ perceptions about the use of TI-Nspire™ graphing calculators and technology in the teaching of Advanced Algebra. Pre- and post-surveys of the students were used to measure the students’ comfort with, usage of, and knowledge of graphing calculators in general and specifically the TI-Nspire™ graphing calculator. Achievement was measured by students’ ability to reach scores of 89% on quizzes and tests. Students’ perceptions about the use of TI-Nspire™ graphing calculators and technology in the teaching of Advanced Algebra were measured using a questionnaire at the end of the study. End of project interviews with participants and teacher journaling were also part of the study. Integration of TI-Nspire™ graphing calculators into my pedagogy did have a positive effect on enhancing my students’ achievement on exams while also increasing their comfort with, usage of, and knowledge of graphing calculators in general and specifically the TI-Nspire™ graphing calculator. I was also able to determine that my students had positive perceptions regarding the TI-Nspire™ and the use of technology in the teaching of Advanced Algebra.
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Chapter One

Introduction

This action research study looks at the TI-Nspire™ graphing calculator and how it can be used in the mathematics classroom to enhancing student performance in Advanced Algebra. It is important to keep in mind the statement by Pomerantz (1997):

Graphing calculators are like computer word processors to English students. Computer word processors do not “create” essays but they do considerably facilitate the creation of an essay. Graphing calculators do not “understand” mathematics but they do considerably facilitate the understanding of mathematics. (p. 5)

There was a set of TI-Nspire™ graphing calculators in my math classroom which were primarily used by the students for performing calculations and seldom used for their graphing capabilities. I believed that using graphing calculators in this manner did a decent job preparing my Advanced Algebra students for courses such as Advanced Math and College Algebra. I also believed that I could do a better job using the TI-Nspire™ to facilitate the students’ understanding of mathematics. According to a study by Heller, Curtis, Jaffe, and Verboncoeur (2005), greater use of a graphing calculator in classroom instruction can lead to increased student achievement in performing mathematical calculations. I wanted to determine whether a more focused approach to incorporating the TI-Nspire™
into my lesson plans and teaching would enhance my Advanced Algebra students’ achievement scores in math and increase their comfort with, usage of, and knowledge of graphing calculators in general and specifically the TI-Nspire™ graphing calculator. I also wanted to determine students’ perceptions about the use of TI-Nspire™ graphing calculators and technology in the teaching of Advanced Algebra.

**Motivation for the Project**

From the late 1990s until 2010, my math classroom had a set of TI-83 graphing calculators for student use. These calculators were seldom used for their graphing capabilities. In the summer of 2009, I received a grant to purchase a classroom set of 30 TI-Nspire™ graphing calculators to replace the TI-83 calculators, and I obtained the TI-Nspire™ calculators in January of 2010. With the purchase of the TI-Nspire™ graphing calculators, I intended to use the calculator’s many attributes (e.g., graphs, spreadsheets, multiple screens) to enhance learning in my Advanced Algebra, Advanced Math, and Calculus classes; but my efforts were unsuccessful. I initially started using the software which came with the graphing calculator (i.e., an emulator) that allowed an electronic version of the calculator to be projected on the classroom ActivBoard. I primarily used the emulator to show the students the correlation between a function and its graph. In my Advanced Algebra classroom, the TI-Nspire™ was
used by my students similar to a basic calculator; its attributes did not become a significant part of the pedagogy.

**Background on the Problem**

Students live in a dynamic world in which they are expected to achieve and succeed using all of the technological tools available. Almost all of my students had computers at home, played interactive video games, and/or had a cell phone that they used to keep in touch with their friends. Some students had cell phones that allowed them to have constant internet access. With all of the technological tools that were available to assist students with mathematics, I had a responsibility to help my students use technology in their understanding of math. To engage the students in my math class I needed to provide them with access to engaging technology, to incorporate its use so the students were actively involved, and to make it a fundamental part of my curriculum design. Making technology a fundamental part of the curriculum translated into using the capabilities of graphing calculator technology on a regular and meaningful basis.

According to Heller et al. (2005), research showed that students who have access to graphing calculators and are taught by teachers who have fully integrated the calculator into their curriculum perform at higher levels than students who do not have such access. The use of graphing calculators can endow students with immediate and powerful problem-solving capabilities. I needed to facilitate my students’ abilities to visualize abstract and complex mathematical
concepts through their use of graphing calculators. Being able to see both an algebraic and graphical representation provides students the opportunity to enhance their achievement in mathematics and their involvement in the lessons. Knuth and Hartmann (2005) noted that “technology offers a unique and powerful means of fostering students’ understandings and intuition of the mathematics they study and, accordingly, should play an important role in classroom instruction” (p. 151). The Center for Technology in Learning (2006) addressed the capability of TI-Nspire™ graphing calculators to show different representations of the same problem on the same screen. The Center for Technology and Learning also noted that different representations correlate to the existing research on linked multiple representations. “Researchers have found that students learn concepts more readily when they experience the concepts across different forms of notation” (Center for Technology in Learning, 2006, p. 8).

With greater use of graphing calculators in mathematics, the teacher is able to give guidance or direction for explorations while allowing the students to create their own learning experiences, which can result in increased mathematics achievement. The freedom to use new technology to explore age-old mathematical concepts is one which many students would enjoy. As noted by DePeau and Kalder (2010), the TI-Nspire™ should first be used as a demonstration tool before allowing the students to explore and hypothesize independently (p. 270). None of the research recommended exposing students to
the TI-Nspire™ without the teacher having an understanding and appreciation for how this technology could improve the lesson. Graham, Headlam, Sharp, and Watson (2007) noted that the role of the teacher is vital in the use of graphing calculators. The teacher needs to make sure to direct students in how to use the calculator effectively so it can enhance their learning. “Technology itself is not a panacea that will remedy students’ difficulties as they learn mathematics” (Hollebrands & Zbiek, 2004, p. 259). It is not just the presence of technology that will help the students learn mathematics, it is the teachers’ decisions about how, when, and where to use technology which determine whether its use will enhance or hinder students’ understandings of mathematics (Hollebrands & Zbiek, 2004).

I believed the integration of technology into the lessons would provide greater opportunity for involving students more directly or more actively in the learning process. I hoped that this would improve their attitude toward math and get them more involved with their learning. Thus, if I expected students to have positive perceptions of their learning, and be proficient in their mathematics achievements, then I needed to use engaging technology in education.

**Statement of the Problem**

My classroom set of TI-Nspire™ graphing calculators was not being fully used in teaching mathematics. My goal in obtaining the TI-Nspire™ calculators was to improve my students’ math and calculator skills by using current technology to facilitate the teaching of age-old mathematics concepts and ideas. I
believed not using the TI-Nspire™ to its full potential was a waste of a valuable resource, but I was not sure I needed to saturate my class with lesson material that focused on the TI-Nspire™. There needed to be a balance between using the TI-Nspire™ graphing calculator to supplement lesson material and saturating the curriculum with lessons that used only the TI-Nspire™ as the primary pedagogical method in the classroom. My curriculum needed to encompass frequent use of the TI-Nspire™ calculator to hopefully enhance the students’ achievement in the math concepts presented in Advanced Algebra. The TI-Nspire™ had been used by my students as a crutch to help with a problem; it needed to become an essential tool in their mathematical approaches to solving problems.

Statement of Purpose

The purpose of this study was three-fold: (1) to determine whether use of the TI-Nspire™ graphing calculator would increase students’ comfort with, usage of, and knowledge of graphing calculators in general and specifically the TI-Nspire™ graphing calculator; (2) to determine if use of the TI-Nspire™ would enhance student achievement in mathematics; and (3) to determine students’ perceptions of the TI-Nspire™ and technology in the teaching of Advanced Algebra. I wanted to determine if implementing a more focused approach incorporating the TI-Nspire™ would better utilize its capabilities when students were presented with relevant mathematical problems.
**Research Questions/Hypotheses**

Would a more focused approach to incorporating the TI-Nspire™ graphing calculators increase my Advanced Algebra students’ comfort with, usage of, and knowledge of the TI-Nspire™ graphing calculator? Would use of the TI-Nspire™ graphing calculator enhance achievement of the Advanced Algebra students to an 89% proficiency level, based on students’ quiz and test scores? What were students’ perceptions of the use of the TI-Nspire™ graphing calculator and technology when used in teaching Advanced Algebra?

I hypothesized that integration of TI-Nspire™ graphing calculators into my pedagogy would increase student comfort with, usage of, and knowledge of graphing calculators in general and specifically the TI-Nspire™ graphing calculator, and enhance student achievement on quizzes and tests. I also hypothesized that students would have positive perceptions of the use of the TI-Nspire™ calculator and technology in the teaching and learning of Advanced Algebra.

**Definitions**

*Graphing calculator* – throughout this paper the term graphing calculator refers to calculators that have the ability to handle basic calculations, calculate trigonometric functions, analyze various functions containing variables, and create a graph on their output screen. Some authors also use the terms graphic calculator and handheld calculator rather than graphing calculator.
TI-Nspire™ – a platform for calculating, representing and communicating mathematically. The TI-Nspire™ is a graphing calculator on which students work in a “document,” an organized presentation of multiple screens of mathematics which can be saved, shared, annotated, and revisited (Center for Technology in Learning, 2006).

Summary

This study required frequent integration of the TI-Nspire™ graphing calculator into the curriculum of my Advanced Algebra class. My hypothesis was that a more focused use of the TI-Nspire™ graphing calculator would increase student comfort with, usage of, and knowledge of graphing calculators in general and specifically the TI-Nspire™ graphing calculator, and enhance student achievement on quizzes and tests. Also, students would have positive perceptions of the use of the TI-Nspire™ calculator and technology in the teaching and learning of Advanced Algebra.
Chapter Two

Review of Literature

The intent of this action research study was to determine if integration of the TI-Nspire™ into the teaching of my Advanced Algebra students would be to their benefit. A review of the research found that there should be positive benefits, while also noting that the actual value of technology is not in its availability but in its application. This chapter addresses research and other literature regarding use of technology in the math classroom, the influence of the graphing calculator on math education, and the educational benefits of the TI-Nspire™ calculator.

Use of Technology in the Math Classroom

In their March 2008 position paper on the role of technology in the math classroom, the National Council of Teachers of Mathematics (NCTM) noted that technology in the math classroom consisted of “graphing calculators and other technological tools, such as computer algebra systems, interactive geometry software, applets, spreadsheets, and interactive presentation devices” (para. 1). Merriam-Webster (n.d.) defined technology as “a manner of accomplishing a task especially using technical processes, methods, or knowledge,” and technical as “having special and usually practical knowledge especially of a mechanical or scientific subject.” These definitions suggest that technology is the process of using something that has knowledge humans do not possess. Technology in the
math classroom can include items like computers, graphing calculators, and the ActivBoard to supplement the lesson material. None of these items has knowledge not possessed by the teacher.

Students today have an increased familiarity with technology, as well as an attraction to the constant technological changes that occur. The increased familiarity and attraction has made it increasingly possible for teachers to use various forms of technology in instruction (DePeau & Kalder, 2010, p. 268). This attraction to technology can also help students pay better attention to the material presented as well as gives them the opportunity to explore on their own. Beckmann, Senk, and Thompson (1999) found that “in a technology-rich classroom environment, technology impacts not only what is taught and how it is taught but what students learn and how they learn it” (p. 451). According to the Center for Technology in Learning (2007), “Technology can go beyond what is possible in books by allowing students to directly interact with different representations, including graphs, tables, algebraic expressions, and geometric figures” (para. 1).

The availability of technology is not the only item which must be addressed when discussing the use of technology. In their position paper, NCTM (2008) noted that strategic use of technology had the ability to provide access to math for all students. Technology by itself is not a remedy for all the problems found with students’ difficulties as they learn math (Hollebrands & Zbiek, 2004,
Hollebrands and Zbiek (2004) believed that whether or not technology would enhance a students’ understanding of math was based upon how the teacher used that technology in the lesson. The actual value of technology is not in its availability but in its application. “Technology itself is not a panacea that will remedy students’ difficulties as they learn mathematics” (Hollebrands & Zbiek, 2004, p. 259).

**Influence of Graphing Calculators on Math Education**

Roschelle and Singleton (2008) noted that “an interpretive review of research on graphing calculators concluded that graphing calculators have become one of the most widely adopted technologies in education because they are a proven-effective, affordable, handheld device with direct linkages to curricula” (p. 951). In their research, they found graphing calculators to “support valuable pedagogical practices, such as increasing attention to conceptual understanding and problem solving strategies by having the calculator handle the laborious computations” (Roschelle & Singleton, 2008, p. 951).

The use of a calculator in the math classroom is a topic frequently under debate or discussion among math teachers. Some teachers allow the use of graphing calculators only for “rather complex operations,” as defined by the teacher, and some teachers allow the students to use the calculator for any and all math problems. An NCTM (2011) research brief reviewed nearly 200 research studies, conducted between 1976 and 2009, that addressed calculator use in the
classroom. This review found the body of research consistently showed that
calculator usage in the teaching and learning of math “enhances the understanding
of mathematics concepts and student orientation toward mathematics” (NCTM,
2011, para. 1). Even with the research findings, the discussion of calculator use in
the classroom does not get any easier when it includes graphing calculators. “The
proliferation of graphing calculators since the late 1980s has impacted
mathematics curriculum and instructional practices” (Beckmann et al., 1999, p.
454). No longer are graphing calculators used simply to accomplish simple math
calculations. According to Roschelle and Singleton (2008), graphing calculator
use enables students to explore connections across multiple representations (p.
951).

Some teachers allow students to use a graphing calculator to make their
calculations easier, but the lessons do not focus on use of the graphing calculator
in the teaching and learning of mathematics. Kastberg and Leatham (2005) found
that when the graphing calculator was used as an add-on to traditional teaching,
rather than in an iterated way, its use failed to improve learning (p. 6). By making
the graphing calculator available for the students to use, but not making it a key
component of instruction, students had no added benefit than if they used a
regular calculator (Kastberg & Leatham, 2005, p. 8). Kastberg and Leatham
(2005) also noted that students should use the graphing calculators to solve
problems and incorporate its use into learning the lesson material. Heller et al.
(2005) found that giving students access to graphing calculators, and increasing their use during algebra instruction, led to an increase in the students’ end-of-course test scores, even if the end-of-course test was taken without the use of the graphing calculators (p. 18). In their research, Heller et al. (2005) also noted that “student achievement was significantly higher for teachers who reported participating in trainings on how to use a graphing calculator or other computerized graphing technology, in contrast to those who reported being self-taught using the manual” (p. 18).

Much of the discussion regarding the benefits of graphing calculators focused on how graphing calculators allow investigation of functions through tables, graphs, and equations in ways that were not possible before their proliferation (Beckmann et al., 1999, p. 451). There is a benefit to having a student see a mathematical idea represented many different ways. Beckmann et al. (1999) also noted that use of a graphing calculator allowed for “the use of multiple representations, interpretation from one representation to another and analysis requiring interplay between graphic, numeric, and symbolic information” (p. 451). Beckmann et al. (1999) believed that assessment should do more than just provide the teacher with information about which of the paper-pencil algorithms have been replaced with the button presses on a calculator (p. 455). “In a graphing calculator environment, classroom assessment should contain a
balance of technology – active, neutral, and inactive items” (Beckmann et al., 1999, p. 452).

Graphing calculators have been shown to have a great influence on the teaching of math. Not only can the use of graphing calculators improve test scores, but “graphing calculators can improve classroom dynamics, boost students’ confidence levels, and promote the understanding of mathematical concepts and functions, and advance problem-solving ability” (Pomerantz, 1997, p. 13). The research of Heller et al. (2005) found that, when teachers incorporated graphing calculators into their curriculum more frequently and with greater intensity, student achievement was higher. This finding does not mean graphing calculators should be used for everything. Heller et al. (2005) also found an increase in scores for classes in which the students’ were sometimes not allowed to use a graphing calculator. It is clear that the graphing calculator should be incorporated into, and become a part of, the teachers’ pedagogy as it is an important tool available for teaching their students, but it is not the only tool.

Graphing calculators should be used to supplement the material. Leng, Chuen, and Nancy (2009) found a positive effect when using the various capabilities of a graphing calculator as a supplementary tool. This use helped students achieve understanding of the concepts and enhanced their problem solving abilities (Leng et al, 2009, p. 2). The research by Heller et al. (2005) concurred with this finding as they found “students’ scores were higher in classes
in which they were sometimes not allowed to use a graphing calculator than where students always had access to the graphing calculators” (p. 10).

**Educational Benefits of the TI-Nspire™ Graphing Calculator**

At their inception, graphing calculators were designed with a screen that allowed for individual representation of mathematical analysis (e.g., students were unable to view a graph of a function and the mathematical equation at the same time). The screen of the TI-Nspire™ allows for linked representations and the viewing of up to four separate concepts on the same screen. “TI-Nspire™ learning handhelds have bigger, sharper screens, allowing graphs to be explicitly labeled and for students to see graphed functions in more detail” (Center for Technology in Learning, 2006, p. 8).

A study by Leng et al. (2009) involved students whose use of the TI-Nspire™ graphing calculator was fully integrated into the teacher’s pedagogy. This integration into the curriculum was accomplished by the design and use of “TI-Nspire™ activities which offered intriguing mathematical starting points for students and promoted exploration leading directly to mathematical generalization” (Leng et al., 2009, p. 4). In the study, Leng et al. (2009) found that incorporation of the TI-Nspire™ graphing calculator into the teacher’s pedagogy allowed the students to use it as a learning tool (e.g., exploratory, confirmatory, problem solving, visualization, calculation, and graphing). This finding supported their hypothesis that the dynamic features and new
mathematical experiences afforded by the TI-Nspire™ gave students a rich setting in which to explore math concepts. The Center for Technology in Learning (2006) noted that these linked representations helped focus students’ attention on the relationships among algebraic equations, graphs, and tables of data (p. i).

The TI-Nspire™ graphing calculator has the ability to “display expressions in standard mathematical notation and in a textbook-like format (e.g., $\frac{1}{3}x^2$) rather than a computer-like format (e.g., 1/3x^2)” (Center for Technology in Learning, 2006, p. 8). According to Ozgun-Koca and Edwards (2011), one added benefit of the TI-Nspire™ technology is the ability for students to manipulate a graphed line by grabbing it and sliding or turning it when trying to fit data to the graph.

In the conclusion of their paper, Leng et al. (2009) stated that “the TI-Nspire™ should be used to stimulate students to think mathematically so that they [can] engage strongly with mathematical structures and concepts in ways that are not possible with traditional paper and pencil approaches” (p. 11).

Summary

Students’ increased familiarity and attraction to technology have made it increasingly possible for teachers to use various forms of technology in instruction (DePeau & Kalder, 2010, p. 268). This attraction to technology helps students pay better attention to the material presented as well as gives them the opportunity to explore individually. The actual value of technology is not in its
availability but in its application. One form of technology, the graphing calculator, has “become one of the most widely adopted technologies in education because they are a proven-effective, affordable, handheld device with direct linkages to curricula” (Roschelle & Singleton, 2008, p. 951). Graphing calculators have been shown to have a great influence on the teaching of math. When discussing graphing calculators, the benefits of the TI-Nspire™ learning handhelds include bigger, sharper, screens and the ability to display expressions in standard mathematical notation in a textbook-like format (e.g., $\frac{1}{3}x^2$) (Center for Technology in Learning, 2006, p. 8). As noted by Leng et al. (2009), the dynamic features and new mathematical experiences afforded by the TI-Nspire™ give students a rich setting in which to explore math concepts.
Chapter Three

Research Design and Method

This action research study analyzed whether a more frequent integration of the TI-Nspire™ into the pedagogy for my Advanced Algebra class: enhanced the students’ achievement; increased their comfort with, usage of, and knowledge of graphing calculators in general and the TI-Nspire™ in particular; and affected their perceptions about the use of TI-Nspire™ graphing calculators and technology in the teaching of Advanced Algebra. To find answers to my research questions, the TI-Nspire™ graphing calculator was integrated into my curriculum and the students were taught using lesson plans specifically designed around programs installed on the TI-Nspire™. I also used pre- and post-surveys, quizzes and tests that were designed in two parts (calculator and non-calculator), a teacher journal, and a questionnaire at the end of the study in conjunction with interviewing ten (28%) of the Advanced Algebra students.

Setting

I am a mathematics teacher at a small rural school in North Dakota. At that school I have taught Eighth Grade Mathematics, Pre-Algebra, Geometry, Advanced Algebra, Advanced Math, and Calculus.

This action research study took place in two separate high school Advanced Algebra classes; one class contained 25 students (17 female and 8 male) and the other class contained 11 students (6 female and 5 male). The
students varied in grade level with 11 sophomores, 23 juniors, and 2 seniors. The school used for this project had a K-12 student population of about 500 students with an average of 40 students per grade. It was a small school district that had one elementary school, one middle school, and one high school. The district had a small minority population and an even mix of males to females. A majority of the students lived within four miles of the school they attended.

Factors Affecting the Study

The specific type of TI-Nspire™ graphing calculators used in the classroom, prior knowledge students had about using a graphing calculator, and student attendance were all factors affecting the study. Each of the two math classrooms in our school had a set of TI-Nspire™ graphing calculators; one set with a click-pad faceplate, and one set with the touch-pad faceplate. My classroom used the TI-Nspire™ calculators with the click-pad. The functioning of the graphing calculators is the same; the differences in faceplates are in the method of moving the cursor and how the buttons are configured. The movement of the cursor gives the two models their different names, but it is a slight adjustment in operating the calculator. The primary difference is that some of the buttons are located in different positions; the touch-pad has all of the letter buttons at the bottom of the calculator faceplate and the click-pad has the letters interspersed with the other calculator keys. Some of the students in this study had previously used the touch-pad system and needed to become familiar with the
click-pad system; some students had never before used the TI-Nspire\textsuperscript{TM} graphing calculator. Student attendance was a factor since much of the calculator work was designed to be completed in class.

**Intervention/Innovation**

As part of the study, the students had a much greater need to use the TI-Nspire\textsuperscript{TM} calculators for both in-class activities and homework. The school policy was TI-Nspire\textsuperscript{TM} graphing calculators had to remain at the school; so this required the creation of lessons that could be completed in class, or for which a couple of days was given prior to collection of the homework assignment. For some lessons, I used the in-class activities with the TI-Nspire\textsuperscript{TM} to introduce and explain the concept, and gave the students a homework assignment out of the book that did not require use of the calculator. These lessons were used to remind students that it is not *essential* they have a graphing calculator to complete many of their assignments.

I did not use the TI-Nspire\textsuperscript{TM} graphing calculator for every single lesson. One aspect of this study was to increase the use of the TI-Nspire\textsuperscript{TM} in the classroom without saturating the students with a constant series of lessons which required a graphing calculator. This study covered a nine-week period during which I covered two chapters in the Advanced Algebra textbook (polynomial functions and powers, roots, and radicals). Each chapter had two quizzes and one test in addition to preparation days for each quiz and each test. I used lesson
plans based on the TI-Nspire™ graphing calculator for five of the lessons. I also
utilized unit-specific worksheets in conjunction with programs on the TI-Nspire™
graphing calculator. The lessons which were not built on use of the TI-Nspire™
were modified to note those places where the TI-Nspire™ calculator could be
used to assist with the problem or to check students’ work.

Design

Pre- and post-surveys of the students were used to measure the students’
comfort with, usage of, and knowledge of graphing calculators in general and
specifically the TI-Nspire™ graphing calculator. To address achievement, the
design of this study was primarily quantitative in nature as it involved an analysis
of the grades on quizzes and tests. Students’ perceptions of the TI-Nspire™ and
technology in the teaching of Advanced Algebra were measured using a
questionnaire at the end of the study. I also interviewed ten students to get their
direct feedback. As part of the process, I kept a journal of the experience in order
to document successes, challenges, observations, and reflections on the study.

Using these different methods of assessment allowed me to assess student
achievement in the material presented (i.e., quizzes and tests) as well as evaluate
their perceptions about the TI-Nspire™ graphing calculator as used in the
specifically designed lessons (i.e., questionnaire and journal). The interviews
allowed for a better understanding of the students’ views of the pedagogy
involving the TI-Nspire™ graphing calculator. The pre- and post-surveys
allowed me to determine whether comfort with, usage of, and knowledge of
graphing calculators in general and specifically the TI-Nspire™ graphing
calculator increased. Keeping a journal documented student interaction and
identified how things could be revised for future use of the lesson material.

**Description of Methods**

Before beginning the study in my classroom, the Minot State University
Institutional Review Board provided written approval of the study (see Appendix
A). Written consent was also received from school officials allowing the study to
take place in my classroom (see Appendix B). All participants were informed of
the study and a letter preapproved by the Minot State University Institutional
Review Board was sent home to the participants’ parents/guardians asking
permission for their students to take part in the study (see Appendix C). The
student participants also signed a student assent letter, similar to the letter
parents/guardians signed (see Appendix D). All participants and their data
remained confidential. Any information about their views and achievement was
presented only in aggregate form so no individual could be identified.

Once all consent letters were collected, use of the TI-Nspire™ took place
the third nine weeks of class and was implemented in conjunction with other
technology in my classroom. I began the study by explaining it to my Advanced
Algebra students. The explanation included the study’s purpose, problem, and
questions as well as an overview of the methods of instruction and assessment
used. Prior to beginning any lessons incorporating the TI-Nspire™, I gave each student a survey (see Appendix E) to determine comfort with, usage of, and knowledge of graphing calculators in general and specifically the TI-Nspire™ graphing calculator. At this point I was ready to start the lessons.

The presentation and assessment portion of the study began by introducing the students to the TI-Nspire™ graphing calculator using a modified PURIA model as discussed by Hollebrands and Zbiek (2004, p. 260). This method includes Play, Use, Recommend, Incorporate, and Assess Incorporation. By first allowing the students to play with the technology, not necessarily for a mathematical topic, they became familiar with its capabilities. After the students were familiar with the TI-Nspire™ graphing calculator, I asked them to use it on a homework assignment, allowing them to obtain a personal mathematical understanding of the calculator’s potential. The next step was to recommend the students use the calculator more regularly on assignments and involved observations of how the TI-Nspire™ graphing calculator was used. By the time the students were familiar with the operation of the TI-Nspire™ graphing calculator, I began to incorporate it into my classroom setting as part of instruction. The final step was to assess the incorporation of the TI-Nspire™ graphing calculator and use the students’ experiences to change the lessons and use of technology, as necessary.
The TI-Nspire™ graphing calculator was not just added to the standard curriculum; lessons were developed around the calculator (see Appendix F). I used a more hands-on learning environment to guide my students in use of the TI-Nspire™ as a resource. This learning environment included the use of other technology in my classroom (i.e., Promethean ActivBoard and ActivExpression) as well as modified seating arrangements. For lessons involving the TI-Nspire™ graphing calculator, it was most effective for the students to sit in groups of four desks per group. Having four desks per group allowed two pairs of two students to help each other understand the lesson material. Effective integration and use of the TI-Nspire™ were designed to enhance my Advanced Algebra students’ achievement in the mathematical concepts. To measure their achievement, I created quizzes and tests designed in two parts; the first part required use of the TI-Nspire™ graphing calculator (see Appendix G), and the second part was completed without the use of a calculator. This process was completed for the two chapters covered during the third quarter. At the end of the quarter, I analyzed the students’ quiz and test scores to determine whether learning of the Advanced Algebra students met an 89% proficiency level.

Upon completion of the final test, I gave the Advanced Algebra students a final survey asking the same questions as on the initial survey (see Appendix E). Comparing the data from the two surveys determined whether students’ comfort with, usage of, and knowledge of graphing calculators in general and specifically
the TI-Nspire™ graphing calculator increased. To measure student perceptions of the use of the TI-Nspire™ and technology in the classroom, I used a questionnaire (see Appendix I) at the end of the study in conjunction with interviewing (see Appendix J) ten of the Advanced Algebra students. In picking the ten students to interview I only had two specific criteria: more students from my largest class and an equal number of boys and girls from each class. This led to me interviewing six students from my largest class and four from my smallest. Other than these two criteria, the selection was random based on student availability at the time of the interview. During the study, I maintained a journal identifying successes, challenges, and any changes which needed to be made to the lesson material. I also recorded any student comments or areas of concern.

The final step in this process was to analyze and interpret the data collected to answer the project’s research question. The following section describes how this was done.

**Analysis Strategy**

The quantitative data collected consisted of the students’ quiz and test scores. The quizzes were graded on a basis of an aggregate (calculator questions plus non-calculator questions) 20 points per quiz; the tests were worth an aggregate 100 points each. At the end of the quarter, the quizzes and tests were analyzed to determine whether students scored at an 89% proficiency level.
Measures of central tendency and spread were also calculated for tests and quizzes.

Quantitative and qualitative data were collected using pre- and post-surveys to measure students’ comfort with, usage of, and knowledge of graphing calculators and a questionnaire to measure student perceptions of use of the TI-Nspire™ graphing calculators. Students’ survey responses were summarized (Table 1 and Table 2). Qualitative data consisting of free response questions on the questionnaire and personal interviews were used to determine student perceptions and thoughts about teaching with technology and the TI-Nspire™.

To determine if comfort with, usage of, and knowledge of graphing calculators in general and specifically the TI-Nspire™ graphing calculator increased, pre-survey and post-survey scores were compared using a one-tailed matched-pairs t-tests of dependent samples, with level of significance of 0.05. The null hypothesis was there would be no difference in the pre- and post-survey data. The alternative hypothesis was an increase in comfort with, usage of, and knowledge of graphing calculators in general and specifically the TI-Nspire™ graphing calculator.

The questionnaire and interviews gathered students’ responses to assess their perceptions of, and thoughts about, the lessons, technology, and use of the TI-Nspire™. Interview responses were analyzed using inductive analysis, and questionnaire responses were summarized in a table. I also maintained a journal
throughout the study. The quantitative and qualitative data were validated using triangulation, auditor, and member checking.

**Expected Results**

I hypothesized that my use of the TI-Nspire™ graphing calculators would enhance my Advanced Algebra students’ achievement in key mathematical concepts to an 89% proficiency level; increase their comfort with, usage of, and knowledge of graphing calculators in general and specifically the TI-Nspire™ graphing calculator; and students would have a positive perception of the use of the TI-Nspire™ in the teaching and learning of Advanced Algebra. In addition, I created one fourth of the lessons necessary to have a complete year of Advanced Algebra lessons utilizing the TI-Nspire™ graphing calculator.

The primary obstacle in utilizing the TI-Nspire™ graphing calculator was the school’s requirement that the classroom graphing calculators not leave the school building; this required in-class time for calculator-based lessons and the assignment of non-calculator lessons for homework. Also, because this study involved heavy use of new technology, I had to make sure the students knew how to use the basic functionality of the TI-Nspire™ before addressing the lesson specific areas of concern. Initially it was difficult to create the lessons and make sure the handout material augmented the calculator documents; this became much easier as the study progressed.
Timeline for the Study

The intervention and data collection took place during the third quarter of the 2011-2012 school year, from January 12 through March 14. There were two units of study covered during this time (polynomial functions and powers, roots, and radicals). Following the study, the data were analyzed, summarized, and presented.

Summary

The action research study addressed in this chapter was completed with my high school Advanced Algebra students. The students were given lesson plans specifically designed around worksheets that were used in conjunction with programs installed on the TI-Nspire™. The design was primarily quantitative in nature as it involved an analysis of the grades on quizzes and tests to measure achievement. To augment the quantitative assessment, I used a questionnaire and interviews to measure student perceptions of the TI-Nspire™; kept a journal to document observations and thoughts; and used pre- and post-surveys to measure comfort with, usage of, and knowledge of graphing calculators in general and specifically the TI-Nspire™ graphing calculator.
Chapter Four

Results and Interpretations

The purpose of this study was to determine whether a more frequent integration of the TI-Nspire™ into the pedagogy for my Advanced Algebra class would enhance students’ achievement and would increase student comfort with, usage of, and knowledge of graphing calculators in general and specifically the TI-Nspire™ graphing calculator. I also wanted to determine students’ perceptions about use of TI-Nspire™ graphing calculators and technology in the teaching of Advanced Algebra. This chapter addresses the results and analysis of data gathered from the surveys, questionnaires, quizzes and tests, interviews, and a teacher journal from the study.

Results of Data Analysis

Student survey. Each student was given a survey (see Appendix E) to determine their comfort with, usage of, and knowledge of graphing calculators in general and specifically the TI-Nspire™ graphing calculator. The survey was administered to 36 students, 23 female and 13 male. The students varied in grade level with 11 sophomores, 23 juniors, and 2 seniors. Likert-type survey items were scored with a whole number value ranging from 1 to 5 (i.e., 1 = Strongly Disagree to 5 = Strongly Agree). The same survey was given to the students prior to beginning the study and at the end of the study. Comparing the data from the
two surveys identified any changes in the students’ comfort with, usage of, and knowledge of using graphing calculators.

The initial survey found the students to average almost seven years of calculator use (6.92) with close to 1½ years of graphing calculator use (1.44). The survey contained eight general items which were scored with a whole number value. Two items addressed the students’ comfort with using graphing calculators and two items addressed the students’ usage and knowledge of graphing calculators in general and the TI-Nspire™ in particular. The two items on usage and knowledge of graphing calculators had students rate their ability to perform nine different functions on a graphing calculator (e.g., graph a function, create a table), and six different functions on the TI-Nspire™ (e.g., create a new document, use the MENU function). The data regarding the ability to perform functions on a graphing calculator and on the TI-Nspire™ calculator were aggregated in analyzing the means for these two items; meaning, the scores for all sub-items were averaged and used as the overall score on each of these two items. Four of the items on the survey were not specifically related to the project question; they addressed the students’ general perception of their math skills. The means of each item were calculated for pre- and post-surveys. These results are included in Table 1.
### Table 1

<table>
<thead>
<tr>
<th>Question</th>
<th>Pre-survey $M_{pre}$</th>
<th>Post-survey $M_{post}$</th>
<th>Difference $M_{post} - M_{pre}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>I feel very comfortable that I know how to use a calculator</td>
<td>4.44</td>
<td>4.64</td>
<td>0.20</td>
</tr>
<tr>
<td>I feel very comfortable that I know how to use a GRAPHING calculator</td>
<td>2.39</td>
<td>3.86</td>
<td>1.47</td>
</tr>
<tr>
<td>I feel very comfortable that I know how to perform functions on a graphing calculator</td>
<td>2.52</td>
<td>4.14</td>
<td>1.62</td>
</tr>
<tr>
<td>I feel very comfortable that I know how to perform functions on the TI-Nspire™ calculator</td>
<td>3.00</td>
<td>4.32</td>
<td>1.32</td>
</tr>
<tr>
<td>Graphing calculators are easy to use</td>
<td>2.86</td>
<td>3.89</td>
<td>1.03</td>
</tr>
<tr>
<td>Students should be allowed to use a calculator in the math classroom</td>
<td>4.67</td>
<td>4.72</td>
<td>0.05</td>
</tr>
<tr>
<td>I must have a calculator available when doing my math</td>
<td>3.56</td>
<td>3.5</td>
<td>-0.06</td>
</tr>
<tr>
<td>I am good at math</td>
<td>3.61</td>
<td>3.64</td>
<td>0.03</td>
</tr>
</tbody>
</table>

There was a positive change in the students’ comfort with using a graphing calculator in addition to a positive change in their usage and knowledge of graphing calculators and the TI-Nspire™. It is interesting to note that there was a slight increase in the comfort level with a calculator, use of a calculator in the math classroom, and the students feeling they are good at math. There was a slight decrease in the mean regarding the students’ need to have a calculator available when doing their math.
A matched-pairs $t$-test of dependent samples was run to determine whether my increased focus on incorporating the TI-Nspire™ graphing calculators increased students’ comfort with, usage of, and knowledge of graphing calculators in general and specifically the TI-Nspire™. A mean difference (post-survey – pre-survey) greater than zero represented growth in comfort from pre-survey to post-survey. The null hypothesis for each $t$-test was that there would be no change from pre-survey to post-survey (mean difference equals zero). The alternative hypothesis was that there would be an increase in their scores from pre- to post-survey (mean difference greater than zero); thus, an increase in their comfort using a graphing calculator and in their usage of and knowledge of a graphing calculators in general and specifically the TI-Nspire™. The results of the analysis are summarized in Table 2. A $t$-test was not run on each of the four items not specifically related to the research questions.

For each of the survey questions noted in Table 2, I can reject the null hypothesis. There was sufficient evidence at the $\alpha = 0.05$ level of significance to conclude that Advanced Algebra students comfort with, usage of, and knowledge of graphing calculators in general and the TI-Nspire™ in particular increased during the study.
Table 2

Analysis of Paired Differences in Pre- and Post-Surveys

<table>
<thead>
<tr>
<th>Questions</th>
<th>M Difference</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>I feel very comfortable that I know how to use a GRAPHING calculator</td>
<td>1.47</td>
<td>9.39</td>
<td>&lt; 0.001*</td>
</tr>
<tr>
<td>I feel very comfortable that I know how to perform functions on a graphing calculator</td>
<td>1.62</td>
<td>13.74</td>
<td>&lt; 0.001*</td>
</tr>
<tr>
<td>I feel very comfortable that I know how to perform functions on the TI-Nspire™ calculator</td>
<td>1.33</td>
<td>10.83</td>
<td>&lt; 0.001*</td>
</tr>
<tr>
<td>Graphing calculators are easy to use</td>
<td>1.03</td>
<td>5.44</td>
<td>&lt; 0.001*</td>
</tr>
</tbody>
</table>

* Indicates significance at the $\alpha = 0.05$ level.

**Questionnaire.** Each student was given a questionnaire at the end of the study (see Appendix I) as a quantitative assessment to measure perceptions about use of the TI-Nspire™ graphing calculator in the teaching and learning of Advanced Algebra. Each questionnaire statement was scored with a whole number value ranging from 1 to 5 (i.e., 1 = Strongly Disagree to 5 = Strongly Agree). The mean, standard deviation, median, minimum value, and maximum value for these questionnaire items are shown in Table 3.
Table 3

*Questionnaire Results*

<table>
<thead>
<tr>
<th>Question</th>
<th>M</th>
<th>SD</th>
<th>Mdn</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using the TI-Nspire™ in math class was much better than using a regular calculator.</td>
<td>4.21</td>
<td>0.81</td>
<td>4</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>It was easy for me to learn how to use the TI-Nspire™ .</td>
<td>4.03</td>
<td>0.63</td>
<td>4</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>I was much more interested in the lesson when we used the TI-Nspire™ calculator.</td>
<td>3.50</td>
<td>0.79</td>
<td>3.5</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Using the TI-Nspire™ helped me better understand the math taught in class.</td>
<td>3.79</td>
<td>0.54</td>
<td>4</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>When I use the TI-Nspire™ I am more confident that my answers are correct.</td>
<td>4.38</td>
<td>0.49</td>
<td>4</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I liked math class better when I was able to use the TI-Nspire™ calculator.</td>
<td>4.00</td>
<td>0.70</td>
<td>4</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>I always used the TI-Nspire™ calculator to check my answers.</td>
<td>3.03</td>
<td>0.87</td>
<td>3</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Did you like using the TI-Nspire™ calculator to learn math?</td>
<td>4.29</td>
<td>0.46</td>
<td>4</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Using the TI-Nspire™ helped me learn the material.</td>
<td>3.97</td>
<td>0.63</td>
<td>4</td>
<td>2</td>
<td>5</td>
</tr>
</tbody>
</table>

As noted from the data in Table 3, the students tended to agree with every question. There was a definite agreement among the students that using the TI-Nspire™ in math class was much better than using a regular calculator, it helped them better understand the math taught in class, made them more confident their
answers were correct, and helped them learn the material. There was also definite agreement among the students that it was easy to learn how to use the TI-Nspire™ and they liked using the TI-Nspire™ calculator to learn math; in fact, they liked math class better when they were able to use the TI-Nspire™ calculator. The students were midway between ambivalent and agreement on the question of being much more interested in the lesson when using the TI-Nspire™ calculator. The students had no opinion or were split in their agreement regarding always using the TI-Nspire™ calculator to check their answers.

In addition to the quantitative data collected, the questionnaire also asked each student to provide a response to the statement, “Did using the TI-Nspire™ calculator make you feel more comfortable with the lesson being taught? Why or why not?” In the responses, 29 of the 34 students stated “yes,” three said “sometimes,” and two said “no.” The “yes” responders noted: “I got a better understanding of the lessons taught with the TI-Nspire;” “It put everything you are learning at your fingertips;” “It showed me what the graphs looked like when you change certain variables or numbers;” and “I understood the lessons better.” For those that said “sometimes,” their comments included, “Some lessons were easy to do on it but others were confusing” and “Sometimes I think it just complicated it.” The “no” responses were insightful in noting, “There were parts that I had to do the math myself and I didn’t know how because I was only taught
on the calculator” and “It did it all by itself, and I learn more by going through the steps.”

**Quiz and test scores.** I analyzed the students’ third quarter quiz and test scores to determine whether they scored at an 89% proficiency level. The quizzes given during the study were graded on the basis of an aggregate 20 points per quiz (calculator questions plus non-calculator questions); the tests were worth an aggregate 100 points each. Three of the quizzes (Appendix G) allowed the students to earn from one to two extra credit points. For Quiz 6-1 (calculator), the students earned an extra point by showing an in-depth understanding of the material when answering question number six. On Quiz 6-1 (non-calculator) and Quiz 6-2 (calculator), extra credit points were earned for answering questions that demonstrated an advanced level of understanding of the material. To evaluate the scores, a percentage was calculated for each quiz and test, and these percentages were then analyzed. Measures of central tendency and spread were also calculated. For the quiz and test percentages, the mean, standard deviation, median, first quartile (Q1), and third quartile (Q3) are shown in Table 4. Median and Q3 values greater than 100% are due to extra credit points. The overall mean of the quiz and test grades for the study quarter was 91.97%, greater than an 89% proficiency level.
### Table 4

**Quiz and Test Scores (Percentages)**

<table>
<thead>
<tr>
<th>Quiz / Test Scores</th>
<th>M</th>
<th>SD</th>
<th>Mdn</th>
<th>Q1</th>
<th>Q3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quiz 6-1 Calculator</td>
<td>93.03</td>
<td>17.94</td>
<td>100.00</td>
<td>80.00</td>
<td>110.00</td>
</tr>
<tr>
<td>Quiz 6-1 No Calculator</td>
<td>99.39</td>
<td>17.17</td>
<td>105.00</td>
<td>87.50</td>
<td>112.50</td>
</tr>
<tr>
<td>Quiz 6-2 Calculator</td>
<td>100.00</td>
<td>11.41</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
</tr>
<tr>
<td>Quiz 6-2 No Calculator</td>
<td>81.11</td>
<td>15.36</td>
<td>85.71</td>
<td>73.21</td>
<td>92.86</td>
</tr>
<tr>
<td>Test 6 Calculator</td>
<td>96.54</td>
<td>5.43</td>
<td>100.00</td>
<td>94.29</td>
<td>100.00</td>
</tr>
<tr>
<td>Test 6 No Calculator</td>
<td>89.14</td>
<td>10.63</td>
<td>92.31</td>
<td>83.08</td>
<td>96.92</td>
</tr>
<tr>
<td>Quiz 7-1</td>
<td>91.44</td>
<td>12.33</td>
<td>95.00</td>
<td>87.50</td>
<td>100.00</td>
</tr>
<tr>
<td>Quiz 7-2</td>
<td>90.61</td>
<td>11.88</td>
<td>92.50</td>
<td>82.50</td>
<td>100.00</td>
</tr>
<tr>
<td>Test 7 Calculator</td>
<td>88.79</td>
<td>12.31</td>
<td>90.00</td>
<td>80.00</td>
<td>100.00</td>
</tr>
<tr>
<td>Test 7 No Calculator</td>
<td>89.70</td>
<td>9.02</td>
<td>91.25</td>
<td>83.75</td>
<td>96.25</td>
</tr>
<tr>
<td>All Quizzes &amp; Tests</td>
<td>91.97</td>
<td>13.75</td>
<td>94.29</td>
<td>85.00</td>
<td>100.00</td>
</tr>
</tbody>
</table>

**Teacher journal.** A journal was used to document my observations of student activity in the classroom and observations on student use of the TI-Nspire™ as part of the lessons. The journal also documented successes, challenges, observations, and reflections on the study. The first four days of the study were spent teaching the students some basic uses of the calculator. This activity included watching online videos from Atomic Learning (2012) which were designed to address specific functions on the TI-Nspire™ graphing calculator. The students were engaged in the videos and followed along using their classroom TI-Nspire™ calculator to keep pace with the videos. Some of the students said they were watching the video and getting ahead of the lesson,
because it was basic, and then they would get lost trying to find the screen being
discussed.

Following three days of videos, the students spent one day going through a
tutorial lesson installed on all of the graphing calculators. The students found this
to be very beneficial as it allowed them to learn at their own pace while moving
through the tutorial. The first assigned lesson involved use of the calculator to
complete a worksheet; submitted work included work on the calculator and work
on a worksheet. Some students were confused about how the lesson was to be
completed. This opportunity was used to inform the students that the calculator
lessons weren’t ones in which they could just answer the questions; they were
supposed to think about what they were seeing on the calculator and what was
happening to the polynomial equation.

By the third calculator-specific lesson it appeared that about 80% of the
students were trying to understand what was going on instead of just filling in the
blank to answer a question. One day was spent reviewing the calculator lessons
to make sure everyone understood how to use the calculator. Though this lesson
was primarily a lecture format, the students were much more involved in asking
questions and helping each other through the lesson material. The students
appeared to look forward to the calculator lessons and the freedom it allowed
them in the classroom. The final calculator lesson did not give the students a
downloaded lesson plan; it required them to create their own document in order to
answer worksheet questions. Students collaborated significantly in completing this lesson. In my class of 25 students, most of the class was very involved in working through the material and asking each other questions; in my class of 11 students, all of them were involved.

**Interviews.** I interviewed ten of the Advanced Algebra students (see Appendix J) to determine students’ perceptions about use of the TI-Nspire™ and other technology in the teaching and learning of Advanced Algebra. These responses were analyzed using inductive analysis. In picking the ten students to interview I only had two specific criteria: more students from my largest class and an equal number of boys and girls from each class. This led to me interviewing six students from my largest class and four from my smallest. Other than these two criteria, the selection was random based on student availability at the time of the interview.

When asked what they think of when someone says they teach using technology, the common answer was the use of computers, and a few responses were SMART Boards and calculators. It was interesting to hear the students mention SMART Boards since many of the teachers in our school use ActivBoards and none of our teachers use SMART Boards. When asked if I teach using technology, the students all responded yes. One student qualified his answer by stating yes for the calculators but no because I do a lot of verbal on my own, “The teacher puts it into his own words; doesn’t get it from a program.” The
primary answer regarding types of technology used in the math classroom was the TI-Nspire™ graphing calculators and SMART Boards. A few students also mentioned the use of voters (ActivExpressions). I was surprised to find that one of my students considers using SmartPals (two clear plastic sheets with a piece of paper in the middle) as teaching using technology.

The students stated that some benefits of teaching using technology are: the ability to better learn the material at a faster pace; it shows the student many different ways to complete certain tasks; the teacher can go back a page without erasing things; it is more hands-on; and the belief that students’ get more involved in the lesson. One student noted, “You can learn how to use everything since everything is turning to technology.” Problems associated with technology focused on confusion with not knowing how to use the technology and the inability to complete tasks if the technology isn’t present. A few students mentioned there can also be a lack of comfort with using the technology as well as a greater possibility to fall behind.

On the question of using calculators in the math classroom, there was agreement from all of the students interviewed that calculators should be used in math class; mostly for the harder problems or for a student to check their work. The students liked the calculator and non-calculator quizzes they took as part of the study; there was a general feeling that it would have been nice to use a calculator for the entire quiz so they could check their work. One student stated,
“The calculator quizzes and tests were effective on learning how to use the calculator and also learn the lesson by thinking.” All of the students thought they have at least a medium or medium to high level of expertise with using a graphing calculator. There were numerous positive comments about using graphing calculators in the teaching of high school juniors and seniors: “Helped me understand some of the lessons a lot more; especially the graphs;” “I like the graphing calculator. There were things you were able to understand more;” and a statement that the graphing calculators were “a different way of doing things and made it more interesting.”

All ten of the students interviewed stated that using the TI-Nspire™ made them more involved in the lesson. The general feeling was that using the calculator allowed the students to physically be doing something instead of just listening to the teacher and watching the teacher write on the board. Some quotes regarding involvement included: “Working in groups to find the answers on the worksheets was better than a lecture” and “Pushing the buttons kept me more focused. I liked having the step by step instructions with the calculator.”

**Interpretation of Results**

The one constant in this study was the school’s requirement that the classroom graphing calculators not leave the school building. This requirement made it difficult for students to explore the calculator-based lessons outside the classroom; it was necessary for them to find time during the school day to
complete calculator lessons. The importance of attendance became more apparent as the study progressed; it was a much greater factor than initially anticipated. I made it clear to the students at the beginning of the study that if a student was gone during a calculator lesson it was crucial for them to complete the lesson shortly after returning to school. I only had a few students that missed class during the calculator lessons. Those who missed the lesson needed to have me teach it to them outside of normal class time and this became difficult to schedule; especially for lessons that needed to be uploaded and/or downloaded.

This study was based on students having at least some interest, even minimal interest, in understanding and utilizing the TI-Nspire™ graphing calculator. I did have two students who were not present for a majority of the calculator lessons, did not actively participate, and did not follow up on the lesson material. One student was absent for 10 class days out of 43 and the other student was absent for 5 of the 8 calculator based lessons. I received no feedback or attempt to learn from these two students every time I approached them to follow-up on their understanding of how to use the calculator. All of the calculator work was designed to be completed in class and the assessments required an understanding of the TI-Nspire™ graphing calculator. If the students didn’t wish to participate in class, the lesson material was not information they could obtain by reading the textbook.
**Question 1.** Would a more focused approach to incorporating the TINspire™ graphing calculators increase my Advanced Algebra students’ comfort with, usage of, and knowledge of the TI-Nspire™ graphing calculator? I believed that there would be an increase in the pre- to post-survey data; thus, highlighting an increase in their comfort using a graphing calculator and in their usage and knowledge of a graphing calculator. The data from the survey definitely showed a positive change in the students’ comfort with using a graphing calculator in addition to a positive change in their usage and knowledge of graphing calculators and the TI-Nspire™. The matched-pairs $t$-tests that analyzed the growth from pre-survey to post-survey total scores found sufficient evidence at the $\alpha = 0.05$ level of significance to conclude that Advanced Algebra students comfort with, usage of, and knowledge of graphing calculators in general and the TI-Nspire™ in particular increased.

There was agreement among the students that it was easy to learn how to use the TI-Nspire™ and they liked using the TI-Nspire™ calculator to learn math; in fact, they liked math class better when they were able to use the TI-Nspire™ calculator. When using the graphing calculators the students became more active in their learning and they showed an increased participation in the learning process. To quote one student, “When you used the calculator you got more involved.”
Question 2. Would use of the TI-Nspire™ graphing calculator enhance student learning of the Advanced Algebra students to an 89% proficiency level, based on students’ quiz and test scores? I believed that upon analysis of the students’ test and quiz scores I would find sufficient evidence to support the conclusion that student learning was enhanced to an 89% proficiency level. The overall mean of the quiz and test grades for the study quarter was 91.97%, greater than an 89% proficiency level. The graphing capability of the calculator benefitted the students because it allowed them to spend their time learning about the graphs instead of working to create the document; “It helped me understand graphing a lot more than I would have,” said one student.

Question 3. What were students’ perceptions of the use of the TI-Nspire™ graphing calculator and technology when used in Advanced Algebra? I expected the students to have positive perceptions regarding the use of the TI-Nspire™ calculator and technology in the teaching and learning of Advanced Algebra. The positive perceptions by the students were very obvious and much greater than I originally expected. As noted on the questionnaires, there was a definite agreement among the students that using the TI-Nspire™ in math class was much better than using a regular calculator. Using the TI-Nspire™ helped them better understand the math taught in class, made them more confident their answers were correct, and helped them learn the material. Some comments regarding the students’ perceptions included, “Helped me understand some of the
lessons a lot more; especially the graphs,” and a statement that the graphing
calculators were “a different way of doing things and made it more interesting.”

All ten of the students interviewed stated that using the TI-Nspire™ made them more involved in the lesson. The general feeling was that using the calculator allowed the students to physically be doing something instead of just listening to the teacher and watching the teacher write on the board. Some quotes regarding involvement included, “Working in groups to find the answers on the worksheets was better than a lecture” and “[You] couldn’t just do it on your own and had to work together more.” The lessons that involved graphing seemed to go better this year than previous years. The students were more receptive to understanding how graphs vary due to changing variables without having to take the time to manually create the graph. I did encounter a few students who did not want to think any further than was necessary to answer a specific question. These students were able to graph a function using the calculator, but their answers on non-calculator quiz and test questions showed a lack of understanding how the graph is affected by changing variables.

Summary

A more focused approach to incorporating the TI-Nspire™ graphing calculators in my Advanced Algebra class definitely increased my students’ comfort with, usage of, and knowledge of the TI-Nspire™ graphing calculator as evidenced in the pre- and post- survey responses. The quizzes and tests
demonstrated that use of the TI-Nspire™ graphing calculator enhanced student learning of the Advanced Algebra students to an 89% proficiency level. The students had positive perceptions of the use of the TI-Nspire™ graphing calculator and technology when used in Advanced Algebra as noted in their responses to the questionnaire questions at the end of the study as well as their comments during the interviews. The results of this project agree with the conclusion of a paper by Leng et al. (2009) which stated that “the TI-Nspire™ should be used to stimulate students to think mathematically so that they [can] engage strongly with mathematical structures and concepts in ways that are not possible with traditional paper and pencil approaches” (p. 11).
Chapter Five

Conclusions, Action Plan, Reflections, and Recommendations

In the summer of 2009 I received a grant to purchase a classroom set of 30 TI-Nspire™ graphing calculators. Prior to this action research study, I did not use these graphing calculators in any special way to enhance the learning for my students. This study necessitated developing a curriculum around the calculator and implementing a more hands-on learning environment to guide my Advanced Algebra students in using the TI-Nspire™ as a resource. The main benefit of this project may not lie in obtaining the answers to my research questions, but in the work which was done in completing the study. To complete the study it was essential to do the following: to learn how to incorporate the TI-Nspire™ technology in the classroom; to research and edit calculator specific lesson material; to create and grade calculator and non-calculator specific quizzes and tests; and to upload and download lessons to the TI-Nspire™. I believe the interview process gave my students an opportunity to be more honest with me regarding their thoughts on the learning that was taking place. This chapter addresses conclusions about the research questions, identifies lessons learned, and discusses my plan of action after completing the study.

Conclusions

The overlying purpose of this study was to determine whether a more frequent integration of the TI-Nspire™ into the pedagogy for my Advanced
Algebra class would enhance the students’ achievement. An analysis of the students’ test and quiz scores during the nine-week study found them to average 91.97%; greater than the desired 89% proficiency level. One unforeseen benefit of analyzing the achievement came from using two-part quizzes and tests; a calculator portion and a non-calculator portion. When reviewing the students’ work, this format allowed me to gain much better insight into their understanding of the mathematical concepts behind the non-calculator lessons. The separate assessments allowed me to better understand those concepts in the lessons where individual students were having difficulties; allowing for a more focused approach during re-teach.

In addition to enhanced achievement, I wanted to determine if incorporating the TI-Nspire™ into my lessons would increase student comfort with, usage of, and knowledge of graphing calculators in general and specifically the TI-Nspire™ graphing calculator. The data from the survey showed an increase in the students’ comfort, usage, and knowledge regarding the use of a graphing calculator and the TI-Nspire™. I found that using the graphing calculators also increased the students’ interest in determining and understanding the characteristics and behaviors of the functions they evaluated; their interest in the analytical aspect of the lesson increased.

While reviewing the pre- and post-survey data I noticed two questions which seemed to have minimal change, yet warrant further research in a different
study. For the survey question, “Should students be allowed to use a calculator in the classroom,” the median value on the pre-survey was 4.67 and there was a slight increase of 0.05 to the post-survey median of 4.72. This increase can be interpreted to mean the students increased their reliance on a calculator during this study. However, the survey question, “I must have a calculator available when doing my math,” showed a slight decrease in the mean score from 3.56 to 3.5. Even though allowing students to use a calculator increased, the need to have a calculator available decreased. Further research is warranted to see if there is a correlation between these two questions, teaching using the TI-Nspire™ graphing calculator, and/or using assessments which are broken into calculator and non-calculator sections.

I also wanted to determine students’ perceptions about use of TI-Nspire™ graphing calculators and technology in the teaching of Advanced Algebra. The questionnaire at the end of the study and the student interviews were powerful in showing a strong positive perception by the students. According to the students, it was beneficial to use technology, especially the TI-Nspire™ graphing calculator, when teaching Advanced Algebra.

**Action Plan**

As a result of this project I plan to continue to use the TI-Nspire™ graphing calculator for many of the lessons in Advanced Algebra and make it part of the Math 8 and Advanced Math lessons as well. As part of this study it was
essential to download, upload, and grade lesson material specific to the graphing calculator, in addition to creating two-part assessments. Now that I am comfortable with doing these various operations, my fear of them has disappeared and been replaced with a desire to allow the students in all of my classes to experience the positive changes of using this technology. When researching lesson plans for Advanced Algebra, I found numerous lessons that will be very beneficial to students in all of my classes.

With completion of the initial study I have created an increased curiosity in me, and amongst my students, about the many different ways the TI-Nspire™ can be used to help in understanding math. I am constantly telling my advanced students they need to understand the “why” of mathematics, not just memorize a bunch of formulas and plug in numbers. When using the graphing calculators I saw the students beginning to understand why the math works, which led to discussions of the lesson material. Some of the students became comfortable explaining to me their understanding of the lesson, which led to mathematics discussions at a much higher level.

Reflections and Recommendations for Teachers

The first recommendation for any lesson involving technology is to be fully prepared in everything that will be shown to students, then expect them to quickly be ahead of the teacher. Many of my students started out as novices and
by the end of the study they were very adept at using many different functions on the calculator.

The second recommendation is to make sure teachers use the latest operating system and everything is fully powered. The first day of the study I found seven of the calculators had batteries at less than 25% power and two calculators had no batteries. Also, one of my students noted that my calculator emulator operating system was a newer version than that shown on the graphing calculators. That evening I spent over an hour updating the operating system on all of the calculators. On the second day I found that a piece of Texas Instrument software was not working properly with my emulator. After 45 minutes with technical support I was able to download and run the necessary patch to make everything compatible.

With the assessments I found it best to give the calculator section first and then the non-calculator section. Originally I gave the non-calculator section first and then the calculator section. After the first assessment I changed the order because I found it created problems when I had some students who needed to download a lesson at the same time other students had finished and were ready to upload their finished lesson.

The TI-Nspire™ graphing calculator should be used for lessons that involve graphing. The ability to see the algebraic function with the graphical representation was very powerful in helping the students understand complex
graphs. The ability to manipulate the graphs also helped the students understand how functions and graphs are affected by changes in parameters, without having to go through the pain of paper and pencil graphs. I believe this freedom gave them a much more in-depth understanding of the material. Instead of worrying about graphing they were able to focus on the parent graph and child graph relationship.

**Summary**

This action research study was a success. I found that integration of TI-Nspire™ graphing calculators into my pedagogy increased my students' comfort with, usage of, and knowledge of graphing calculators in general and specifically the TI-Nspire™ graphing calculator while also having a positive effect on enhancing their achievement on exams. I was also able to determine that my students’ have positive perceptions regarding the TI-Nspire™ and the use of technology in the teaching of Advanced Algebra.

By creating two part assessments I was able to get a better insight into the students’ understanding of the mathematical concepts behind the non-calculator lessons. As an added benefit, I found that using the TI-Nspire™ graphing calculator also increased the students’ interest in the analytical aspect of the lesson. With greater use of the TI-Nspire™ in the math classroom, students can create their own learning experiences. Students appreciated the freedom to use new technology to explore age-old mathematical concepts.
References


Appendices
Appendix A

IRB Approval

Notice of IRB Approval

Name of Principal Investigator: Jonathan N. Fugleberg

University Address: Mathematics & Computer Science

Title of Project: Increasing Student Performance by Incorporating the TI-NspireTM into Advanced Algebra

Protocol Number: 1195

November 30, 2011

The above project has been reviewed and approved by the IRB under the provisions of Federal Regulations 45 CFR 46.

This approval is based on the following conditions:

1. The materials you submitted to the IRB provide a complete and accurate account of how human subjects are involved in your project.

2. You will carry on your research strictly according to the procedures as described in materials presented to the IRB.

3. You will report to the chair of the Institutional Review Board any changes in procedures that may have a bearing on this approval and require another IRB review.

4. If any changes are made, you will submit the modified project for IRB review.

5. You will immediately report to the IRB Chair any problems that you encounter while using human subjects in your research.

[Signature]
Chair, Minot State University’s IRB
Appendix B

Principal / Superintendent Approval

Dear Mr. Ulland and Mr. Bradner;

I am completing work toward the Master of Arts in Teaching: Mathematics degree through Minot State University. As a degree requirement, I am to conduct a research project in my classroom during the third quarter this year. I am planning to integrate the TI-Nspire™ graphing calculator into my classroom to determine if a more focused approach incorporating the TI-Nspire™ into my lesson plans and teaching will increase my Advanced Algebra students’ engagement in the math lessons as well as enhance their achievement scores in mathematics; curriculum will be developed around the graphing calculator. To accomplish this, I plan to work with the students in my Advanced Algebra classes.

During the project, students will take pre- and post-study surveys regarding their knowledge about graphing calculators and will be instructed on use of the TI-Nspire™ prior to it being part of the instruction. New quizzes and tests will be created in two parts; the first part will be completed without the use of a calculator and the second part will require use of the TI-Nspire™ graphing calculator. To measure increased student engagement with use of the TI-Nspire™ I will use a questionnaire at the end of the project in conjunction with interviewing at least 25% of the Advanced Algebra students. All of the students will complete a survey to see how they feel about use of the TI-Nspire™ as part of the lessons. At the end of the project, at least ten students will be interviewed regarding their personal impressions of the augmented lessons. Homework assignments requiring use of the TI-Nspire™ graphing calculators will be able to be completed in class or there will be extra time given to complete the assignment. Not all of the homework assignments will require use of the calculator. I will also be taking notes on my own observations.

At the completion of the study, I will analyze the data from the surveys, quiz and test scores, and my journal of observations to determine the results. Classroom and student confidentiality will be observed regarding all data collected and no individual will be identified by name.

Before the study begins, I will send home consent forms for parents/guardians to notify them of this project and request their permission allowing their student to participate in the research study. A copy of each letter is attached for your inspection.
I am requesting that you permit me to carry out this research in my classroom. Please contact me if you have any questions. Thank you for your consideration.

[Signature]

I, Scott Ulland, grant permission for Jonathan Fugleberg to conduct the above mentioned research in his classroom.

[Signature]

I, Scott Ulland, DO NOT grant permission for Jonathan Fugleberg to conduct the above mentioned research in his classroom.

[Signature]

Date

11-21-11

Signature of Mr. Scott Ulland
Principal at MayPort CG High School

[Signature]

Date

11-21-11

Signature of Mr. Michael Bradner
Superintendent of MayPort CG Public School District

[Signature]

I, Michael Bradner, grant permission for Jonathan Fugleberg to conduct the above mentioned research in his classroom.

[Signature]

I, Michael Bradner, DO NOT grant permission for Jonathan Fugleberg to conduct the above mentioned research in his classroom.
Appendix C

Parent / Guardian Consent Form

Enhancing Student Performance by Incorporating the TI-Nspire™ into Advanced Algebra
by Jonathan Fugleberg

Purpose of the Research
I am currently completing work toward my Masters of Arts in Teaching: Mathematics degree through Minot State University. For my final degree requirement, I am conducting an action research project during the third quarter, January 12th through March 14th, to determine if integration of the TI-Nspire™ graphing calculator into my Advanced Algebra classroom will increase my student engagement in the math lessons as well as enhance students’ achievement in math. The TI-Nspire™ will not just be added to the standard curriculum; curricula will be developed around the calculator.

Specific Procedures
Students in my two Advanced Algebra classes will cover the normal Advanced Algebra curriculum while using the TI-Nspire™ graphing calculator to augment the lesson material. At the beginning of the study, your student will complete a survey to assess his/her prior use, comfort level, and knowledge of graphing calculators in general and the TI-Nspire™ in particular. The students will be instructed on use of the TI-Nspire™ prior to it being part of the instruction. The school policy is to not let the classroom TI-Nspire™ graphing calculators leave the school. Homework assignments requiring use of the TI-Nspire™ graphing calculators will be able to be completed in class or there will be extra time given to complete the assignment. Not all of the homework assignments will require use of the calculator. At the end of the quarter, students will complete the survey again to assess their knowledge of the TI-Nspire™.

All of the students will also complete a questionnaire to see how they feel about use of the TI-Nspire™ as part of the lessons. At least ten students will be chosen to be interviewed regarding their personal impressions of the augmented lessons. Survey and questionnaire responses, quiz and test scores, and my observations will be analyzed to determine if integration of the TI-Nspire™ graphing calculator enhances the students’ engagement and achievement. My results will be summarized and included in my research paper. None of the students in my class will be identified in my results. Mr. Scott Ulland, principal of MayPort CG
High School, and Mr. Michael Bradner, superintendent of MayPort CG Public School District, have both approved this research study.

**Duration of Participation**
Your student will participate in TI-Nspire™ graphing calculator enhanced lessons during the third quarter of the academic school year. They will be expected to complete two surveys and a questionnaire, in addition to normal homework, quizzes, and tests during the duration of the unit.

**Benefits to the Individual**
There are no direct benefits in participating in this study, but participation will give your student additional tools to help him/her prepare for math tests. The study may show the benefits of using the TI-Nspire™ graphing calculator to increase their involvement in the math classroom and enhance their achievement in Advanced Algebra.

**Risks to the Individual**
The risks to your student are no more than he/she would encounter in a regular classroom setting.

**Confidentiality**
All data will be treated confidentially by the researcher. Names of participants and their data sets will be kept in a locked filing cabinet in the researcher’s office or password-protected computer and will be destroyed once the paper has been defended and approved. The researcher agrees to maintain strict confidentiality which means your student’s name will not be discussed or divulged with anyone outside of this research project. The researcher will also make sure confidential information will not be discussed in an area that can be overheard that would allow an unauthorized person to associate or identify the student with such information.

**Voluntary Nature of Participation**
During this study, the responses from your student do not have to be included. Also, your student does not have to be interviewed. However, I hope you approve of your student being involved in this study because more responses improves the accuracy of the results of my study and better informs me about how to continue to improve my teaching practices. If you decide to participate, you are free to withdraw your consent at any time. If you do not consent or withdraw your consent, your student’s data will not be included in my results and your student will not complete the surveys, questionnaire, or interview, but your student will
still be asked to use the TI-Nspire™ graphing calculator in class since this is a regular part of my course.

**Human Subject Statement**
The Institutional Review Board of Minot State University has given me permission to conduct this research. If you have questions regarding the right of research subjects, please contact the Chairperson of the MSU Institutional Review Board (IRB), Dr. Vicki Michels at 701-858-3594 or Vicki.Michels@minotstatu.edu.

**Offer to Answer Questions**
If you have any questions or concerns now or during the study, feel free to contact me at 701-430-9846 or email me at jonathan.fugleberg@may-portcg.com, Mr. Scott Ulland at 701-788-2281, or Mr. Michael Bradner at 701-788-2281. Thank you for your consideration.

**Consent Statement**
You are voluntarily making a decision whether or not to participate in this study. With your signature below, you are indicating that upon reading and understanding the above information, you agree to allow your student’s survey, questionnaire, and interview results to be used in this study. You will be given a copy of the consent form to keep.

Participant (Please Print Student’s Name)

__________________________________________  ___________________
Signature of Parent/Guardian                     Date

__________________________________________  ___________________
Signature of Researcher                          Date
Appendix D

Student Participant Assent Form

Enhancing Student Performance by Incorporating the TI-Nspire™ into Advanced Algebra
Jonathan Fugleberg

Purpose of the Research
I am currently completing work toward my Masters of Arts in Teaching: Mathematics degree through Minot State University. For my final degree requirement, I am conducting an action research project during the third quarter, January 12th through March 14th, to determine if integration of the TI-Nspire™ graphing calculator into my Advanced Algebra classroom will increase student engagement in the math lessons as well as enhance students’ achievement in math. The TI-Nspire™ will not just be added to the standard curriculum; curricula will be developed around the calculator.

Specific Procedures
You will cover the normal Advanced Algebra curriculum while using the TI-Nspire™ graphing calculator to augment the lesson material. At the beginning of the study, you will complete a survey to assess your prior use, comfort level, and knowledge of graphing calculators in general and the TI-Nspire™ in particular. You will be instructed on use of the TI-Nspire™ prior to it being part of the instruction. The school policy is to not let the classroom TI-Nspire™ graphing calculators leave the school. Homework assignments requiring use of the TI-Nspire™ graphing calculators will be able to be completed in class or there will be extra time given to complete the assignment. Not all of the homework assignments will require use of the calculator. At the end of the quarter, you will complete the survey again to assess your knowledge of the TI-Nspire™.

You will also complete a questionnaire to see how you feel about use of the TI-Nspire™ as part of the lessons. At least ten students will be chosen to be interviewed regarding their personal impressions of the augmented lessons. Survey and questionnaire responses, quiz and test scores, and my observations will be analyzed to determine if integration of the TI-Nspire™ graphing calculator enhances the students’ engagement and achievement. My results will be summarized and included in my research paper. None of the students in my class will be identified in my results. Mr. Scott Ulland, principal of MayPort CG High School, and Mr. Michael Bradner, superintendent of MayPort CG Public School District, have both approved this research study.
Duration of Participation
You will participate in TI-Nspire™ graphing calculator enhanced lessons during the third quarter of the academic school year. You will be expected to complete two surveys and a questionnaire, in addition to normal homework, quizzes, and tests during the duration of the unit.

Benefits to the Individual
There are no direct benefits in participating in this study, but participation will give you additional tools to help you prepare for math tests. The study may show the benefits of using the TI-Nspire™ graphing calculator to increase your involvement in the math classroom and enhance your achievement in Advanced Algebra.

Risks to the Individual
The risks to you are no more than you would encounter in a regular classroom setting.

Confidentiality
All data will be treated confidentially by the researcher. Names of participants and their data sets will be kept in a locked filing cabinet in the researcher’s office or password-protected computer and will be destroyed once the paper has been defended and approved. The researcher agrees to maintain strict confidentiality which means your name will not be discussed or divulged with anyone outside of this research project. The researcher will also make sure confidential information will not be discussed in an area that can be overheard that would allow an unauthorized person to associate or identify the student with such information.

Voluntary Nature of Participation
During this study, your responses do not have to be included. Also, you do not have to be interviewed. However, I hope you approve of being involved in this study because more responses improves the accuracy of the results of my study and better informs me about how to continue to improve my teaching practices. If you decide to participate, you are free to withdraw your consent at any time. If you do not consent or withdraw your consent, your data will not be included in my results and you will not complete the surveys, questionnaire, or interview, but you will still be asked to use the TI-Nspire™ graphing calculator in class since this is a regular part of my course.
Human Subject Statement
The Institutional Review Board of Minot State University has given me permission to conduct this research. If you have questions regarding the right of research subjects, please contact the Chairperson of the MSU Institutional Review Board (IRB), Dr. Vicki Michels at 701-858-3594 or Vicki.Michels@minotstatu.edu.

Offer to Answer Questions
If you have any questions or concerns now or during the study, feel free to contact me at 701-430-9846 or email me at jonathan.fugleberg@may-portcg.com, Mr. Scott Ulland at 701-788-2281, or Mr. Michael Bradner at 701-788-2281. Thank you for your consideration.

Consent Statement
You are voluntarily making a decision whether or not to participate in this study. With your signature below, you are indicating that upon reading and understanding the above information, you agree to allow your survey, questionnaire, and interview results to be used in this study. You will be given a copy of the consent form to keep.

________________________________________________________________________
Participant (Please Print Your Name)                                      

________________________________________________________________________
Signature of Participant  ___________________________ Date

________________________________________________________________________
Signature of Researcher  ___________________________ Date
Appendix E
Math Class Survey

The purpose of this survey is to help me understand how you feel about GRAPHING calculators, calculators, and math. Using the code below, check the box that describes how much you agree with each statement. Respond to each statement as honestly as possible. Check only one box for each statement.

SD – Strongly Disagree  D – Disagree  N – No opinion
A – Agree  SA – Strongly Agree

1. How many years have you used a calculator                     years
2. How many years have you used a GRAPHING calculator           years

3. I feel very comfortable that I know how to use a calculator
4. I feel very comfortable that I know how to use a GRAPHING calculator
5. I feel very comfortable that I know how to perform the following functions on a graphing calculator
   a. Graph a function
   b. Graph more than one function on the same screen
   c. Graph an inequality
   d. Graph a relation (e.g., y=x^2)
   e. Create a table
   f. Use the TRACE feature
   g. Use the ZOOM feature
   h. Use the WINDOW feature
   i. Use the MAXIMUM and MINIMUM features
6. I feel very comfortable that I can perform the following functions on the TI-Nspire™ calculator:
   a. Create a new document
   b. Use the MENU function
   c. Use the SPREADSHEET function
   d. Work with variables
   e. Create and use TABLES
   f. Work on multiple screens simultaneously
7. Graphing calculators are easy to use.
8. Students should be allowed to use a calculator in the math classroom
9. I must have a calculator available when doing my math.
10. I am good at math.
Appendix F

Lesson Plans Developed for the TI-Nspire™

Lesson 6.2 – Polynomial End Behavior (Ellison, 2009)

TI-nspire™

Polynomial End Behavior
Tiffani S. Ellison

Activity Overview

In this activity, students will discover the relationship between the degree and leading coefficient of a polynomial and the number of turns and end behavior of a graph. They will discover the maximum number of turns is always one less than the degree. They will also find that negative leading coefficients will result in the right end behavior going down. Lastly the students will find that the graphs of even degree polynomials will be the same on each end and odd degree will be different. When complete, students should be able to describe the graph of a polynomial given its equation.

Concepts:

Tennessee Algebra II Standard
SPI 3102.3.11 Analyze nonlinear graphs including quadratic and exponential functions that model a contextual situation.

Teacher Preparation

• This activity is designed to be completed in an Algebra I or II class.

• Prior to this activity students should have an understanding of polynomials, degrees, coefficients and standard form of a polynomial. It is suggested that students have previously graphed linear and quadratic functions.

• This activity requires students to graph polynomials as needed.

The Classroom

• The activity is designed to be completed by students individually with or without partner checks throughout.

TI-Nspire Applications

Notes, Graphs & Geometry

Assessment and Evaluation

• Students can be given sample polynomial equations and asked to describe the graph. They can be given a chart similar to the one from the handout. A teacher may find adding the column indicating whether the end behavior is “same” or “different” may help students more. Further discussion needs to take place about the maximum number of turns and how that number can be reduced by an even whole number.
Lesson 6.2 – Polynomial End Behavior (continued)

**Polynomial End Behavior**

*Student Worksheet*

In this activity, you will explore:

- Maximum number of turns of the graph of a polynomial
- End behavior of the graph of a polynomial
- Effects of leading coefficient and degree of the polynomial on the graph of the polynomial

Open the document and read through the first three pages. Answer the questions on page 2 and check your answer.

Once on page 1.4 you will need to record your answers in the table below.

To help you get started. The figure to the right is from Page 1.4

Record the equation of the polynomial below along with the degree and the leading coefficient.

Grab and pull the screen to verify the graph does not change direction again before completing the chart. Once you have the answers for this graph move along to the remaining graphs.

<table>
<thead>
<tr>
<th>Polynomial Equation</th>
<th>Degree of Polynomial</th>
<th>Leading Coefficient</th>
<th>Number of Turns (How many times does it change direction?)</th>
<th>Direction of Left Arrow</th>
<th>Direction of Right Arrow</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

**PAUSE** Discuss the problem with your partner.
Lesson 6.2 – Polynomial End Behavior (continued)

WRITE THE RULES:

You can determine each of the rules for the graph of a polynomial simply by looking at the equation of the polynomial.

Discuss the following with your partner:

1. How do you determine the maximum number of turns in a graph?

2. What determines if the end behavior of the graph will be the same or different?

3. What must exist for the right end behavior to be down?

4. According to your rules can a 5th degree polynomial turn three times? Why or why not?
Lesson 6.5 – Factors, Roots, and Zeros (Texas Instruments, 2011)

Polynomials—Factors, Roots, and Zeros
Student Activity

Open the TI-Nspire document
Polynomials_Factors_Roots_and_Zeros.tns.

This activity examines the connections between the roots or zeros of a polynomial equation and the x-intercepts of the graph of the polynomial function. It also looks at how the graph of the function can help identify the factors of the equation.

Move to page 1.2.

1. Using the sliders, set $y_1 = x + 1$ and $y_2 = x - 2$. Observe that the graph of $y_1 = 1x + 1$ appears to cross the x-axis at $x = -1$. When $x = -1$, $y_1 = 0$ because $-1 + 1 = 0$.
   x = -1 is called a zero or root of the function $y_1 = 1x + 1$.
   a. Where does the graph of $y_2 = 1x - 2$ appear to cross the x-axis?

   b. Write a simple equation to verify that this value of $x$ is a zero of $y_2$.

   c. When $y_1 = 1x + 1$ and $y_2 = 1x - 2$, what is the function $y_3$?

   d. The graph of $y_3$ is a parabola. How many times does the graph of $y_3$ cross the x-axis?

   e. What are the zeros of $y_3$?

   f. Factor $y_3$. 

©2011 Texas Instruments Incorporated
Lesson 6.5 – Factors, Roots, and Zeros (continued)

<table>
<thead>
<tr>
<th>$y_1$</th>
<th>$y_2$</th>
<th>Zeros of $y_1$</th>
<th>$y_3$</th>
<th>Zeros of $y_2$</th>
<th>Factors of $y_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$(x + 4)$</td>
<td>$(x + 5)$</td>
<td>$2x^2 + 5x - 6$</td>
<td></td>
<td></td>
<td>$(x - 5)(x + 1)(x - 2)$</td>
</tr>
<tr>
<td>$(3x + 3)$</td>
<td></td>
<td>$-1$</td>
<td></td>
<td>$-1$ and $4$</td>
<td>$(2x + 4)(3x - 3)$</td>
</tr>
</tbody>
</table>

h. Write a conjecture about the relationship between the zeros of the linear functions and the zeros of the quadratic function.

i. How do the factors of the quadratic equation relate to the zeros of the function?

Move to page 2.2.

2. Use the sliders to make $f_1 = 1x + 4$, $f_2 = 1x + 2$, and $f_3 = x - 1$. Observe that the graphs of each appear to cross the x-axis at $-4$, $-2$, and $1$, respectively.
   a. Verify algebraically that each is a zero of each linear function.

   b. When $f_1 = 1x + 4$, $f_2 = 1x + 2$, and $f_3 = x - 1$, what is $f_4$?

   c. How many times does $f_4$ cross the x-axis and where?
Lesson 6.5 – Factors, Roots, and Zeros (continued)

Polynomials—Factors, Roots, and Zeros

Student Activity

Name__________________  
Class_________________

d. Show that the multiplication of the factors of \( f_1, f_2, \) and \( f_3 \) equal \( f_4 \).

e. Try other slider values and make a conjecture about the relationship between the zeros of the linear equations and the zeros of the cubic function.

3. Use the sliders to make \( f_1 = x + 4, f_2 = x + 2, \) and \( f_3 = x + 2 \).
   a. How has the graph changed? The value \(-2\) is called a double root.

   b. Change \( f_1 = 1x + 2 \). How has the graph changed?

4. Use the sliders to make \( f_1 = 3x - 3, f_2 = x + 1, \) and \( f_3 = x - 2 \).
   a. Observe the graph and identify the zeros. What is \( f_4 \)?

   b. Now change the sliders to make \( f_1 = x - 1, f_2 = x + 1, \) and \( f_3 = x - 2 \). Observe the graph.  
      What are the zeros? What is \( f_4 \)?

   c. Identify similarities and differences between the sets of equations in 4a and 4b.
Lesson 6.6 – Zeros of Polynomials (Texas Instruments, 2009)

Problem 1 – Finding Zeros Graphically

<table>
<thead>
<tr>
<th>Function</th>
<th>Zeros</th>
</tr>
</thead>
<tbody>
<tr>
<td>( f(x) = x^3 - 3x^2 - x + 3 )</td>
<td></td>
</tr>
<tr>
<td>( f(x) = x^2 - 3x - 2 )</td>
<td></td>
</tr>
<tr>
<td>( f(x) = x^4 + 5x^3 + 3x^2 - 5x - 4 )</td>
<td></td>
</tr>
<tr>
<td>( f(x) = x^4 - x^3 - 7x^2 + x + 6 )</td>
<td></td>
</tr>
<tr>
<td>( f(x) = x^4 - 3x^3 - 6x^2 + 28x - 24 )</td>
<td></td>
</tr>
<tr>
<td>( f(x) = x^2 - 2.6x^4 - 1.11x^3 - 3.74x^2 - 0.73x + 0.3 )</td>
<td></td>
</tr>
</tbody>
</table>

1. Make a conjecture about the number of real zeros of a polynomial in relation to the degree of the polynomial.

2. A fourth degree polynomial has four zeros: Sometimes Always Never.

3. A polynomial can have more zeros than the highest degree of the function. True False.

4. What is the greatest number of zeros possible for the function \( f(x) = x^6 - 15x^4 + 10x^2 + 60x - 72 \)?

5. Determine the number of real zeros for \( f(x) = x^3 - 15x^2 + 10x^2 + 60x - 72 \).

6. What are the real zeros of \( f(x) = x^3 - 15x^2 + 10x^2 + 60x - 72 \)?
Lesson 6.6 – Zeros of Polynomials (continued)

### One Of The Many Ways

**Problems 2-6 – Rational Root Theorem**

For each polynomial given, use the Rational Root Theorem to list the possible rational zeros. When you have the possible zeros, use the handheld to determine which values are actual zeros of the function.

On each spreadsheet, type the possible rational zeros of \( f(x) \) into the first column. The second column will return a zero if it is an actual zero.

<table>
<thead>
<tr>
<th>Function</th>
<th>Possible Zeros</th>
<th>Actual Zeros</th>
</tr>
</thead>
<tbody>
<tr>
<td>( f(x) = x^3 + 2x^2 - 11x - 12 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( f(x) = x^4 + 4x^3 - 6x^2 - 36x - 27 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( f(x) = 10x^4 - 3x^3 - 29x^2 + 5x + 12 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( f(x) = x^4 - 2x^3 - x^2 - 2x - 2 )</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Lesson 6.8 – Analyzing Graphs of Polynomial Functions

Algebra II
Lesson 6.8 Worksheet

Name

Use a graphing calculator to graph the function. Identify the coordinates of the x-intercept(s) and the points where the local maximum and minimums occur.

1. \( f(x) = 3x^4 - 5x^2 + 2x + 1 \)  
   x-intercepts  
   local maximum(s)  
   local minimum(s)

2. \( f(x) = x^3 - 3x^2 + x + 1 \)  
   x-intercepts  
   local maximum(s)  
   local minimum(s)

3. \( f(x) = -2x^3 + x^2 + 4x \)  
   x-intercepts  
   local maximum(s)  
   local minimum(s)

4. \( f(x) = x^5 + x^4 - 4x^3 - 3x^2 + 5x \)  
   x-intercepts  
   local maximum(s)  
   local minimum(s)

5. \( f(x) = -\frac{1}{4}x^4 + 2x^2 \)  
   x-intercepts  
   local maximum(s)  
   local minimum(s)

6. \( f(x) = x^5 - 6x^3 + 9x \)  
   x-intercepts  
   local maximum(s)  
   local minimum(s)
Lesson 6.8 – Analyzing Graphs of Polynomial Functions (continued)

You are designing an open box to be made from a piece of cardboard that is 10 inches by 15 inches. The box will be formed by making the cuts shown in the diagram and folding up the sides so the flaps are square. You want the box to have the greatest volume possible. How long should you make the cuts? What is the maximum volume? What are the dimensions of the finished box?

To find the maximum volume, you first need to write an equation for the volume of the finished box [hint: Volume = (length)(width)(height)].

Once you find the formula for volume, graph it on a graphing calculator. The maximum volume is the point where the local maximum occurs. You consider only the interval $0 < x < 5$ because this describes the physical restrictions on the size of the flaps. The $x$-coordinate of the graph is the $x$ value in the above diagram. The $y$-coordinate of the graph is the volume.

\[
\text{Volume} = \underline{\phantom{00000}}
\]

Coordinates of the local maximum(s) \underline{\phantom{0000000000}}

Length of the cuts \underline{\phantom{0000000000}}

Maximum volume \underline{\phantom{0000000000}}

Dimensions of the finished box \underline{\phantom{0000000000}}
Lesson 7.4 – Inverse Functions

Algebra II
Lesson 7.4 Worksheet

Name____________________

For each of the functions noted below:

1. Find an equation for the inverse relation. Label it \( g(x) \)
2. Verify that \( f(x) \) and \( g(x) \) are inverse functions.
3. Use the TI-Nspire™ to graph the original function \( f(x) \) and its inverse \( g(x) \).
   Graph them on the noted page.

1. \( f(x) = 6x + 4 \) \hspace{1cm} \( g(x) = \) ______________
   Graph on page 1.2

2. \( f(x) = \frac{1}{3}x^2 \) \hspace{1cm} \( g(x) = \) ______________
   Graph on page 1.3

3. \( f(x) = 2 - 2x^2 \) \hspace{1cm} \( g(x) = \) ______________
   Graph on page 1.4

4. Make a conjecture about the graph of a functions inverse in relation to the line \( y = x \).
Appendix G

Quizzes and Tests for Advanced Algebra

Advanced Algebra
Quiz 6-1 (Lessons 6.1 - 6.3) – PART A
TO BE COMPLETED USING THE TI-NSPIRE

Name ______________________

These questions are to be answered on the TI-Nspire™ graphing calculator.

Step 1 – Download the TNS file (Quiz 6-1A.tns)
Step 2 – Open the file and enter your name on page 1.1.
Step 3 – Record your answers directly on the worksheet noted for each question.
Step 4 – Save the file.
Step 5 – When you are done, upload your file to Mr. Fugleberg’s computer.

1. Use the Calculator on page 1.2 to answer the following. According to figures from 1990, the population of China is 1,203,097,268. The land mass of China is 3,696,100 square miles. If the land mass of China is divided evenly amongst the population, how many square miles of land per person is there?

2. On page 1.3 to state the left and right behaviors of the graph of 
   \( f(x) = -x^3 + 7x + 4 \).

3. Graph this function on page 1.4. 
   \( f(x) = -x^3 + 7x + 4 \).

4. On page 1.5, tell me if this is a polynomial function. If it is, state its degree and leading coefficient. 
   \( f(x) = 2x^3 - 2x^2 + 3 \).

5. On page 1.6, graph both of the following functions. 
   \( f(x) = x^3 \)  
   \( f(x) = -x^3 \).

6. Referring to the graphs on page 1.6, use page 1.7 to explain how the sign of the leading coefficient affects the behavior of a polynomial function’s graph as \( x \to \pm \infty \).
### Advanced Algebra
Quiz 6-1 (Lessons 6.1 - 6.3) – **PART B**
**NO CALCULATOR ALLOWED**

Name ______________________

<table>
<thead>
<tr>
<th>Simplify:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ( (xy^3)^5 )</td>
<td>5. Using scientific notation, add: ((7.3 \times 10^2) + (6.4 \times 10^4))</td>
</tr>
<tr>
<td>2. ( \frac{6x^2 \cdot y^{-2}x^3}{y^3 \cdot 9x^2} )</td>
<td>6. Perform the indicated operations. ((2x + 5) - (3x^2 + 7x - 5))</td>
</tr>
</tbody>
</table>

3. Use synthetic substitution to evaluate \( f(c) = 9c^3 - 2c^2 + 5c - 7 \) when \( c = 2 \).

4. Using scientific notation, multiply: \((3 \times 10^5) (5 \times 10^{-4})\)

7. Add: \((6f^5 + 8f^3 - 8) + (5f^5 - 3f + 8)\)

8. Multiply: \((x - 3)(x^2 + 2x + 4)\)
9. Perform the indicated operations.
\[(x + 4)(x - 2)(2x + 3)\]

**Extra Credit**

(+1)
The sides of a rectangle have lengths \(x + 9\) and widths \(x - 5\). What is the equation for perimeter, \(P\), of the rectangle in terms of \(x\)?

10. Subtract:
\[(x^2 + 2x - 5) - (-7x^2 - 3x - 4)\]

(+1)
What is the equation for area, \(A\), of the rectangle in terms of \(x\)?
These questions are to be answered on the TI-Nspire™ graphing calculator.

Step 1 – Download the TNS file (Quiz 6-2A.tns)
Step 2 – Open the file and enter your name on page 1.1.
Step 3 – Record your answers directly on the worksheet noted for each question.
Step 4 – Save the file.
Step 5 – When you are done, upload your file to Mr. Fugleberg’s computer.

1. Use the graph on page 1.2 to find the real zeros of the function:
y = 4x^3 - 12x^2 - x + 15

2. Graph the following function on page 1.4:
f(x) = 3x^4 - 5x^2 + 2x + 1

Type your answers on page 1.3.

On page 1.5 identify the:
x-intercepts
local minimums
local maximums

EXTRA CREDIT
(+ 1)
You are designing an open box to be made of a piece of cardboard that is 18 inches by 18 inches. The box will be formed by cutting and folding up the sides so that the flaps are square. You want the box to have the greatest volume possible.

Use the graph on page 1.6 to help you answer the question. On page 1.7, tell me how many inches you should cut from each side and the maximum volume.

(+ ½)
On page 1.7, tell me the dimensions of the box you have created.
1. Factor: \(9y^2 - 25\)

2. Factor completely.
\(x^4 - 13x^2 + 36\)

3. Factor completely.
\(2x^3 - 3x^2 + 4x - 6\)

4. Divide by using long division:
\((-6x^3 - 2x^2 + 2x - 5) ÷ (2x + 2)\)

5. Divide using synthetic division:
\((4x^4 - 12x^3 - 48x - 59) ÷ (x - 4)\)

6. Find all the zeros of the function:
\(f(x) = -5(-x + 1)(-5x + 4)\)
7. A rectangle has an area of 
\((x^3 + x^2 - 10x + 8)\) square meters 
and a width of \((x + 4)\). 
Find its length.

8. Find all the zeros of the function: 
\(f(x) = x^3 + 72 - 5x^2 - 18x\)

9. Decide whether the given x-value 
is a zero of the function. Show your work. \(x = -2\)

\(f(x) = x^4 + 5x^3 + 5x^2 - 5x - 6\)
Advanced Algebra
TEST on Chapter 6 – PART A
TO BE COMPLETED USING THE TI-NSPIRE

Name ______________________

These questions are to be answered on the TI-Nspire™ graphing calculator.

Step 1 – Download the TNS file (Test 6.tns)
Step 2 – Open the file and enter your name on page 1.1.
Step 3 – Record your answers directly on the worksheet noted for each question.
Step 4 – Save the file.
Step 5 – When you are done, upload your file to Mr. Fugleberg’s computer.

1. Graph the following on page 1.1.
   \[ f(x) = x^4 - x^2 + 3x - 7 \]
   On the Notes page (1.2) state if this is a polynomial function. If it is, state its degree, type, and leading coefficients.

2. Graph the following on page 1.3.
   State the left and right behaviors of the graph.
   \[ f(x) = 3x^3 - x^2 + 4 \]

3. Graph the following on page 1.4.
   One zero of the function is \( x = -3 \), find the other zeros of the function. Note these points on the graph.
   \[ f(x) = x^4 - 2x^3 - 7x^2 - 8x + 12 \]

4. Create a page to find the zeros of the function
   \[ f(x) = x^3 - 7x + 6 \]
Advanced Algebra
TEST on Chapter 6 – PART B
NO CALCULATOR ALLOWED

Name ______________________

Simplify:

1. \( \left( \frac{c^1}{d^2} \right)^7 \)

2. \( (-2s^3t^4u)^2 \)

3. Solve for \( x \).
   \( (3^3)(3^x)(3^{x-1}) = 3^{12} \)

4. Evaluate the polynomial when \( w = 3 \)
   \( 3w^2 + 5w^2 + 2w + 5 \)

5. Evaluate:
   \( (4b^4 - 7b^3 - 3) + (9b^4 - 3b - 2) \)

6. Evaluate:
   \( (3x + 7) - (5x^2 - 6x + 2) \)

7. Write in standard form:
   \( (x + 1)(2x - 1)(x + 3) \)

8. Factor completely:
   \( 4x^3 - 8x^2 - 12x \)
9. Solve: \( x^2 - 6x = 0 \)

10. Divide using synthetic division:
\[
\left( 2x^4 - 6x^3 - 24x - 28 \right) \div (x - 4)
\]

11. Divide using long division:
\[
\left( 6x^4 + 20x^2 - 4 \right) \div (x^2 + 3)
\]

12. Find all zeros of the function:
\[
f(x) = x^4 + 2x^3 - 7x^2 - 8x + 12
\]

13. Write a polynomial function that has the zeros 2, -3, and 1.
1. Rewrite the expression using rational exponent notation.
   \((\sqrt[3]{16})^5\)

2. Rewrite the expression using radical notation.
   \(\sqrt[5]{7^2}\)

3. Simplify the expression.
   \(\frac{5}{3^3} \cdot 3^3\)

4. Simplify the expression.
   \(\frac{\sqrt[3]{4}}{\sqrt[3]{32}}\)

5. Write the expression in simplest form.
   \(\sqrt[5]{21}\)

6. Let \(f(x) = x^2 - 5x + 8\) and \(g(x) = x^2 - 4\). Perform the indicated operation and state the domain.
   a) \(f(x) + g(x)\)
   b) \(f(x) + f(x)\)
7. Let \( f(x) = 10x \) and \( g(x) = x + 4 \).
Perform the indicated operation and state the domain.

a) \( f(g(x)) \)

b) \( f(f(x)) \)

8. Find an equation for the inverse relation.
\[
y = \frac{1}{2}x + 6
\]

9. Verify that \( f \) and \( g \) are inverse functions. **You MUST show your work.**
\[
f(x) = 3x^3 + 1
\]
\[
g(x) = \left( \frac{x-1}{3} \right)^{\frac{1}{3}}
\]

10. Find the inverse power function.
\[
f(x) = 10x^3
\]

Extra Credit (+ \( \frac{1}{2} \))

Name two countries that border Iran. (there are seven)
Advanced Algebra
Quiz 7-2 (Lessons 7.5 to 7.8)
NO CALCULATOR ALLOWED

Name ______________________

Graph:

1. \( f(x) = \sqrt{x} - 5 \)
   
   [A]
   
   [B]
   
   [C]
   
   [D]

2. \( f(x) = \frac{1}{2}\sqrt{x-3} - 2 \)
   
   [A]
   
   [B]
   
   [C]
   
   [D]
Solve the equation. Check for extraneous solutions.

3. \[ \sqrt[3]{x - 5} = -4 \]

4. \[ (3x - 8)^{1/2} = 5 \]

5. \[ \sqrt{2y - 7} = 11 \]

6. \[ 3x^{\frac{3}{4}} = 192 \]

7. \[ \sqrt[3]{5x + 3} - \sqrt[4]{4x} = 0 \]

8. \[ (x - 1)^{\frac{1}{3}} + 2 = 0 \]

9. \[ \frac{1}{x^3} - \frac{2}{5} = 0 \]

10. \[ \sqrt[3]{x + 40} = -5 \]
11. Find the median of the set of numbers.

13, 22, 26, 4, 33, 3, 21, 18, 34

12. Mike was in charge of collecting contributions for the Food Bank. He received contributions of $70, $100, $30, $70, $60. The next potential contributor wanted to give an amount in line with the other contributions so he asked, “What is an acceptable amount to give?”

Find the following:
mean (average)
median
mode
range

13. Find the mode of the set of data.

10, 18, 19, 13, 18, 19, 10, 13, 19, 12

14. The test scores for the 27 members of the Advanced Math class are represented in the histogram below. How many students had scores between 90 and 109?
Advanced Algebra
TEST on Chapter 7 – PART A
TO BE COMPLETED USING THE TI-Nspire

Name ______________________

These questions are to be answered on the TI-Nspire graphing calculator.

Step 1 – Download the TNS file (*Test 7.tns*)
Step 2 – Open the file and enter your name on page 1.1.
Step 3 – Record your answers directly on the worksheet noted for each question.
Step 4 – Save the file.
Step 5 – When you are done, upload your file to Mr. Fugleberg’s computer.

1. Find the inverse of the following function:
   \[ f(x) = 5x + 3 \]
   \[ f^{-1}(x) = \]
   On page 1.2, graph both the function and its inverse.

2. Graph the following on page 1.3.
   \[ f(x) = \sqrt{x-5} - 3 \]
   How do you obtain a graph of this function from the parent graph \( y = \sqrt{x} \)?

3. Graph the following on page 1.4.
   \[ f(x) = \sqrt[3]{x+2} + 5 \]

   How do you obtain a graph of this function from the parent graph \( y = \sqrt[3]{x} \)?

4. Using the spreadsheet on page 1.5, find the mean, median, range and standard deviation of the following data:
   \[ 33, 15, 26, 10, 37, 48, 39, 40, 39, 23, 37, 14, 26, 51 \]
   \[ \sigma \]
   \[ \bar{x} \]
   \[ \text{median} \]
   \[ \text{range} \]
Advanced Algebra

TEST on Chapter 7 – PART B

NO CALCULATOR ALLOWED

Name ______________________

(6) 1. Simplify the expression.

\[
\left( \frac{1}{4^5} \right)^{\frac{1}{4^5}} - 10
\]

Let \( f(x) = 1 - x^3 \) and \( g(x) = 1 + x^2 \).

Perform the indicated operation and state the domain.

(6) 5. \( f(x) + g(x) \)

Domain –

(6) 2. Rewrite the expression using radical notation.

\[
\frac{4}{7^9}
\]

(6) 6. \( g(x) - f(x) \)

Domain –

(6) 3. Simplify the expression.

\[
\frac{4}{8^3}
\]

(6) 7. \( f(x) \cdot g(x) \)

Domain –

(6) 4. Simplify the expression.

\[
\left( \frac{\sqrt[3]{25}}{\sqrt[5]{15}} \right)^{3/5}
\]

(6) 8. \( \frac{f(x)}{g(x)} \)

Domain –
9. Find an equation for the inverse relation.
\[ y = 4x^2 - 5 \]

10. For the function \( f(x) = 1 + \sqrt{x+3} \), what is the domain of \( f(x) \)?

11. Solve the equation. Check for extraneous solutions.
\[ \sqrt{x + 56} = x \]

12. Solve the equation. Check for extraneous solutions.
\[ \sqrt[3]{x-5} = -4 \]

13. Solve the equation. Check for extraneous solutions.
\[ 3\sqrt[3]{x} = 192 \]
Appendix H

Third Quarter Advanced Algebra Average Scores

<table>
<thead>
<tr>
<th>Quiz / Test</th>
<th>Total Points</th>
<th>Class Average</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quiz 6-1 - calc</td>
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<td>Overall Average as a Percentage</td>
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<td></td>
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Appendix I

Student Questionnaire

The purpose of this questionnaire is to help me understand how you feel about using the TI-Nspire™ graphing calculator during our lessons this past quarter. Using the code below, check the box that describes how much you agree with each statement. Respond to each statement as honestly as possible. Check only one box for each statement.

SD – Strongly Disagree  D – Disagree  N – No opinion  A – Agree  SA – Strongly Agree

1. Using the TI-Nspire™ in math class was much better than using a regular calculator.
2. It was easy for me to learn how to use the TI-Nspire™.
3. I was much more interested in the lesson when we used the TI-Nspire™ calculator.
4. Using the TI-Nspire™ helped me better understand the math taught in class.
5. When I use the TI-Nspire™ I am more confident that my answers are correct.
6. I liked math class better when I was able to use the TI-Nspire™ calculator.
7. I always used the TI-Nspire™ calculator to check my answers.
8. Did you like using the TI-Nspire calculator to learn math?
9. Using the TI-Nspire™ helped me learn the material.

Did using the TI-Nspire™ calculator make you feel more comfortable with the lesson being taught? Why or why not?

Was the TI-Nspire™ calculator easy to use for the calculations and graphing? Why or why not?

How did you use the TI-Nspire calculator when completing your homework? (e.g., only as required, to check your work)
Appendix J

Interview Guide

Use of technology / Use of calculators in the classroom
(the primary question is not indented, the follow-up questions are italicized)

Interview With Students

– What do you think of when someone says they “teach using technology?”
  → Expand on the various types of technology they mention (e.g., how does the ActivBoard help with the instructing?)

– Would you say that I teach using technology?
  For a Yes answer:
  → What types of technology are used?
  → How is technology used in your math classroom?
  → Did use of technology help engage you in the lesson being taught?
  For a No answer:
  → Why do you think I don’t use technology?

– What do you believe are some benefits of teaching using technology?
  → Does it make some lessons easier to understand? Is it more engaging?

– What do you believe are some of the problems associated with teaching with technology?

– How do you feel that calculators should be used in the math classroom?
  No calculators – What about the fact that calculators are easily available in your everyday life? (e.g., ipod touch, cell phone)
  Calculators OK – Should they be allowed for everything or are there some questions which shouldn’t allow the use of calculators? (e.g., plug a problem into a calculator and take what comes out, saying a number is rational because the calculator decimal stops, using a calculator for 12 + 23)

– Do you feel you have a Low, Medium, or High level of expertise with using a graphing calculator?
  → For what calculator models do you feel you have the noted level of expertise? Explain.
– What is your opinion on the use of graphing calculators in teaching high school juniors and seniors?
  **Should not** be used – Why not?
  **Should** be used – *If the student has familiarity with another type of graphing calculator, ask their preference between that calculator and the TI-Nspire.* Why?

– Did using the TI-Nspire™ make you more engaged in the lesson (e.g., actively participating in the learning process)? If **yes**, *how did it do this?*