

THE MOTIVATIONAL EFFECTS OF A GPS MAPPING PROJECT
ON STUDENT ATTITUDES TOWARD MATHEMATICS
AND MATHEMATICAL ACHIEVEMENT

by

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ABSTRACT

The purpose of this study was to investigate how student attitudes and mathematical achievement would be affected by a mathematics-based GPS mapping project. The participants were 75 ninth-grade students taking algebra 1A. These students were freshmen at a small, rural 9-12 high school located in the southeast. Two different methods for assessing attitudes were used, and one method for measuring mathematical achievement was used. The Attitudes Toward Mathematics Inventory (ATMI) is a 40-item mathematics attitude survey that was administered to the entire study population in both a pre-treatment and post-treatment format. A GPS Attitude Survey was administered to the treatment group at the end of the study. The mathematics diagnostics portion of the New Century Education system was used for the entire population in a pretest/posttest format. The treatment consisted of GPS mapping activities that incorporated solving algebra problems with the relatively new sport of geocaching. The students had to solve correctly the equations that would provide the latitude and longitude of their next clue for completing the activity. The quantitative data were analyzed using a three-way ANOVA for the surveys and an ANCOVA for the NCE mathematics diagnostic test. Results indicated that there was a small gain for the ATMI and the NCE mathematics diagnostics test by the control group. In addition, information gained with informal interaction with the students indicated that most of them enjoyed doing GPS activities to the point that they did not consider themselves to be “doing math.” Based upon the formal and informal assessments of this study, it is suggested that students would benefit by the incorporation of more mathematics-based GPS mapping activities into the curriculum.

CHAPTER I

INTRODUCTION

Although the study of mathematics and its practical applications have been a mainstay and priority of American schools, confirmed by its inclusion in the standard curriculum, the twentieth century's modern technology catalyzed and necessitated the federal government's periodic revisiting of our educational standards. For example, the application of modern technology, which enabled the former U.S.S.R. to launch Sputnik I, the first earth-orbiting satellite, prompted a major revamping of the American school curriculum. This transformation was commenced when Congress, in 1958, passed the *National Defense Education Act* (NDEA, Public Law 85-864, 72 Stat. 1580). Signed by then-President Dwight D. Eisenhower, this law was intended to stimulate advances in science, mathematics, and foreign languages achievement. During the Reagan Administration, U.S. Secretary of Education Terrence Bell (1981-1985) formed the National Commission on Education to assess the condition of the education in the United States. In April 1983, the findings were released as *A Nation at Risk: The Imperative for Educational Reform* (National Commission on Education, 1983), which stressed, among other things, the importance of mathematics education for a technologically vital citizenry.

In 1989, President George H.W. Bush hosted an educational summit to which each governor in the country was invited. The focus of his summit was the establishment of national education goals, the outcome of which was published as the *National Education Goals Report, Building a Nation of Learners 1999* (National Education Goals Panel, 1999). Once again, apprehension was expressed regarding students' achievement levels in mathematics. The fundamental imperative to increase those achievement levels continued

to be communicated. In attendance at the 1989 summit was then-Governor Bill Clinton who, as President approximately a decade later, signed *Goals 2000* (1994) into law.

More recently, President George W. Bush supported the *No Child Left Behind Act of 2001* (NCLB, Public Law 107-110, 115 Stat. 1425), which was signed into law on January 8, 2002. The expressed purpose of NCLB was “to close the achievement gap with accountability, flexibility, and choice, so that no child is left behind.” NCLB represents the federal government’s effort to achieve a variety of educational mandates, including grade-level reading attainment by every student in the United States by the year 2014. Other mandates support improvements in mathematics and science education through actions such as recruiting science, mathematics, and engineering candidates into the teaching profession with stipends, signing bonuses, performance incentives, and advanced education scholarships. NCLB also recognizes the need to encourage women and minorities to enter the fields of mathematics, science, and engineering.

Ultimately, these educational reforms are oriented toward maintaining U.S. hegemony in the world rather than the study of mathematics, science, or engineering for study’s sake (American Competitiveness Initiative, 2006). The study of mathematics and its applications are just a means to a greater end, i.e., super power status. Metaphorically speaking, attaining a goal is achieved when a path to it is followed, and, in this scenario, the path is paved, in part, with the study of mathematics.

Unfortunately, this path also is full of obstacles, which may be inherent in the implementation of current national mandates, e.g., standardized testing. It is possible that America must rethink those mandates that purport to rebuild her mathematics foundation. A comparison of test scores achieved by the nation’s fourth- and eighth-graders using the

National Assessment of Education Progress (NAEP) (a NCLB testing component) revealed no significant improvement in mathematics between the two groups. Results from the NAEP test revealed no significant narrowing of the achievement gaps that exist among ethnic groups and/or among socioeconomic levels (Fuller, Wright, Gesicki, & Kang, 2007; Lee, 2006).

A lack of significant improvement in mathematics achievement by eighth-graders since the fourth grade indicates a fundamental problem that may have its origins in the prevalence of negative attitudes held by students toward the study of mathematics. At present, students who are educated in the United States do not rank among the top five positions internationally in mathematics. Although students may agree to the importance of the study of mathematics, many do not pursue additional and/or advanced mathematics courses. According to Public Agenda (2007), students and parents indicated that secondary education higher mathematics courses were important to a student's overall education, but should be emphasized only for those students entering advanced mathematics fields.

To complicate this issue, race and socioeconomic factors appear to contribute to students' attitudes toward mathematics. Again, both lower socioeconomic and minority populations acknowledged the importance of mathematics for success in life. However, this acknowledgment does not translate into greater numbers of minorities studying mathematics beyond the level required for graduation (Acherman-Chor, Aladro, & Gupta, 2003; Gilroy, 2002).

The use of technology in the study of mathematics has progressed significantly from the mathematics drills of the 1980s and 1990s (see Handal & Herrington, 2003).

Early computer software programs were constructed as basic drill-and-practice functions that informed students whether their responses were correct or incorrect. Today's computer programs are specialized and more sophisticated. Tutorial programs conduct complex computations and can assist students with a systematic guide for solving a problem. Other programs are intended to reinforce student learning. These programs incorporate games and simulations as a means of making tasks enjoyable while obliging the student to use acquired knowledge to solve problems.

Diagnostic software programs, such as those produced by the New Century Education Corporation (see <http://www.ncecorp.com>), can assess a student's current level of mathematics achievement. A teacher can use such diagnostic software to prescribe a course of study for the student to assist her or him with the mastery of certain mathematics skills. These research-based software packages allow teachers to individualize instruction, which facilitates their abilities to help every student attain those skills.

In addition to formally recognized mathematics aids, there are technological devices that can assist students with honing their mathematics skills because their use requires some basic knowledge of mathematical concepts or functions. One of those devices is a Global Positioning System unit (GPS). A variety of activities can be designed with a GPS that integrate the unit's use with mathematics-based components. The purpose of this study is to use a GPS unit to conduct educational activities that require the application of mathematical skills for their successful completion.

Statement of the Problem

The subjects of mathematics and science are emphasized throughout the entire U.S. schooling experience. They are essential components of this country's successful global

market competitiveness. This research focuses upon students' perceptions of the importance of the acquisition of mathematics skills relative to their day-to-day applications. To express their general disinterest, students often indicate that they are not mathematically competent. They often attribute mathematical competence to some innate capacity with which a student is born, not taught (Ma, 2003).

Given this perspective, a student may not appreciate "real world" applications of most of his or her school subjects. Specifically, other than the four basic functions of mathematics—addition, subtraction, multiplication, and division—many students do not perceive the relevance of higher mathematics to daily life. In fact, few have the foresight to realize the advantages of being proficient in mathematics and the concomitant earning power that it generates (Simpkins, Davis-Kean, & Eccles, 2006).

As an example, the present dearth of American engineers has prompted the need to off-shore employment, i.e., the business practice of hiring overseas labor and/or intelligence to compensate for the shortage within the profession or labor field (Friedman, 2005). It is interesting to note that off shoring has had a direct impact on the numbers of foreign nationals enrolling in U.S. higher education institutions or being hired in the U.S. job market. In the not-too-distant past, foreign nationals were entering higher education institutions at the graduate level and the American job market in scientific, engineering, and mathematics fields at a higher rate than were U.S. citizens (Frauenheim, 2004). In the field of mathematics, the majority of foreign nationals came to the United States from China or India to pursue a graduate education, receive a highly specialized degree, and enter the U.S. job market by which they could achieve a comparatively high standard of living. However, the gradual decrease in a highly technical local market due to off shoring has led to the

attrition of foreign talent. Foreign nationals are returning to their native countries where they can enjoy a relatively high standard of living while working at jobs that have moved from the American market to their respective countries (Frauenheim, 2004). The United States may be unable to rely upon foreign nationals for their technical expertise as it has in the past; at the same time, the U.S. is not cultivating technical expertise among its citizens. The irony of this situation is that the resentment expressed toward foreign nationals for usurping American jobs on American soil is countered by the fact that foreigners filled the technical expertise void created by Americans. Now, the jobs have moved off shore, the number of foreign nationals is declining, and the United States still lags in the number of technical experts it is producing (Frauenheim, 2004).

According to Felder (2006), the practice of off shoring promoted instructional complacency among U.S. engineering faculty who were content to continue teaching in a very traditional manner. However, the new breed of engineers, just like the new breed of mathematicians, must be highly educated and skilled as well as creative and flexible to adapt to the changing world milieu. Today's students must be instilled with these qualities. Our engineering schools and our graduate programs must concentrate on educating the left brain as well as focusing on the attributes of the right brain. If greater numbers of students become proficient in mathematical skills applications, then they can improve their employment opportunities, career outlook, and be a part of exciting economic changes as "American ingenuity" prevails.

Although the United States produces exceptionally prepared engineers and mathematicians, modern foreign universities are beginning to produce equally competent talent who will work for less pay. Restructuring U.S. education is contingent upon tandem

national strategies: (a) preparing an evolving labor force, which cannot be outsourced, because it comprises a supply of well-educated, intelligent, hard-working specialists whose talents and expertise are unmatched by those trained in other countries, and (b) launching innovative industries to employ those specialists whose educational training will fill the current voids in the fields of mathematics, science, and engineering (Colvin, 2005).

Purpose of the Study

The purpose of this study was to determine whether completing a mathematics-based GPS mapping activity would have an effect on students' achievement in and perceptions toward mathematics. In this study, using a GPS mapping activity functioned as a motivational device that would improve students' attitudes toward learning and help them appreciate the value of knowing how to use mathematics for practical applications.

Research Questions

Research Question 1: *Will a mathematics-based GPS mapping activity affect students' attitudes toward mathematics?*

Research Question 2: *Will there be a difference in attitudes toward mathematics between males and females?*

Research Question 3: *Will there be a difference in attitudes toward a mathematics-based GPS activity between males and females?*

Research Question 4: *What are the attitudes of students toward GPS mapping activities?*

Research Question 5: *Will a mathematics-based GPS mapping activity affect students' mathematics achievement as demonstrated by NCE Test scores?*

Significance of the Study

This study contributes to the professional knowledge base regarding students' attitudes toward a core subject and is significant for its introduction of a creative method for applying learned information. It demonstrates how the incorporation of a novel, recreational technology (i.e., a GPS unit), can improve students' attitudes toward learning mathematics. The information gleaned from this research supplements educators' repertoire of existing teaching techniques and methods and provides guidance for the development of activities that will improve students' attitudes toward the study of mathematics and its applications.

Other benefits may include greater student attentiveness and eagerness to learn mathematics skills. In addition, this study may promote an investigation of pedagogical methods relevancy vis-à-vis the development of alternate, more innovative methods for teaching certain subjects. This study may assist teachers, tutors, and administrators to identify and implement activities that contribute to the effective learning of mathematics and promote student interest in the subject, which should increase student achievement.

Because GPS technology has been applied only recently for recreational use among the general population, little research exists regarding its incorporation as an educational tool. This study may serve to assist other researchers with building upon the knowledge base that exists about the use of technological innovations in pedagogy. Finally, this study is significant to any educator who is seeking innovative approaches to teaching and learning.

Assumptions

The following assumptions were made about the participants of this study:

1. The participants have studied mathematics each year of their education.
2. The participants have mastered the four basic functions of mathematical operations (i.e., addition, subtraction, multiplication, and division), but may not be familiar with some advance mathematics concepts/functions.
3. The participants know how to use a GPS. This assumption was ascertained and met with their successful completion of pre-study activities incorporating the use of a GPS.
4. Most of the mathematics operations required for the GPS activities were skills that should have been taught to the students during their K-8 mathematics classes.
5. The participants would learn additional mathematics skills to which they were introduced during the pre-study GPS mapping activities. These skills would be mastered prior to the beginning of the treatment protocol.

Limitations

This study is limited by the number of participants of a convenient sample of 75 students that comprised approximately 17% of the total student population of one rural high school. Another possible limitation is the brevity of treatment, which was conducted during a 3-week period in a single school term. As such, it will be difficult to generalize from the findings.

Operational Definitions of Terms

For the purpose of this study, the following terms are defined operationally as follows:

Global Positioning System Unit (GPS): A hand-held device that receives triangulation data from satellites to display latitude and longitude information on its video screen.

Muggle: A term in geocaching that describes a non-geocacher, who might stumble upon a cache. This term is used especially to denote a person who has intent to do harm, such as moving or taking a geocache. The geocaching term muggle is borrowed from the Harry Potter books by A.K. Rowling, which refers to a non-magical person.

Off shoring: The practice of using overseas labor and/or intelligence to reduce business costs. Off shoring has been implemented throughout numerous industries, including those employing technology experts with backgrounds in such fields as the sciences, engineering, and mathematics.

Put-in/Take-out: A launch point or ending point for recreational boating, such as canoeing or kayaking. Put-ins and take-outs can be the same point depending upon the trip route. An example would be a river that had five allocated locations for recreational access. If a person was kayaking from the first location to the second, the first would be the put-in and the second would be the take out. If a person was kayaking from the second allocated location to the third, then the second location would be the put-in and the third would be the take out.

Waypoint: A reference point (i.e., a set of coordinates) in physical space that is used for the purpose of navigation. For the purposes of this study, the coordinates of the waypoint are longitude and latitude, which are saved in the GPS.

Organization of the Study

This study consists of five chapters. Chapter I includes an introduction to the study, the statement of the problem, and the purpose of this research. In addition, research questions are posed. The significance, assumptions, and limitations of the study are introduced. The operational definitions of terms also are included in Chapter I. Chapter II is a review of the professional literature pertinent to this study and two pre-studies completed by the researcher. Chapter III introduces some background understanding for the study as well as its research design and methodology. Chapter IV presents the analyses of the data and the results of the study. Chapter V discusses the findings and includes the conclusion as well as implications and recommendations for further study of this topic.

CHAPTER II

REVIEW OF THE LITERATURE

Basic Issues of Mathematics

Receiving a good education is viewed mostly as a means to an end. If one is well educated, then it is believed that he or she will get a high-paying job with benefits. Employment trends can be mapped to identify job markets that are saturated and those in which there are hiring opportunities. This information can guide the decisions of high school and university students as they choose their fields of study. One field currently reporting career opportunities is engineering. The majority of the population of American-born engineers in the U.S. is now middle aged (Friedman, 2005); therefore, students who graduated or will graduate with an engineering degree in the U.S. between 2007 and 2012, inclusive, can almost be assured of a high-paying job. However, for unknown reasons, American-born students are not making great strides in trying to gain admittance to university engineering programs. According to the American Competitiveness Initiative (2006), the basis for the lack of American-born engineering students rests firmly upon the subject of mathematics. Students in this country, for a variety of reasons, do not perform well in mathematics: Some of those reasons will be discussed.

The core subject of mathematics and the lack of achievement in the subject is an ongoing concern for teachers and administrators throughout the United States. In 2003, United States eighth-graders did not score in the top 10 countries that took the latest *Trends in International Mathematics and Science Study* (see <http://www.hoover.org>). In Baltimore, Maryland, the 2007 average SAT score in mathematics declined for the second year in a row and was below the national average (see <http://www.baltimoresun.com>). A

decline in mathematics scores in Michigan during the first part of the twenty-first century prompted the state to enact programs to improve mathematics scores. Their concern, diagnosis, and treatment appeared to work; the seventh-grade classes across the state showed marked improvement (Lewis, 2008).

Issues Affecting Mathematics Achievement

Ethnicity

There is evidence, in the form of test scores, of a gap in achievement as early as age 9 between minority (African-American and Hispanic) children and white children. Although at times this gap may lessen to some degree, it never closes (Balli & Alvarez, 2004). It was suggested that African-American children may be attending inferior schools in their primary years; therefore, building a foundation for a lack of success in later grades (Balli & Alvarez, 2004). The concern for student's developing a poor attitude toward mathematics is magnified in schools that have large minority population, particularly of a lower socioeconomic level (Horn, 2004).

Minority students' attitudes that can develop from initial low performance results are a detriment to their academic progress in mathematics. Whereas minority middle school-aged children indicate that they know they will need mathematics and science courses to do well in life, many do not continue to enroll in the advanced courses as they get older (Gilroy, 2002). It is suggested that many minority children also live in situations where they see a lack of success in their parents, even though their parents may work very hard. As the children get older they may begin to believe that a good education will not enable them to have a better life. There also may be unintentional racism from teachers as they challenge white students, but not minorities. Their intentions may be good as they

strive to help their students not to fall behind, but they may unconsciously think that minority children cannot “catch up.” The undercurrent is a perceived belief by students that they are incapable of being successful in mathematics (Gardner, 2007). However, evidence indicates that when adjustments were made to control for three classes of predictors of success or failure: (a) parent education, (b) exposure to quality academic opportunities, and (c) self-perceptions, ethnic difference accounted for only 5% of the variance in mathematics performance (Byrnes, 2003).

A lack of parity within higher education continues to exist with minorities striving for a college education at much lower percentages than majority students. A 2001 survey conducted by the National Science Foundation (NSF, 2004) revealed that only 30% of U.S. college graduates are from minority populations. As percentages of the total college student population, only 6% are Asian, 9% are African American, 8% are Hispanic, and 7% are Native American. The percentages of minorities that pursue advanced degrees are comparable to Caucasians, but due to sheer numbers, there is still inequality. Five percent of Caucasians receiving a master’s degree in science or engineering translates to 50,000 graduates. Five percent of African Americans receiving the same degree translates to only 6,117 persons (Jacobs & Simpkins, 2005).

A 2008 report released by the National Action Council for Minorities in Engineering (NACME, 2008) indicates that the gap between minorities (non-Asian) and whites is not lessening and in the case of African Americans, the gap is widening. According to the report, in 1995, 3.3% of bachelor’s degrees in engineering were awarded to African Americans. In 2005, only 2.5% of the bachelor’s degrees in engineering were

conferred upon African Americans. The NACME claims that many minority students are not being prepared for science, technology, engineering, and mathematics fields.

Socioeconomic Issues

There also are issues that include, yet transcend, race. The socioeconomic factors that influence a student's lack of success in mathematics can start before birth. Poor nourishment and prenatal care can affect the development of the fetus. Poor nourishment of a small child also can hamper both mental and physical development. Beyond this, parents in such situations may have to work more than one job or work shifts during the afternoon and evenings, limiting time with their children. In addition, the cultural opportunities for children of lower socioeconomic households may be limited and the values for such experiences by the parents may be low. All of these factors are ingredients in a recipe for school failure before the child begins kindergarten (Gardner, 2007).

Shaping Students' Attitudes

There are various aspects that make students different, such as gender, race, and socioeconomic levels. The common factor among all students is their attitude toward a subject and how a positive attitude can be encouraged. However, to foster a student's desire to learn, one must understand the scope of attitude. In addition, there is a complex issue of motivation that shapes a student's attitude about a subject. The students that high school teachers inherit started developing their motivational makeup when they first entered school as a small child, if not before (Tollefson, 2000).

One piece of the cognitive, motivational framework is the "expectancy of success" theory. This theory states that if a child believes that he or she can successfully complete a task, then the effort to do so will be expended. This effort is contingent upon the value

placed upon the reward. If the reward has little value, then the most capable student may not be interested in the task. If a student desires the reward but believes that regardless of his or her efforts the level of success needed would fall short of the acceptable minimum, then the student may not even attempt the task. The resulting attitude of the student for tasks of this type would become negative (Tollefson, 2000).

In schoolwork, the reward would be a good grade. In addition, especially in the primary grades, it may be gold stars or extra play time. The grades bring praise from parents, and the gold stars begin to establish social status. The reward method can have adverse actions. A kindergarten student may be capable of completing an assignment and is quite confident in his or her abilities, but does not like gold stars; therefore, he or she does not do the assignment. In another instance, a student may desire the reward of extra playtime, but does not think he or she can finish a task in the time allotted to be granted the extra time outside. The result will again be a lack of effort (Tollefson, 2000).

A second cognitive motivational theory is known as “self-efficacy” theory. This theory is based upon the idea that students will mentally inventory accomplishments and failures to set goals or make decisions concerning future endeavors. A student’s beliefs about his or her personal abilities comprise the sense of self-efficacy (Tollefson, 2000). If a student believes that certain course work is beyond his or her abilities, then the work will be avoided. In the high school setting, this would be reflected in certain courses being either selected or not selected. In addition, this theory also encompasses the premise that students establish their individual goals, which eventually become personal standards. They evaluate themselves by those standards (Tollefson, 2000). Some students avoid negative personal feelings by setting standards that they can achieve easily.

A student with high self-efficacy will attempt difficult tasks with the belief that a certain course of action (i.e., hard work and study) will achieve success. A student with low self-efficacy will exert little effort and surrender easily because he or she knows the task will be too hard (Tollefson, 2000).

Part of self-efficacy theory is goal orientation. Students encounter two broadly based types of goals: performance goals and learning goals. Performance goals are most often evaluated by others while learning goals represent a personal, self-evaluation. Students with high self-efficacy will try harder tasks, even if failure is encountered. Students with a low self-efficacy will perceive failure simply as a lack of ability and most likely withdraw from the task (Tollefson, 2000). However, a student can have several different performance goals. A student may be a leader in playground sports, demonstrating high self-efficacy, but may surrender easily when challenged by the study of mathematics.

Students who have low performance goals can have high learning goals because failure can be viewed as an opportunity to learn rather than as an effort to be judged. The students who can successfully incorporate learning goals can find this to be a safer avenue by which to attain achievement. In addition, an increased effort as part of a learning goal can lead to an improved performance standard of a student and a resulting positive attitude for the task (Legault, Green-Demers, & Pelletier, 2006).

Another cognitive theory of motivation is the effort or “attribution” theory. Young students will attribute ability to effort. The harder one works, the greater that person’s ability. The older a student becomes, the more this philosophy will be modified. Once a student determines that natural abilities are not equal among all students, he or she will

begin to modify efforts toward tasks that match his or her self-efficacy level. Students who have developed a strong self-efficacy will continue to attribute success to a work ethic (Tollefson, 2000). A student at this level may have begun to modify difficult tasks because he or she does not want to expend the effort or time that successful completion of the task would require. This student may make the cognitive decision that he or she wishes to be engaged in another activity; one that may be as equally demanding as the one that was bypassed. A student with a low self-efficacy will contribute success or failure with the ability he or she perceives is innate (Tollefson, 2000).

A highly successful summer mathematics program in Harlem in the early 1990s incorporated a one-on-one approach to teaching mathematics to challenged students. Engineering students from Columbia University and the State University of New York participated to improve the mathematics skills of inner-city students. The emphasis focused upon improving students' attitudes toward their mathematics abilities rather than improving mathematics skills. This program was an effort to help less-advantaged students with advanced high school mathematics, which could prepare them for a career in the engineering field. The feedback from the initial summer program was that most of the students' mathematics skills improved because they proved to themselves that they were capable of "doing" mathematics (McGourty & Lopez, 2000).

In another instance, a calculus program in Claremont, California was conducted for Hispanic students who performed poorly in mathematics (Drew, 1998). In the facilitator's opinion, the two factors that changed students' performance from poor to highly capable were teaching them new study patterns and treating them like the "winners they could be, not like helpless losers" (p. 17).

Solutions for Poor Performance in Mathematics

There are ample data demonstrating that many American students perform poorly in mathematics (Dechter, 2007; Garelick, 2006; Lewis, 2008). There are ample reasons for the poor performance, including gender, ethnicity, socioeconomic situations, as well as cognitive theories of motivation. These reasons range from students not exerting effort because they (a) do not desire the rewards offered or (b) know that even their best efforts will not achieve success. In essence, they have developed a negative attitude about their abilities in mathematics (Tollefson, 2000).

The research literature includes articles about mathematics being “less boring” or “more interesting” (Drew, 1998). The majority of these articles were written by teachers about their approaches to teaching the subject. Although none presented details about methodologies, a consistent theme was student attitudes rather than student ability. The advice proposed in one summary article was, “Livelier, more positive teaching has a greater effect on improving pupil’s motivation to learn mathematics than grouping by sex or ability” (“Boring maths,” 1997, p. 29).

In an effort to improve student attitudes toward mathematics, educators are willing to incorporate new ideas that spark students’ motivation to study and to improve their mathematics skills regardless of race, gender, or socioeconomic factors. Various techniques such as contests and games have been employed to make learning fun. Research indicates that using games does have a positive impact on students’ learning, especially mathematics (Randel, Morris, Wetzel, & Whitehill, 1992).

Technology has been used as an aid to help students with the acquisition of mathematics skills. With the use of computers and individualized, computerized lessons,

student achievement can be easily monitored and analyzed. A student who is having difficulty in mathematics can receive additional practice on the level of his or her needs. The extra practice fosters better understanding and higher achievement. It yields better self-esteem and, therefore, a more positive student attitude toward mathematics (Tankersley, 1993).

The notion that mathematical skills are innate is detrimental to developing positive attitudes toward studying mathematics. It negates the fact that mathematical skills are learned and can be improved. In addition, many students believe that learning higher levels of mathematics has little relevance to either daily living or career goals. Many students believe that most of the mathematics operations they are taught other than the basic four functions—addition, subtraction, multiplication, and division—will never be used beyond the classroom in which they are being taught. They see no practical applications of algebra or geometry (Neale, 1969; Public Agenda, 2007).

Gender and Mathematics Achievement

It is, perhaps, the notion that gender determines mathematical abilities, which has caused the greatest debate on the subject. The role of gender in has been examined at the college level and in the work force: mathematics-based college majors and careers such as engineering and computer programming continue to be dominated by males.

According to the National Science Foundation (NSF, 2004), a 2001 survey revealed that approximately 32% or one-third of all male and female college graduates earned a degree in science or engineering. However, only 28% of all female graduates earned degrees in these fields compared to 36% of all male graduates. As education levels increased, the percentages of both men and women seeking advanced degrees in science

and engineering fields *decreased*. Among all graduates pursuing a master's degree, only 16% were enrolled in a science or engineering program. Among all females pursuing a master's degree, only 6% were enrolled in a science or engineering program. For all males enrolled in master's degree programs, 10% were pursuing science or engineering degrees. The percentages decline further at the doctoral level. Only 1% of all females working toward a doctoral degree is enrolled in a science or engineering program, and only 3% of all males working toward a doctorate are enrolled in a science or engineering program. These percentages demonstrate that the numbers of students pursuing degrees in the sciences and engineering are low, in general, and that females continue to be underrepresented (Jacobs & Simpkins, 2005).

Women's underrepresentation does not appear to be reversing. Women continue to choose care-centered rather than scientific careers, a preference exemplified by the following: At Cornell University, women comprised 88% of the School of Veterinary Medicine's 2006 graduating class, but only 26% of the doctoral graduates in engineering. As of 2004, women held fewer than 18% of the doctorates in the field of engineering (Maines, 2007).

The emerging information is that many women, for a variety of speculated reasons, simply choose not to pursue mathematics-based careers. One theory is that women have more life choices than men and choosing not to enter a highly competitive field allows career choices juxtaposed with being a wife and mother (Lupart, Cannon, & Telfer, 2004). Another theory suggests that many mathematics-based jobs are solitary. This apparently is appealing for men, whereas women prefer situations requiring collaboration.

An analysis of the gender gap at the secondary school level reveals that, generally speaking, girls were believed to be unable to perform as well as boys in mathematics. There has been evidence that there is a gulf between girls and boys not only in mathematics achievement, but in attitudes, with boys having higher achievement scores and more positive attitudes about mathematics than girls do (Tocci & Engelhard, 1991). However, this belief is beginning to be dissected to understand why it persists. In a more recent study, there is conflicting information concerning females and success in mathematics. Although girls tend to produce better in-class mathematics grades than boys do, they do not perform as well as boys do on achievement tests. Possible reasons for this discrepancy include how girls approach their schoolwork and have less disruptive classroom behaviors, and parents' differing expectations for girls and boys (Kenney-Benson, Pomerantz, Ryan, & Patrick, 2006).

There is supporting information that maintains that the difference between males and females' decisions to pursue mathematics-based opportunities is not ability-related, but attitude-based (Lupart et al., 2004). These attitudes form during the secondary level of their education and influence their career paths. Females indicate a preference for careers that there are English, languages, arts, or health related. Males indicate an interest in pursuing science-based careers. This would include mathematics and computer programming (Lupart et al., 2004).

The reasons cited for gender differences in mathematics were part of an interesting academic volley that has occurred during the past three decades among a few prominent as well as some lesser-known researchers. Research has documented differences between boys and girls for more than a quarter of a century. Fennema (1974) reviewed much of the

extant work on the topic. In subsequent research (Fennema, 1993), she concluded that her hypothesis for the difference in mathematics achievement between boys and girls was due to a preconceived notion that

turned me into an active feminist, compelling me to recognize the bias that existed toward females, which was exemplified by the recognition and acceptance by the mathematics education community at large of gender differences in mathematics as legitimate. (<http://www.woodrow.org/teachers/math/gender/02fennema.html>)

Fennema and her colleague Julia Sherman conducted several studies sponsored by the National Science Foundation in the late 1970s that addressed male and female achievement in mathematics and participation, especially in advanced mathematics courses. This research, known as the Fennema-Sherman studies, used Likert-type rating scales to measure the attitudes of students toward mathematics. Representative general and gender-specific statements included, for example, “I am sure that I can learn math,” and “Males are not naturally better than females in math.” Student responses revealed a deficit of females pursuing upper-level high school mathematics courses, which led Fennema and Sherman to hypothesize that if more girls could be encouraged to study the advanced mathematics courses then the difference in achievement levels between genders would disappear. This hypothesis was labeled by Fennema and Sherman as the differential course-taking hypothesis.

The supposition made by Fennema and Sherman was refuted by Julian Stanley and Camilla Benbow (Stanley & Benbow, 1980) who studied approximately 1,000 junior high school students during an 8-year period. They concluded from their studies that their results demonstrated repeatedly that gender differences in mathematics were genetic:

We favor the hypothesis that sex differences in achievement in and attitude toward mathematics result from superior male mathematical ability, which may in turn be related to greater male spatial tasks. This male superiority is probably an expression of a combination of both endogenous and exogenous variables. We recognize, however, that our data are consistent with numerous alternative hypotheses. Nonetheless, the hypothesis of differential course-taking was not supported. . . . putting one's faith in boy-versus-girl socialization processes as the only permissible explanation of the sex difference in mathematics is premature. (p. 1264)

However, while in junior high school, both girls and boys are enrolled in the same level mathematics courses; therefore, the research of Stanley and Benbow would be moot relative to the Fennema-Sherman hypothesis.

The Stanley and Benbow (1980) study was reported in *Time*, a consumer news magazine, and quoted Benbow, who suggested that many women “can't bring themselves to accept sexual difference in aptitude, but the difference in math is a fact. The best way to help girls is to accept it and go from there” (p. 2).

Stanley and Benbow were chastised by Jacobs and Eccles (1985) for an incomplete and misconstrued presentation of findings in the *Time* article. Jacobs and Eccles criticized researchers who seek publicity by reporting research through the popular press. Jacobs and Eccles's article appeared in scholarly press; therefore, their refutation of Stanley and Benbow's work was not as widely read and the damage remained!

More recent data suggest that Fennema and Sherman's original hypothesis of gender stereotyping is proving to be true. In the three decades since Fennema first published her literature review, women have been encouraged to pursue a number of fields

that were once considered the purview of men. In addition, standardized tests are showing comparable scores for both genders. There continue to be mathematics-based fields that are underrepresented by females such as engineering and physics. Reasons cited for this by Eccles (see Cavanagh, 2008) could be that women still view those fields as male-dominated or unsuited to personal interests such as starting a family. It is yet to be determined how quickly the gender gap will close.

Technology in Mathematics

Technologies of various types have been used with mathematics since 300 B.C. with the invention of the Salamis tablet. The Chinese “Suan-pan” abacus, which is the abacus that is commonly known today, first appeared in China approximately 1200 A.D. (Fernandez, 2004). The slide rule was invented in the late seventeenth century and was used for complex mathematics by most people in the mathematics and science fields until almost the twenty-first century (Hicks, 2007).

The four-function calculator made its appearance in the consumer market about 1972. Texas Instruments was a leading company in the development of hand-held calculators. Their TI-2500 model, their first consumer product, was introduced in September of 1972 with a suggested price of \$119.95. By 1978, their TI-50 “slide rule” scientific calculator was able to perform 60 mathematical and statistical functions and sold for \$35.00. The use of calculators is now so common place that there is debate as to when students should be allowed to use them. The prevailing attitude is that students should master basic mathematics skills and concepts and use calculators for tedious computations, which would allow them to spend more time understanding the problems (Starr, 2002).

During the past decade, computer technology has entered the mathematics classroom. As computers become abundant, as hardware and software become better, and as teachers become more comfortable using technology, there is a desire to be creative with it in the classroom. Podcasts are being used to bring mathematics lessons off the page. Students also are able to assume a leadership role in learning by helping create podcasts. In addition, there are open source programs available for producing podcasts that remove cost barriers to being creative (Herman & Lugo, 2007). These audio and video reinforcements and annotations add instructional value that does not exist on the basic, flat page. Audio and animations allow students to review the instruction as often as needed to understand the concepts being introduced (Roberts, Kelley, & Sanders, 2007).

Teachers are becoming creative by using various software packages that help students understand concepts. The use of the Excel application and baseball statistics to teach a statistical concept helped to drive instruction by engaging students in an activity that was real, practical, and interesting. By combining a familiar topic with a program that could easily handle large quantities of data (e.g., Excel), the advanced topics of the Central Limit Theorem and Multiple Regression were more easily taught by the teacher and understood by the students (Kovac, Sparks, & Teixeira, 2007).

Three commercial “intelligent” mathematics programs for understanding basic mathematics are MathXpert, Math Professor, and xyAlgebra. All three offer step-by-step guidance for solving problems rather than requiring a student to guess a correct answer from multiple-choice options. In this regard, students receive an individualized instruction that fosters greater success and overcomes frustration from simple feedback (i.e., right or wrong), which promotes blind guessing until a correct answer is achieved (Miller, 2007).

Teachers also are beginning to use other manipulatives, such as GPS units, as a creative way to add dimension to learning. For example, the added dimension of knowing latitudes and longitudes assists students with comprehending distances and areas (Kuhl, 2002). GPSs also can incorporate advanced mathematics by calculating the circumference of the globe, thereby double-checking Ptolemy's mathematics (Royster, 2002).

The Use of GPS Devices

The use of Global Positioning System (GPS) devices for recreational purposes is steadily increasing in popularity as outdoors enthusiasts find them helpful for a variety of activities. Hunters can mark favorite shooting spots. Fishermen can mark the areas on a lake where they have had luck with big catches. Hikers can leave a marked trail without worrying about becoming helplessly lost (Letham, 2003).

There is a GPS sport that is gaining in worldwide popularity called "geocaching." The most common form of this game involves hiding caches in a public area such as a park or river bank. The cache can consist of several small items such as toys, paperback books, markers, or any other thing that the geocacher can fit into a waterproof container. The container could be a Tupperware box, ammunition box, or any other container that can keep the contents dry. A small note pad also is included. The latitude and longitude coordinates of the geocache are posted on a geocaching website such as <http://www.geocaching.com/>. Geocachers can obtain the coordinates from the website and seek the hidden cache. The person who finds the cache removes an item from the box and replaces it with another item. He or she signs and dates the note pad. The final step is for the find to be entered on the geocaching website.

Farmers are finding more uses that are practical for a GPS; it is helpful in estimating seed and water needs for expanses of land. Although not as accurate as a surveyor's measurement, the GPS is quite accurate for acreage estimates. Farmers can calculate the measurements without the expense of a surveyor (Carlson & Clay, 2007).

It is possible for technologically savvy individuals to design maps and load them onto a recreational GPS. These maps can show details of a town, or even a temporary venue such as Burning Man, a festival held in the Black Rock Desert of Nevada every September. Although these same maps can be produced on paper, the GPS version places the individual IN the map as it is being navigated. Once the map below is loaded in the GPS, the individual using the device on this venue will appear as an arrow. As the person walks, the arrow will point in the direction of motion.

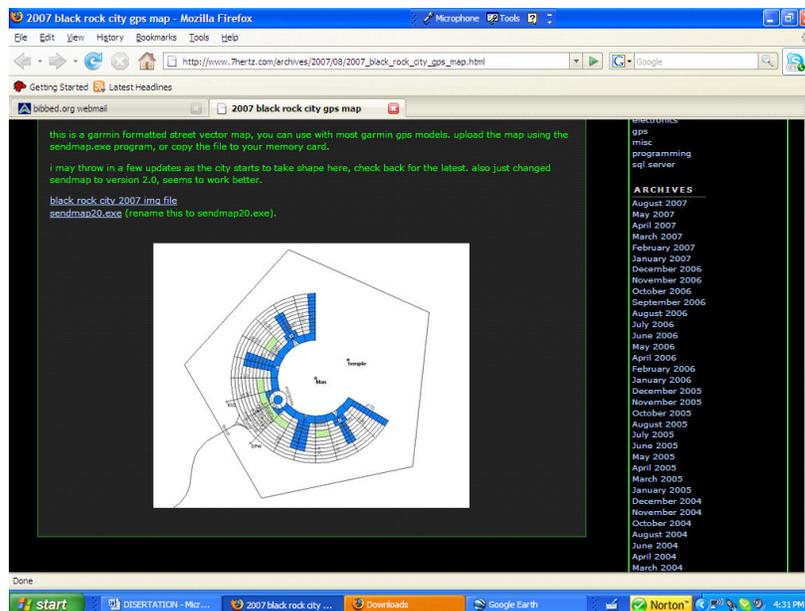


Figure 1. A GPS downloadable map of Burning Man venue in the Black Rock Desert of Nevada.

Reprinted from http://www.7hertz.com/archives/2007/08/2007_black_rock_city_gps_map.html.

Both the recreational and practical uses of GPS devices continue to increase as more people are introduced to their use. Introducing them into the classroom is a logical step in integrating devices that students will probably use in their everyday lives. Using these devices as a motivational teaching tool is a way to fully engage students in school subjects that they often find difficult or boring.

Using a GPS as a Motivational Device to Improve Student Attitudes

The unifying thread in the literature is that mathematics is being taught mostly as theory rather than as a “hands on” tool with practical applications. Although computers have been used with success in aiding student learners, it is suggested that teaching with computers removes students from contact with the real world (Broda & Baxter, 2003). However, with the advancement of technology, there is now an increasing number of devices that are used in recreational activities. One such device is a Global Positioning System Unit, or GPS. This device is used to pinpoint locations based upon longitude and latitude coordinates. The GPS receives satellite signals upon which the coordinates are based. This device also is being used in classrooms throughout the country as an aid to teach various subjects. With a GPS, students can collect various data about locations throughout the world. In their own community, data can be collected, analyzed, and conclusions drawn. One such example may include marking the location of points of interest in the community and comparing them with the area’s population density. In addition, this activity, which requires higher-order thinking skills, demonstrates how mathematics can be used in “real life” (Broda & Baxter, 2003). As students become comfortable with the use of the device, they can discover other uses and activities for it such as construction, surveying and map making, search and rescue, city planning, and

even hunting and fishing (Royster, 2003). Many of these vocations and avocations do not require advanced mathematics or a college degree. However, they do require a competency in good fundamental mathematics. Activities such as these change mathematics from solely being theoretical to being a tool they must be able to use to complete the task.

Because GPS devices are so new for the civilian population, no major research has been located that examined their impact on student learning. However, schools throughout the county are using GPS devices as learning and motivational aids in mathematics, science, and social studies. Articles touting their use are appearing in educational journals. The educational website THINKFINITY.org has numerous lesson plans that incorporate the use of a GPS. Many of these activities include mapping, which in turn, integrates mathematics. In addition, because the devices are small and easy to use, students master them quickly. Several researchers have determined that student attitudes are positive when conducting projects that make use of a GPS (Berrett, 2005; Broda & Baxter, 2003; Schlatter & Hurd, 2005).

By completing various GPS activities that have been designed to incorporate mathematics, it was hoped that students would be motivated to thoroughly embrace using mathematical skills. It was the goal of this study that such motivation would cross gender, ethnic, and socioeconomic boundaries. The intent was to engage students in an enjoyable activity requiring mathematics skills to improve their attitudes toward learning mathematics, to increase their skills acquisition, and to prompt them to realize that good mathematicians are made, not born.

Previous Studies by Researcher

Study 1: Student Attitudes toward the Use of a GPS as an Aid in Learning Mathematics

Buck and Rice (2006) completed a study that involved using GPS devices to map areas around the same school being used for the current study. One class of 21 junior and senior high school students taking an algebra connections course served as the subjects for the study. The purpose was to survey students' attitudes about using a GPS to solve mathematics problems. Students completed the mapping activity and were administered an attitude survey. A Cronbach's alpha was conducted and the survey reliability of .952 suggested that the survey measured potentially unified constructs. In addition, an item-to-total correlation showed only three low items: item 6 with a correlation of .251, item 18 with a correlation of .394, and item 16 with a correlation of .398. The instrument and items for this initial study are in Appendix C.

After running a factor analysis and reviewing the results it was decided that three factors had the best fit. A varimax rotation was used in an effort to push the vectors as far apart as possible. A simple structure was obtained with three factors. The average loading factor was about .66, with the highest loading being .925 and the lowest being .39. The three categories that defined these factors were (a) "Like using GPS for learning math," (b) "Like math and is confident in personal math abilities," and (c) "Like GPS enhanced activities." In addition, with only three factors, 75% of the variance could still be explained. This suggests that 75% of the theoretical constructs established can be found in this result. The results of the study indicated that students' attitudes toward the use of a GPS as a classroom teaching aid were mostly positive. In addition, the level of cooperation from the students suggests that a GPS can be a useful tool as an aid in learning various

mathematics procedures and concepts. This project proved to be worthwhile as evidenced by student feedback and data.

Study 2: Student Attitudes toward the Use of a GPS as an Aid in Learning Mathematics

This second study (Buck, 2006) followed the same philosophy of using a GPS to learn mathematics as the first study, but the main activity was different. A group of 22 students, grades 9-12, enrolled in a business technology essentials course participated in mapping various features of a section of the Cahaba River that is just beyond the geographical limits of a town in a southeastern state. Various mathematics skills were used by the students to determine the distance between points.

The same attitude survey from the previous year's activity was administered and the results analyzed. A Cronbach's alpha was conducted with the survey reliability being .875. This is a relatively high result suggesting that the survey is measuring potentially unified constructs. An item-to-total correlation was conducted and revealed only three significantly low items: item 16 with a correlation of .041, item 6 with a correlation of .063, and item 3 with a correlation of .082. The instrument and items for this second study are in Appendix C.

After running a factor analysis and reviewing the results, it was decided that three factors had the best fit. A varimax rotation was used in an effort to push the vectors as far apart as possible. A simple structure was obtained with three factors. The average loading factor was about .59, with the highest loading being .797 and the lowest being .381. The three categories that defined these factors were (a) "Like using GPS for learning math," (b) "Like math and is confident in personal math abilities," and (c) "Like GPS enhanced

activities.” In addition, with only three factors, 75% of the variance could still be explained. This suggests that 75% of the theoretical constructs established can be found in this result.

This instrument was administered twice. Both used small populations, but the results from the attitude survey in both cases showed an overall positive feedback by the students. The treatment and the attitude instrument should be administered additional times prior to any decision to drop items that are low, but not extremely low.

Summary

A review of the literature reveals one aspect upon which most sources appear to agree. There are too few students in the United States achieving in mathematics at the high-school level and pursuing mathematics-based fields, such as engineering as college majors. There are different agencies that are working hard to help provide both encouragement and financial college support to minorities to increase their numbers as enrollees in and graduates of engineering programs. *No Child Left Behind of 2001* represents the national educational movement that helps improve student performance in all areas of education and emphasizes mathematics. Educators throughout the country are trying various tactics to encourage student engagement and understanding of mathematics to provide a capable pool of applicants for the mathematics-based job market.

CHAPTER III

RESEARCH METHODOLOGY

Introduction

This chapter provides a description of the quantitative research design and procedures employed for the study. The purpose of this study was to determine if completing GPS mapping activities would affect students' attitudes toward mathematics and/or bolster their mathematics achievement. The researcher intended to convey to students the importance of understanding the practical applicability of mathematics through those activities. The fact that they were recreational served to encourage students to recognize that mathematics, indeed, does have practical applications. This recognition can be a catalyzing force that (a) shifts attitudes about mathematics from negative to positive, (b) reinforces the perception (and reality) that mathematics skills are necessary and attainable, and (c) encourages students to generalize the problem-solving applicability of mathematics to other subjects.

In addition, the researcher was interested in examining students' attitudes toward mathematics as well as their attitudes toward applying mathematical functions/operations to analyze data as they performed activities using a GPS. These activities, which were conducted on the school campus, consisted of several types of puzzle-based geocaches.

Data were gathered from responses to two different surveys, the Attitudes Toward Mathematics Inventory (ATMI) and the GPS Attitude Survey, as well as pre- and posttest scores from two administrations of the NCE Test.

Understanding Latitude and Longitude

A basic understanding of longitude and latitude is important for the successful use of a GPS unit. The earth is divided into invisible coordinates. The lines that extend from pole to pole are longitude lines, and the lines that parallel the equator are latitude lines. The area between these lines is designated as 15° apart. These 15° intervals add to equal 360° or a complete circle. Latitude lines remain parallel from the equator to the poles. The distance between latitude lines is 1,035.75 miles and the distance of 1° is 69.05 miles. Although 15° also is the designation between longitude lines, the distance of 1,035.75 miles per 15° or 69.05 miles per 1° exists only at the equator and decreases to zero miles at the poles.

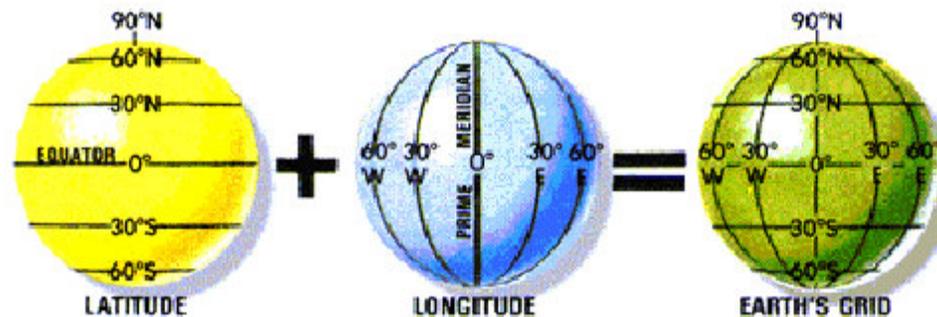


Figure 2. Graphic description of latitudinal and longitudinal lines.

Longitude lines extend from pole to pole. The measurements for longitude begin at zero in the town of Greenwich, England, also known as the Prime Meridian. As one progresses west from Greenwich the designations increase to 180° west to the International Date Line. As one progresses east from Greenwich, the designations increase to 180° east to the International Date Line.

Latitude lines are parallel to the equator. The measurements for latitude begin at zero at the equator. As one progresses north from the equator the designations increase to 180° north at the North Pole. As one progresses south from the equator the designations increase to 180° south at the South Pole. Below are diagrams of latitude and longitude descriptions.

Latitude and longitude can be measured in three different formats, with all three formats listing the latitude designation first, followed by the longitude. One format is designated as hemisphere degrees, minutes, seconds. The next format is hemisphere degrees, minutes. The third format is hemisphere degrees. Below is a sample of all three formats for the exact same location; which is, in this case, the researcher's home.

1. Hemisphere degrees, minutes, seconds	33° 07' 03" N	87° 07' 02" W
2. Hemisphere degrees, minutes	33° 07' 043" N	87° 07' 02" W
3. Hemisphere degrees	33 11.735° N	87 11.718° W

The format of degrees, minutes, seconds yields an easy continuation of further exact breakdown in distances. As noted, there are 1,035.75 miles per 15° or 69.05 miles per 1°. One minute of distance is 69.05 miles divided by 60, or 1.15 miles. One second of distance is 1.15 miles divided by 60 or .019 miles. This converts to 100 feet and 3.5 inches. If the area of land in which an activity occurs is less than a mile in any one direction, such as a school campus, the units for degrees and minutes will not change. The only changes in latitude and longitude will be in the second designation. The nature of the activity will dictate the format used for latitude and longitude.

Setting of the Study

This study was conducted in a small rural high school (grades 9-12) located in a southeastern state. During the 2008-2009 school year, the average daily membership of the student population for the first 40 days was 444. Of this total, the freshman class consisted of 75 white males, 57 white females, 11 black males, 5 black females, 1 Hispanic male, and 1 Hispanic female. The tenth grade consisted of 42 white males, 34 white females, 8 black males, 7 black females, 1 Hispanic male, and 2 Asian males. There were 43 white males, 45 white females, 9 black males, 3 black females, 1 Hispanic male, and 1 American Indian female enrolled in the eleventh grade. There were 42 white males, 41 white females, 4 black males, 3 black females, 1 Hispanic male, and 1 Hispanic female enrolled as seniors.

According to 2007 population estimates, there were 1,419 persons (79.7% white and 19.5% black) living in the town in which the school is located. The estimated average household income of the town in 2006 was \$31,300 compared to the state's average household income of \$38,783. The average value of a home in town was \$56,300 compared to the state average home value of \$97,500. The neighboring town also populated the high school. The 2005 population for that town was 986, 98.1% of whom were white, 1.6% were of "two or more races," and .8% were American Indian. The average income was \$41,200, and the average house value was \$103,400.

According to the 2000 U.S. Census, the percentage of local citizens with only a high school diploma or equivalent is 39.5. The state and national percentages are 30.4 and 28.6, respectively. The percentage of local citizens with some college experience or an associate's degree is 24.1 compared to 25.9% of the state's population and 27.4% of the nation's population. The percentage of local citizens that hold a bachelor's degree is 1.4

compared to 12.2% statewide and 15.5% nationally. The percentage of local citizens with a master's, professional, or doctoral degree is 2.6 compared to 6.9% of the population of the state, and 8.9% of the U.S. population (City-Data.com, 2008).

Participants

The participants of this study were first-time ninth-graders enrolled in one of three different classes of algebra 1A. (Appendix A contains the institutional, parent, and student consent forms for this study.) The class taught during the first scheduling block comprised 32 students: 16 males and 16 females. The class taught during the third scheduling block had an enrollment of 31 students: 12 males and 19 females. The class taught during the fourth scheduling block totaled 12 male students. The second scheduling block was used by the teacher as a planning period.

Students of the first- and fourth-block classes were assigned to the treatment protocol (experimental group); students of the third-block class were designated as the control group. All students in all of the classes successfully completed pre-algebra when they were enrolled in middle school.

The teaching methods employed in these algebra 1A classes were categorized as “very traditional.” The classes were very structured and the teacher's (Mr. Allen, pseudonym) classroom management was excellent. Mr. Allen teaches the state's course of study for algebra 1A (Appendix B), which is aligned with his textbook. His teaching is based upon the traditional method of review, presentation of new material, and practice. Mr. Allen begins each class period daily by reviewing material from the previous day followed by the introduction of new material. The students use any remaining time to perform homework tasks and/or solve practice problems. Mr. Allen does not use

manipulatives with his lessons. The white board is the only tool he uses to demonstrate problems. At times, students are asked to work problems on the white board as well.

All participants have used computers since they attended kindergarten. Some have had access to home computers prior to their kindergarten enrollment. In addition, many participants play video games on a regular basis. Elaborate cell phones, mp3 players, sophisticated video games, and TV remotes have been a part of their tactile vocabulary for much of their adolescence. A few of the students indicated that they had used a GPS previously, but most of them had not. Because these students have been raised with a variety of technologies, they were able to learn the basics of a GPS relatively quickly.

Activity Procedures

Prior to participating in any of the GPS mapping activities, the three classes were administered a mathematics attitude survey. The identical survey was administered to the students in the three classes after the treatment protocol ended. The responses to the pre- and post-treatment administrations of this survey were examined for any significant attitude shifts between students assigned to the control group receiving no treatment protocol and students who participated in the group that did. Responses were examined to compare the attitudes of males and females. A copy of this survey is included in Appendix C and will be discussed in more detail under the Instrumentation section of this chapter.

Students enrolled in the three classes were presented with a brief lecture that described a GPS and its capabilities. A brief discussion of how mariners from earlier times, e.g., Christopher Columbus, navigated the seas. The white board and a small globe were used to demonstrate basic concepts of latitude and longitude, including the pinpointing of an exact location by crossing a latitude point with a longitude point. The

class was given a demonstration on the basic workings of a GPS that included turning the unit on and off, determining when the unit locked onto a sufficient number of satellites to navigate, and how to cycle through the five basic screens of the device. Students were taught how to navigate, via the arrow buttons, to the screen that displays the latitude and longitude information. The GPS units used to teach the students were the small recreational devices that outdoor enthusiasts use, not the more elaborate systems used in automobiles. Each of the three classes was taken outdoors, and Garmin Gecko 201 GPS devices were distributed among the students. A set of 28 Garmin Gecko 201s was recently purchased by the school system's technology department so that all teachers in the county would have access to that technology. In addition, three Garmin Gecko 201s that belonged to the computer applications department were available for use. Because all of the GPS devices were the same brand and model, no extra time had to be taken to teach the students how to use each type of GPS. Because there were ample units, each student had his or her own GPS for the outdoor mapping activities.

Four outdoor GPS mapping activities were planned. They were conducted during the 3-week period between the Thanksgiving and the Christmas holiday breaks. This time frame was selected by the researcher to avert the potential end-of-term doldrums experienced by students. Although these activities can be useful throughout the term, they, perhaps, can be an especially refreshing way of teaching or reviewing material as a term's end draws near. The weather in the study's locale is typically mild in December. Wearing a mid-weight jacket, at the most, is necessary for outdoor comfort. The region's climate makes an outdoor activity possible at the end of the fall and spring school terms.

The first of the four mapping activities was in the style of geocaching. Students self-selected to make groups of three students each for this and all other activities. If necessary, a group could consist of four students. Students solved algebra problems to identify coordinates that would lead them to geocaches. There were three clues leading to four locations for each team. The first two locations represented additional problems requiring solutions. The fourth location was a small prize consisting of candy for each team. In addition to being given their first clue, which could be solved in the classroom, each student was provided a map of the campus. The map was marked with various waypoints such as the corners of the main school building. The waypoints served to orient students in the general direction of the coordinates for their solved problems. The researcher was available to assist with any problems/concerns any students might have had.

The second GPS mapping activity involved calculating the areas of triangles. Students were given a three-sheet assignment. The first sheet listed specific campus sites for which they were to find the coordinates, e.g., home plate on the softball field. Once they completed that sheet, they plotted those points on their second worksheet, which was a map of the campus. The third worksheet instructed the students to find the area of certain distances, such as the distance of the triangle that is formed by the front door of the school, the side door of the new gymnasium, and the left field post on the baseball field.

The third GPS mapping activity began with students receiving a grid map of the campus. Then, the students solved algebra problems to identify an ordered pair. They plotted their responses onto their maps. Then, they used their maps to find the marked place on campus. The first problem-based clue was given to each group. Three more

problem-based clues followed that the students had to find and solve in order. The fourth location was a prize consisting of candy for the group.

The fourth and final GPS mapping activity consisted of a combination of the first three activities. Students had to solve algebra problems to identify three locations on campus. These three locations were permanent fixtures, such as a football goal post. These locations were sequential with each clue leading to the next clue. The third cache instructed each team to plot the three locations on their map and find the area of the triangle that it formed. That number then became an ordered pair that they graphed. This clue led them to their final clue, which instructed them to return to the classroom. This exercise focused upon speed as well as accuracy. The team that finished first had choice of the prizes, which consisted of “fun size” candy bars. The first-place team chose the kind of candy and received 3 pieces per group member. The immediate runner-ups chose 2 pieces of candy each. The next group received one piece of candy each per student. The team that finished last received candy but had to take what was remaining.

The problems that had to be worked for the mapping activities were variations of the items the students had on their 9-week “mid-term” examination. Because the activities were presented almost nine weeks after that examination, students should have demonstrated proficiency solving the problems. The goal of these activities was to foster student success by completing previously learned tasks (rather than mastering new material) while applying them in a newly presented three-dimensional setting. If students were well-versed in the use of a GPS, then reinforcing new material in a “real world” setting would have been an ideal method of demonstrating why they need mathematics for everyday applications.

Although the problems on their “mid-semester” examination represented a variety of topics covered during the first nine weeks of school, the types of items used with the mapping activities were only a fraction of what was tested. The reason rests in the nature of the activities. For the designed activities, all answers had to be whole numbers, either positive or negative. This eliminated any answer that was a fraction or included a letter. The problems also had to be doable in a mobile setting with only a clipboard as a desktop. However, the problems incorporated into the mapping activities were still representative of the algebra skills required of a first-semester freshman. The GPS mapping activities problems are presented in Appendix D.

Instrumentation

Three different instruments were used in this study. The first was the NCE Test:

New Century Education provides schools across the country with technology-based core curriculum instruction to help students of all ages. Our Integrated Instructional System software incorporates a structured approach to individualized learning, and its assessment, curriculum and management capabilities are the product of our rich educational publishing experience and original research in learning behavior. New Century Education has been engaged in academic and educational publishing since 1825, tracing its corporate roots to Appleton-Century-Crofts, the *Century Dictionary*, and the *New Century Encyclopedia*. Forty years of experience as a private provider of individualized instruction and volumes of research have refined New Century’s approach to be most effective for students while also providing the features that teachers and administrators need.

The New Century Instructional System software provides a comprehensive curriculum in reading/language arts, writing and mathematics. Through adaptive assessment, multimedia tutorial lessons and continuous monitoring of individual progress, the program assures that each student is learning level-appropriate content and progressing to mastery of state and national standards. In addition, New Century offers test preparation programs to help students master the content tested on specific state proficiency exams. Results documented by client schools confirm the effectiveness of the program in contributing to meaningful and sustained growth in achievement in elementary, middle and high schools as well as in community-based, alternative and adult education programs.

Currently, New Century software helps schools to achieve their mandated progress goals for all students. New Century Education offers educators a complete program solution including software installation, technical support, training and staff development. Headquartered in Piscataway, New Jersey, the company has a national network of support personnel dedicated to on-site service delivery. (http://www.ncecorp.com/about_us1.htm)

Students in the middle school and high school are administered the NCE Test at the (a) beginning of the school year, (b) end of the first semester or beginning of the second semester, and (c) end of the school year to monitor student grade-level progress in mathematics. Administration of the NCE Test is part of the school-wide plan to meet the Annual Yearly Progress (AYP) requirements as outlined in *No Child Left Behind of 2001*.

The second instrument from which data were collected is a mathematics attitudes survey, Attitudes Toward Mathematics Inventory (ATMI, see Tapia & Marsh, 2004, 2005).

This survey uses a 5-point, Likert-type rating scale. Students were asked to rank their respective levels of agreement with statements using any one of the five potential responses: A = Strongly Disagree, B = Disagree, C = Neutral, D = Agree, and E = Strongly Agree. This unpublished survey was developed initially in 1996 as a 49-item instrument by Dr. Martha Tapia, a professor at Berry College in Rome, Georgia to gauge six categories of students' attitudes toward mathematics. After statistical analyses, it was determined that deleting 9 items increased the Cronbach's alpha statistical measure from .96 to .97. The original instrument was modified to include 40 items that gauged four categories of attitudes toward mathematics and its applications: Self-Confidence, Value, Enjoyment, and Motivation. The mean and standard deviation of the total score for the survey were 169.74 and 32.06. The standard error of measurement was 6.07. No additional changes have been made to the ATMI since the first revision.

The third instrument used in this study, the GPS Attitude Survey, was designed by the researcher to measure students' attitudes toward using mathematics to complete a GPS mapping activity. Students were asked to rank their levels of agreement with statements using a 5-point Likert-type scale as follows: 1 = Strongly Disagree, 2 = Somewhat Disagree, 3 = No Opinion, 4 = Somewhat Agree, and 5 = Strongly Agree.

The GPS Attitude Survey was modified from a survey administered previously by the researcher for other studies. The original instrument included two specific sections: the first addressed students' attitudes toward mathematics; the second surveyed students' attitudes toward conducting a mathematics-based GPS mapping activity. An additional question asked respondents if their parents were "good at math." The instrument was modified to focus solely upon students' attitudes toward applying mathematics skills to

complete a GPS mapping activity thereby eliminating the potential for confounding students' ATMI responses, which indicated their attitudes toward mathematics. The results of the revised survey are discussed in Chapter IV.

Research Questions

Research Question 1: *Will a mathematics-based GPS mapping activity affect students' attitudes toward mathematics?*

Research Question 2: *Will there be a difference in attitudes toward mathematics between males and females?*

Research Question 3: *Will there be a difference in attitudes toward a mathematics-based GPS activity between males and females?*

Research Question 4: *What are the attitudes of students toward GPS mapping activities?*

Research Question 5: *Will a mathematics-based GPS mapping activity affect students' mathematics achievement as demonstrated by NCE Test scores?*

Data Collection

The data collected for this study consisted of NCE Test pre- and posttest scores, Attitudes Toward Mathematics Inventory (ATMI) pre- and post-treatment responses, and GPS Attitude Survey responses. NCE Test scores achieved by students assigned to the treatment protocol were compared to the scores achieved by the students assigned to the control group. The total differences in group means achieved by the control group and the treatment group were analyzed by group assignment and by gender. The NCE Test that served as the pretest was administered to the rising freshmen (eighth-graders) in May 2008. The NCE Test that served as the posttest was the midyear administration, which was

conducted in January 2009. Test administration dates are determined by scheduling feasibility, not by academic reasons. Whereas this reasoning may not be perceived as academically sound, it addressed the reality of a high school environment. However, there was no basis for believing that a difference in testing scores or performance would result from an end of first-term to beginning of second-term administration.

The Attitudes Toward Mathematics Inventory (ATMI) was administered as a pre-treatment assessment to each of the algebra 1A students during their respective class block periods the week that they returned to school from the Thanksgiving holiday break. It was re-administered as a post-treatment assessment to the total sample population shortly after students returned to school from the Christmas holiday break. In both cases, the only personal information gathered was student gender and class block period.

The researcher-developed GPS Attitude Survey was administered at the end of the treatment protocol, which coincided with the final week of the school semester (i.e., a few days prior to the Christmas holiday break). It was administered by the researcher during students' respective algebra 1A class block periods. Each student received a paper copy of the survey on which he or she was asked to identify him- or herself by gender only. The survey was intended to be anonymous; therefore, no names were written on the form.

Data Analyses

Students' pre- and posttest scores on the NCE Test were analyzed and compared using *t* tests. Scores from both administrations (May 2008 and January 2009) of the NCE Test achieved by students assigned to the treatment protocol were compared. A similar comparison was conducted for the scores achieved by students assigned to the control

group. The January 2009 scores achieved by the students assigned to the treatment protocol were compared to the January 2009 scores achieved by the control group students.

Factor analyses using a varimax rotation were applied to the results of the Attitudes Toward Mathematics Inventory (ATMI). This methodology was used in an effort to push the vectors as far apart as possible to obtain discrete factors. In previous applications of the ATMI, a simple structure was obtained with three factors. This outcome was expected for this application. No gender information was collected during the past two applications of the ATMI; however, for this study, it was. As such, a layer of interest was added to the research. Consequently, a chi-square was conducted to analyze the effect of that variable.

CHAPTER IV

RESULTS

Introduction

The purpose of this study was to determine if the participation in and completion of a mathematics-based GPS mapping activity would affect students' achievement in and perceptions toward mathematics. The mathematics-based GPS mapping activity served as a motivational tool that might encourage students to realize the importance of acquiring mathematics skills. Data were gathered to assess students' (a) attitudes toward mathematics and (b) grade-level progress toward the acquisition of those skills. Two different attitude surveys, the Attitudes Toward Mathematics Inventory (ATMI) and the GPS Attitude Survey, were administered. The former measured students' attitudes toward mathematics, and the latter measured their attitudes toward using a mathematics-based GPS mapping activity. Students' scores from a pretest and posttest administration of the NCE Test were analyzed.

Demographic Results

According to the first 40-day principal's attendance report, the total student population of the school was 442 pupils, grades 9 through 12. Of the 91 students in the twelfth grade, 46 (51%) were boys and 45 (49%) were girls. Of the 103 students in the junior class, 55 (53%) were boys and 48 (47%) were girls. The sophomore class contained 93 students: 54 (58%) boys and 39 (42%) girls. The freshman class represented the greatest number of students belonging to a grade level. Of the 154 freshmen, 98 (64%) were boys and 56 (37%) were girls.

The two attitude surveys (ATMI and GPS Attitude Survey) and the NCE Test were administered to a convenient sample of three (3) ninth-grade algebra 1A classes. Each of the students enrolled in these classes was a first-time ninth-grader who had successfully completed a pre-algebra course while enrolled in middle school. Aside from being convenient, this sample was selected to assess attitudes toward and interest in mathematics of incoming freshmen. The population of these three algebra 1A classes was 75 students, which represented 17 % of the total student population.

The algebra class taught during the first scheduling block comprised 32 students or 43% of the sample population and approximately 7% of the school population. There were 16 males and 16 females in this class. The third-block class consisted of 31 students (12 males; 19 females) or 41% of the sample population and approximately 7% of the school population. The class taught during the fourth scheduling block had an enrollment of 12 males. This number accounted for 16% of the sample population and 3% of the school population. The second scheduling block was used by the algebra teacher for planning. The students in the first- and fourth-block classes were assigned to the treatment protocol (experimental) group and the students in the third-block class were designated as the control group.

The Attitudes Toward Mathematics Inventory (ATMI) was administered to those students who had agreed to participate in the study and who were present on the day of the scheduled administration. The pre-treatment ATMI was administered the week that students returned to school from the Thanksgiving holiday break and prior to the treatment protocol. The post-treatment ATMI was administered the week that students returned to school from the Christmas holiday break. Of the 28 boys assigned to the treatment group,

17 (61%) responded to the pre-treatment ATMI and 21 (75%) responded to the post-treatment ATMI. Of the 12 boys who were assigned to the control group, 11 (92%) completed the pre-treatment ATMI and 10 (83%) completed the post-treatment ATMI. Of the total sample population of 40 boys, 28 (70%) took the pre-treatment ATMI and 31 (78%) took the post-treatment ATMI.

Of the 16 girls assigned to the treatment group, 15 (94%) responded to the pre-treatment ATMI and 14 (62%) responded to the post-treatment ATMI. Of the 19 girls assigned to the control group, 13 (68%) responded to the pre-treatment ATMI and 14 (74%) responded to the post-treatment ATMI. Of the total sample population of 35 girls, 28 (80%) responded to the pre-treatment ATMI and 28 (80%) responded to the post-treatment ATMI (see Table 1).

Table 1

Numbers and Percentage of ATMI Respondents by Gender and Group Assignment

Group Assignment	Total <i>n</i>	Participants	
		Pre-Treatment (%)	Post-Treatment (%)
Males			
Treatment	28	17 (61)	21 (75)
Control	12	11 (92)	10 (83)
Total	40	28 (70)	31 (78)
Females			
Treatment	16	15 (94)	14 (86)
Control	19	13 (68)	14 (74)
Total	35	28 (80)	28 (80)

The reasons why only some students responded to the post-treatment ATMI have not been ascertained. It is possible that some of the participants were absent the day that the ATMI was administered. It also is possible that some of the students who had been willing participants changed their minds about participating. Because participation was voluntary and students' identities were anonymous, there was no way to know who did not participate. To assure respondent anonymity, the researcher removed herself from the testing site (classroom) after distributing the surveys. Completed surveys were returned to the researcher later that day.

The GPS Attitude Survey was administered to each student who (a) was assigned to the treatment protocol, (b) agreed to respond to the survey, and (c) was present the day of its administration. The GPS Attitude Survey was administered on the day that the final mathematics-based GPS mapping activity was completed, i.e., three days prior to the Christmas holiday recess. Of the 28 boys assigned to the treatment protocol, 22 (79%) responded to this survey. Eight (50%) of the 16 girls assigned to the treatment protocol responded (see Table 2). When students reported to the designated location to receive their geocaching prizes that same day, they were asked if they had responded to the survey. Those who indicated that they had not responded completed the survey at that time.

Table 2

Numbers and Percentage of GPS Attitude Survey Respondents by Gender

<u>Gender</u>	<u>Participants</u>		
	Total <i>n</i>	GPS Attitude Survey	% of <i>n</i>
Males	28	22	79
Females	16	8	50

It has not been ascertained why only 50% of the girls responded to the GPS Attitude Survey. Some of the students who had agreed to participate in the study may have changed their minds about doing so. Another reason for the lack of participation might be that immediately prior to the administration of the survey some students took a “short cut” through the gymnasium to return to the classroom. Potential participants may have been detained during their detour and returned to the classroom with too little time to complete the survey prior to the beginning of instruction. As with the ATMI, the only “personal” information included on the form was the student’s gender and the algebra class period in which she was enrolled. Because participation was voluntary and students’ identities were anonymous, there was no manner of knowing who did not participate. This limitation is discussed in Chapter V.

The NCE Test administered to eighth-graders in May 2008 served as the pretest for measuring grade-level progress toward attaining mathematics skills. The first administration of the NCE Test for the 2008-2009 school year was conducted January 2009, at which time all students were tested. The January 2009 administration constituted the posttest for this measure. The scores for the total sample population were obtained using the May 2008 and January 2009 data sets. Responses from students who took both administrations of the NCE Test were analyzed for this study.

The *actual* number was less than the *anticipated* number of participants in this study. Several reasons might be attributed to this difference. The pretest NCE Test was administered during the last month of the 2007-2008 school year. Students successfully completing the eighth grade may not have been required to take this test; some might have been absent the day of its administration. Additionally, several students moved into the

school district during the interim between eighth and ninth grades. Newly enrolled students did not take the NCE Test (pretest) as eighth-graders. In addition, some students in the total sample population did not take the January administration of the NCE Test (posttest), the reasons for which are unknown.

In the future, the NCE Test will be administered at the beginning of the ninth grade. An administration of the NCE Test was inadvertently overlooked at the beginning of the 2008-2009 school year due to major renovation of the building during the previous summer. Although no students were displaced from regular classrooms during any part of the 2008-2009 school year as a consequence of this construction, the administration and staff were pushed to have classrooms ready for the first day of school. More time was required for the computer laboratories; therefore, there was no administration of the NCE Test. This one-time mishap is not likely to reoccur. To compensate for the lack of beginning year data, May 2008 NCE Test scores of eight-graders (i.e., rising freshmen) were obtained from the middle school.

Of the 28 boys assigned to the treatment protocol, 17 (61%) took the NCE Test pre- and posttests. Of the 12 boys assigned to the control group, 10 (83%) were pre- and posttested with the NCE Test. Of the total sample population of 40 boys, 27 (68%) took the NCE Test pre- and posttests. Of the 16 girls assigned to the treatment protocol, 11 (69%) completed both NCE Test pre- and posttests. Of the 19 girls assigned to the control group, 15 (79%) completed both NCE Test pre- and posttests. Of the total sample population of 35 girls, 26 (77%) took both NCE Test pre- and posttests (see Table 3).

Table 3

Numbers and Percentage of Pretest and Posttest NCE Test Respondents by Group

Assignment and Gender

Group		<u>Participants</u>	
Assignment	Total <i>n</i>	Pre- & Posttested	% of <i>n</i>
Males			
Treatment	28	17	61
Control	12	10	83
Total	40	27	68
Girls			
Treatment	16	11	69
Control	19	15	79
Total	35	27	77

Research Questions

Research Question 1: *Will a mathematics-based GPS mapping activity affect students' attitudes toward mathematics?*

An examination of Research Question 1 was conducted using a three-way repeated-measures ANOVA. The Huynh-Feldt correction was applied because the Sphericity Assumption was not met and the Epsilon value was greater than .75 (see Table 4). Huynh-Feldt revealed a significant difference for the ATMI between the treatment protocol and control groups, $F(2.640, 287.774) = 32.137, p = .000$ (see Table 5).

The pre-treatment ATMI group mean of 3.231 and the post-treatment ATMI group mean of 3.243 were achieved by the treatment protocol participants, indicating a gain of .012 from pre- to post-treatment surveying. The control group's pre-treatment ATMI

group mean was 3.223, and the post-treatment ATMI group mean was 3.050, indicating a loss of .173 from pre- to post-treatment surveying (see Table 6).

Table 4

Repeated-Measures ANOVA Validation for Treatment Protocol and Control Groups Using Mauchly's Test of Sphericity

Within-Subjects Effects	Mauchly's <i>W</i>	Approx. Chi-square	<i>df</i>	<i>p</i>	Epsilon		
					Greenhouse-Geisser	Huynh-Feldt	Lower Bound
Factor	.705	37.618	5	.000*	.835	.880	.333

* $p < .05$.

In addition, four discrete factors from the ATMI were identified as attributes associated with attitudes toward mathematics: Value, Self-Confidence, Enjoyment, and Motivation. These factors were examined to ascertain attitudinal shifts expressed as mean scoring gains or losses between pre- and post-treatment surveys within and between groups. For Value, the group of students assigned to the treatment protocol obtained a pre-treatment mean 3.6606 and a post-treatment mean of 3.5906, indicating a .07 loss. Control group students obtained a pre-treatment mean of 3.5500 and post-treatment mean of 3.3208, indicating a loss of .2292. Self-Confidence generated pre- and post-treatment group means of 3.3394 and 3.2542, respectively, for students assigned to the treatment protocol, indicating a loss of .0852. The Self-Confidence factor generated pre-and post-treatment means of 3.6139 and 3.0972, respectively, for the control group, indicating a loss of .5167. Students assigned to the treatment protocol exhibited a pre-treatment group mean of 2.9424 and a post-treatment group mean of 3.0094 for the Enjoyment factor. This

Table 5

Tests of Within-Subjects Effects for Treatment Protocol and Control Groups

Source		Type III SS	<i>df</i>	Mean Square	<i>F</i>	<i>p</i>
Category	Sphericity Assumed	28.801	3.000	9.600	32.137	.000*
	Greenhouse-Geisser	28.801	2.506	11.494	32.137	.000*
	Huynh-Feldt	28.801	2.640	10.909	32.137	.000*
	Lower-bound	28.801	1.000	28.801	32.137	.000*
Category*	Sphericity Assumed	1.090	3.000	.363	1.217	.304
	Greenhouse-Geisser	1.090	2.506	.435	1.217	.302
	Huynh-Feldt	1.090	2.640	.413	1.217	.303
	Lower-bound	1.090	1.000	1.090	1.217	.272
Category*PrePost	Sphericity Assumed	2.643	3.000	.881	2.949	.033*
	Greenhouse-Geisser	2.643	2.506	1.055	2.949	.042*
	Huynh-Feldt	2.643	2.640	1.001	2.949	.039*
	Lower-bound	2.643	1.000	2.643	2.949	.089
Category*	Sphericity Assumed	.620	3.000	.207	.691	.558
	Greenhouse-Geisser	.620	2.506	.247	.691	.533
	Huynh-Feldt	.620	2.640	.235	.691	.540
	Lower-bound	.620	1.000	.620	.691	.407
Error (Category)	Sphericity Assumed	97.684	327.000	.299		
	Greenhouse-Geisser	97.684	273.135	.358		
	Huynh-Feldt	97.684	287.774	.339		
	Lower-bound	97.684	109.000	.896		

* $p < .05$.

difference represents a .067 gain. Control group participants exhibited a pre-treatment mean of 2.7792 and post-treatment mean of 2.8167 for Enjoyment, or a gain of .0375. Motivation produced a pre-treatment group mean of 2.9818 and a post-treatment group mean of 3.1187 by the students assigned to the treatment protocol, which represent a gain of .1369. For this factor, the control group produced a pre-treatment mean of 2.9500 and a post-treatment mean of 2.9667 for a gain of .0167 (see Table 7).

Table 6

ATMI Group Means and Gains or Losses by Group Assignment

Group Assignment	Means		Total	Gain/Loss	<i>p</i>
	Pre- Treatment	Post- Treatment			
Treatment	3.231	3.243	3.227	.012	.000*
Control	3.223	3.050	3.1465	-.173	

* $p < .05$.

Plots of the estimated marginal means of the treatment and control groups indicate that the treatment group demonstrated greater means than did the control group for three ATMI factors (Value, Enjoyment, and Motivation), but not for Self-Confidence. The greatest mean differences between the treatment group and the control group existed for Value and Enjoyment. (See Figure 3.)

Table 7

ATMI Group Means by Group Assignment for Value, Self-Confidence, Enjoyment, and Motivation

Factor	Group	Pre-Treatment	SD	N	Post-Treatment	SD	N	Total	SD	N
	Assign.	Mean			Mean			Mean		
Value	Control	3.5500	.88465	24	3.3208	.67501	24	3.4354	.78699	48
	Treatment	3.6606	1.05887	33	3.5906	.83255	32	3.6262	.94741	65
	Total	3.6140	.98242	57	3.4750	.77419	56	3.5451	.88419	113
Self-Confidence	Control	3.6139	.75757	24	3.0972	.62846	24	3.3556	.73647	48
	Treatment	3.3394	.93888	33	3.2542	.73800	32	3.2974	.84048	65
	Total	3.4550	.87070	57	3.1869	.69159	56	3.3221	.79502	113
Enjoyment	Control	2.7792	.96683	24	2.8167	.54026	24	2.7979	.77501	48
	Treatment	2.9424	.91653	33	3.0094	.71543	32	2.9754	.81797	65
	Total	2.8737	.93303	57	2.9268	.64793	56	2.9000	.80134	113
Motivation	Control	2.9500	1.08146	24	2.9667	.70936	24	2.9583	.90479	48
	Treatment	2.9818	1.21693	33	3.1187	.81890	32	3.0492	1.03443	65
	Total	2.9684	1.15189	57	3.0536	.77082	56	3.0106	.97828	113

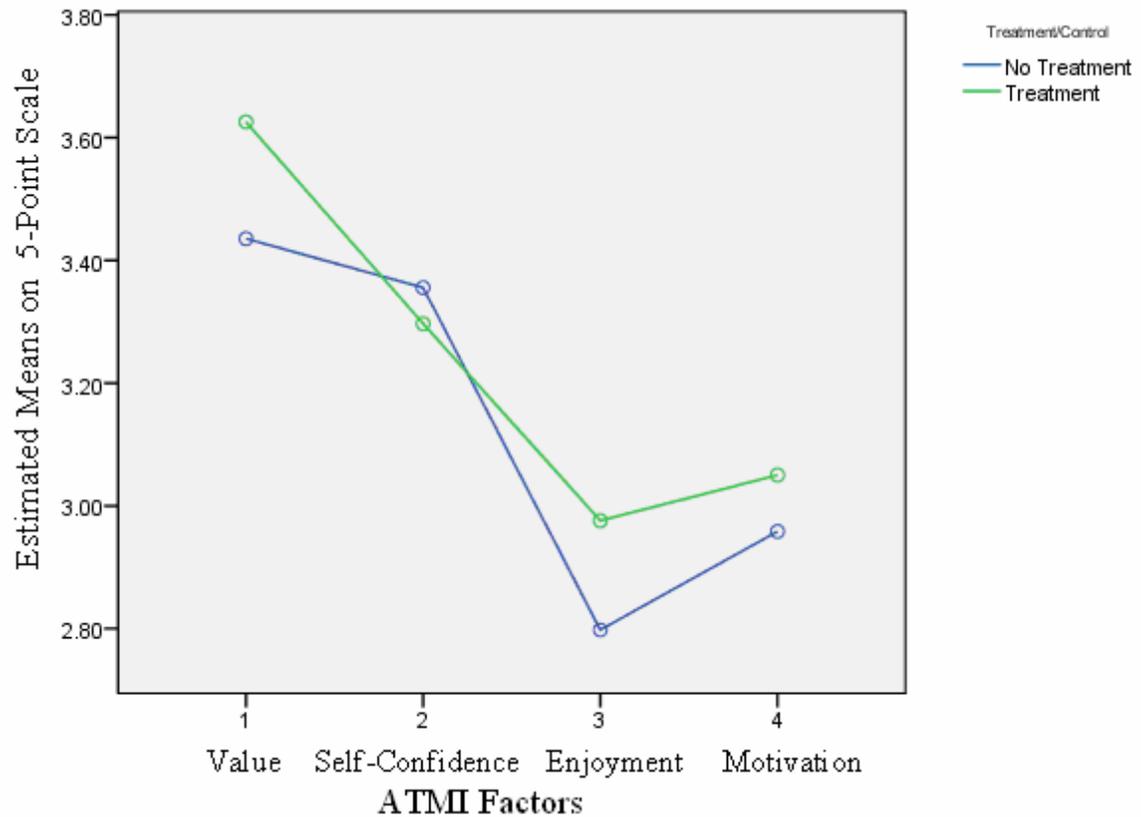


Figure 3. Estimated marginal means of the Value, Self-Confidence, Enjoyment, and Motivation attributes for the treatment group and the control group.

Research Question 2: *Will there be a difference in attitudes toward mathematics between males and females?*

Two separate three-way repeated-measures ANOVA were computed to address Research Question 2. These computations compared the data in the following ways. The first comparison measured ATMI responses of treatment group males with treatment group females. The second comparison measured ATMI responses of control group males with control group females. In addition, the ATMI four factors of Value, Self-Confidence, Enjoyment, and Motivation were examined.

Table 8

Repeated-Measures ANOVA Validation for Treatment Protocol Group Males and Females Using Mauchly's Test of Sphericity

Within-Subjects Effects					Epsilon		
	Mauchly's <i>W</i>	Approx. Chi-square	<i>df</i>	<i>p</i>	Greenhouse-Geisser	Huynh-Feldt	Lower Bound
Factor	.580	32.559	5	.000*	.756	.825	.333

* $p < .05$.

ATMI responses from treatment group males and females were analyzed using a three-way repeated-measures ANOVA. The Huynh-Feldt correction was applied because the Sphericity Assumption was not met and the Epsilon value was greater than .75 (see Table 8). Huynh-Feldt revealed a significant difference on the ATMI between the treatment group males and females $F(2.475, 150.975) = 19.503, p = .000$ (see Table 9).

The pre- and post-treatment ATMI group means for males assigned to the treatment protocol were 3.256 and 3.376, respectively. The pre- and post-treatment group means for females assigned to the treatment protocol were 3.198 and 3.073, respectively. From pre- to post-treatment, the males assigned to the treatment protocol as a group experienced a gain of .12. From pre- to post-treatment, the females assigned to the treatment protocol as a group experienced a loss of .125 (see Table 10).

In addition, the four discrete factors from the ATMI that were identified as attributes associated with attitudes toward mathematics were examined. For the Value factor, the pre- and post-treatment group means of the males assigned to the treatment protocol were 3.4842 and 3.6722, respectively, indicating a .188 gain. The females assigned to the treatment protocol obtained pre- and post-treatment group means of

Table 9

Tests of Within-Subjects Effects for Treatment Protocol Group Males and Females

Source		Type III		Mean		
		SS	<i>df</i>	Square	<i>F</i>	<i>p</i>
Category	Sphericity Assumed	17.631	3.000	5.877	19.503	.000*
	Greenhouse-Geisser	17.631	2.267	7.777	19.503	.000*
	Huynh-Feldt	17.631	2.475	7.124	19.503	.000*
	Lower-bound	17.631	1.000	17.631	19.503	.000*
Category*PrePost	Sphericity Assumed	.769	3.000	.256	.851	.468
	Greenhouse-Geisser	.769	2.267	.339	.851	.442
	Huynh-Feldt	.769	2.475	.311	.851	.450
	Lower-bound	.769	1.000	.769	.851	.360
Category*Gender	Sphericity Assumed	2.191	3.000	.730	2.424	.067
	Greenhouse-Geisser	2.191	2.267	.967	2.424	.085
	Huynh-Feldt	2.191	2.475	.885	2.424	.080
	Lower-bound	2.191	1.000	2.191	2.424	.125
Category*	Sphericity Assumed	.985	3.000	.328	1.090	.355
PrePost*Gender	Greenhouse-Geisser	.985	2.267	.435	1.090	.345
	Huynh-Feldt	.985	2.475	.398	1.090	.348
	Lower-bound	.985	1.000	.985	1.090	.301
Error (Category)	Sphericity Assumed	55.147	183.000	.301		
	Greenhouse-Geisser	55.147	138.296	.399		
	Huynh-Feldt	55.147	150.975	.365		
	Lower-bound	55.147	61.000	.904		

* $p < .05$.

Table 10

ATMI Pre-treatment and Post-treatment Means and Gains or Losses by Gender for Treatment Protocol Group

Gender	Means		Total	Gain/Loss	<i>p</i>
	Pre-Treatment	Post-Treatment			
Males	3.256	3.376	3.316	.12	.000*
Females	3.198	3.073	3.1355	-.125	

* $p < .05$.

3.9000 and 3.4857, respectively, for a loss of .4143. Treatment group males posted pre- and post-treatment group means for Self-Confidence of 3.4281 and 3.4926, respectively, for a gain of .0645. Treatment protocol females posted pre- and post-treatment group means for this factor of 3.2190 and 2.9476, respectively, for a loss of .2714. For Enjoyment, experimental group males achieved a pre-treatment mean of 2.9947 and a post-treatment mean of 3.1056 for a gain of .1109. Experimental group females achieved a pre-treatment mean of 2.8714 and a post-treatment mean of 2.8857 for a gain of .0143. For Motivation, the males assigned to the treatment protocol obtained pre- and post-treatment group means of 3.1158 and 3.2333, respectively, for a gain of .1175. The females assigned to the treatment protocol obtained pre- and post-treatment group means of 2.8000 and 2.9714, respectively, for a gain of .1714 (see Table 11).

Plots of the estimated marginal means of the males and females assigned to the treatment protocol indicate that the males demonstrated slightly smaller group means than did the females for Value, but larger group means for Self-Confidence, Enjoyment, and Motivation. (See Figure 4.)

Table 11

ATMI Group Means of Treatment Protocol Group Males and Females for Value, Self-Confidence, Enjoyment, and Motivation

Factor	Gender	Pre-Treatment			Post-Treatment			Total		
		Mean	SD	N	Mean	SD	N	Mean	SD	N
Value	Male	3.4842	1.02267	19	3.6722	.96333	24	3.5757	.98500	37
	Female	3.9000	1.09755	14	3.4857	.64672	14	3.6929	.90878	28
	Total	3.6606	1.05887	33	3.5906	.83255	32	3.6262	.94741	65
Self-Confidence	Male	3.4281	.94994	19	3.4926	.77952	18	3.4595	.85977	37
	Female	3.2190	.94514	14	2.9476	.56941	14	3.0833	.77802	28
	Total	3.3394	.93888	33	3.2542	.73800	32	3.2974	.84048	65
Enjoyment	Male	2.9947	.95944	19	3.1056	.80474	18	3.0486	.87706	37
	Female	2.8714	.88529	14	2.8857	.58685	14	2.8786	.73704	28
	Total	2.9424	.91653	33	3.0094	.71543	32	2.9754	.81797	65
Motivation	Male	3.1158	1.19688	19	3.2333	.87917	18	3.1730	1.04154	37
	Female	2.8000	1.26491	14	2.9714	.73947	14	2.8857	1.02043	28
	Total	2.9818	1.21693	33	3.1187	.81890	32	3.0492	1.03443	65

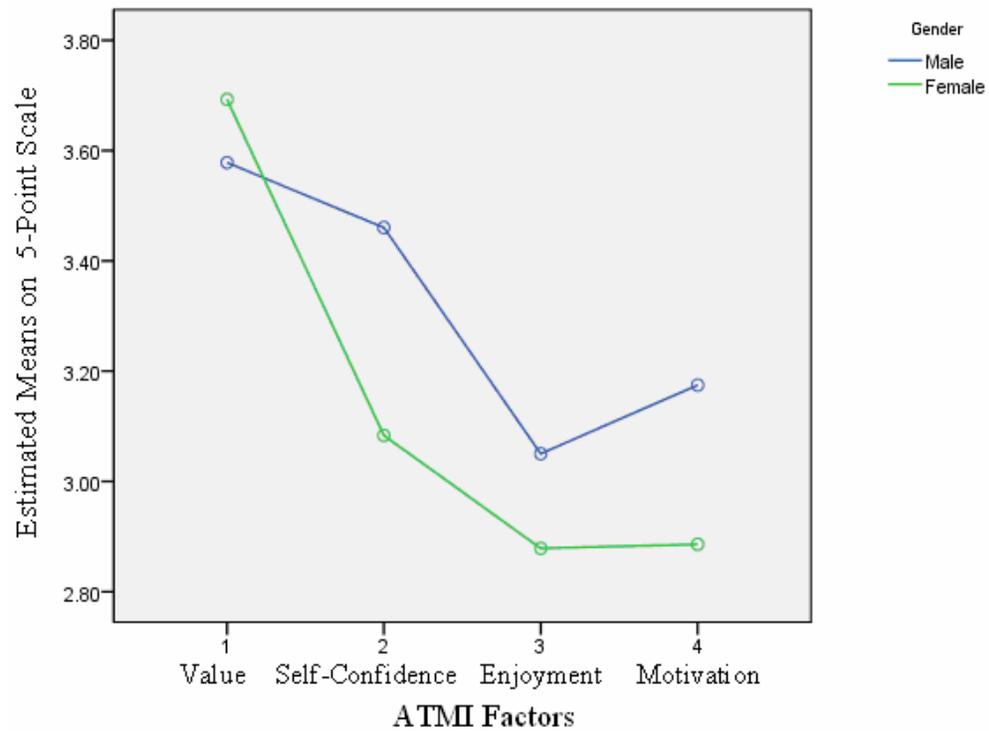


Figure 4. Estimated marginal means of the Value, Self-Confidence, Enjoyment, and Motivation attributes for males and females assigned to the treatment protocol.

A comparison of ATMI responses from males and females assigned to the control group was conducted using a three-way repeated-measures ANOVA. The Sphericity Assumption was not violated so the Sphericity Assumed measure was used (see Table 12). A significant difference between males and females of this group was obtained $F(3, 132) = 15.953, p = .000$ (see Table 13).

Table 12

Repeated-Measures ANOVA Validation for Control Group Males and Females

Using Mauchly's Test of Sphericity

Within-Subjects Effects	Mauchly's W	Approx. Chi-square	df	p	Epsilon		
					Greenhouse-Geisser	Huynh-Feldt	Lower Bound
Factor	.807	9.159	5	.103	.880	1.000	.333

$p < .05$.

Table 13

Tests of Within-Subjects Effects for Control Group Males and Females

Source		Type III		Mean		
		SS	<i>df</i>	Square	<i>F</i>	<i>p</i>
Category	Sphericity Assumed	13.322	3.000	4.441	15.953	.000*
	Greenhouse-Geisser	13.322	2.641	5.045	15.953	.000*
	Huynh-Feldt	13.322	3.000	4.441	15.953	.000*
	Lower-bound	13.322	1.000	13.322	15.953	.000*
Category*PrePost	Sphericity Assumed	2.009	3.000	.670	2.406	.070
	Greenhouse-Geisser	2.009	2.641	.761	2.406	.079
	Huynh-Feldt	2.009	3.000	.670	2.406	.070
	Lower-bound	2.009	1.000	2.009	2.406	.128
Category*Gender	Sphericity Assumed	.355	3.000	.118	.425	.735
	Greenhouse-Geisser	.355	2.641	.135	.425	.710
	Huynh-Feldt	.355	3.000	.118	.425	.735
	Lower-bound	.355	1.000	.355	.425	.518
Category*PrePost *Gender	Sphericity Assumed	2.249	3.000	.750	2.693	.049*
	Greenhouse-Geisser	2.249	2.641	.852	2.693	.056
	Huynh-Feldt	2.249	3.000	.750	2.693	.049*
	Lower-bound	2.249	1.000	2.249	2.693	.108
Error (Category)	Sphericity Assumed	36.743	132.000	.278		
	Greenhouse-Geisser	36.743	116.197	.316		
	Huynh-Feldt	36.743	132.000	.278		
	Lower-bound	36.743	44.000	.835		

**p* < .05.

Pre- and post-treatment ATMI group means for males assigned to the control group were 3.337 and 3.019, respectively, indicating a loss of .358. Pre- and post-treatment ATMI group means for the females assigned to this group were 3.093 and 3.073, respectively, indicating a loss of .02 (see Table 14).

Table 14

ATMI Pre-treatment and Post-treatment Group Means and Gains or Losses by Gender for Control Group

Gender	Means		Total	Gain/Loss	<i>p</i>
	Pre-Treatment	Post-Treatment			
Males	3.377	3.019	3.198	-.358	.000*
Females	3.093	3.073	3.083	-.02	

* $p < .05$.

An analysis of the ATMI Value, Self-Confidence, Enjoyment, and Motivation attitude attributes was conducted. The males assigned to the control group obtained pre- and post-treatment means of 3.7636 and 3.0900, respectively, for Value, indicating a loss of .6736. The control group females obtained pre- and post-treatment means of 3.3692 and 3.4857, respectively, for this factor, exhibiting a gain of .1165. Control group males achieved pre- and post-treatment means for Self-Confidence of 3.6000 and 3.3067, respectively, which shows a loss of .2933. For the same factor, control group females obtained pre- and post-treatment means of 3.6256 and 2.9476, respectively, a loss of .678. For the third factor, Enjoyment, control group males presented pre- and post-treatment means of 2.9455 and 2.7200, respectively, posting a loss of .2255. Control group females

achieved pre- and post-treatment means for this factor of 2.6385 and 2.8857, respectively, indicating a gain of .2472. A gain of .2329 was expressed for Motivation for control group females who obtained pre- and post-treatment means of 2.7385 and 2.9714, respectively. Control group males demonstrated a loss (.24) between pre- and post-treatment means for this factor, 3.2000 and 2.9600, respectively (see Table 15).

Plots of the estimated marginal means of the males and females assigned to the control group indicate that both groups obtained similar means for Value, but the males obtained larger means for Self-Confidence, Enjoyment, and Motivation. (See Figure 5.)

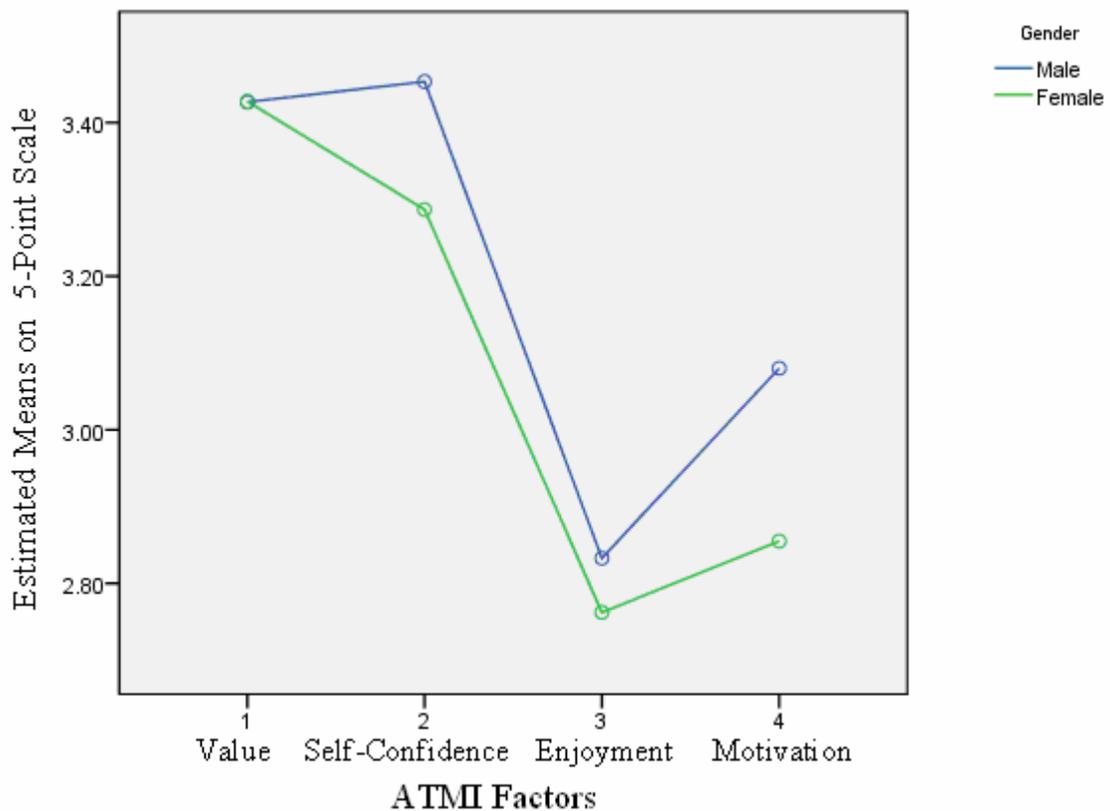


Figure 5. Estimated marginal means of the Value, Self-Confidence, Enjoyment, and Motivation attributes for males and females assigned to the control group.

Table 15

ATMI Group Means of Control Group Males and Females for Value, Self-Confidence, Enjoyment, and Motivation

Factor	Gender/	Pre-Treatment	SD	N	Post-Treatment	SD	N	Total	SD	N
		Mean			Mean			Mean		
Value	Male	3.7636	.53530	11	3.0900	.67733	10	3.4429	.68452	21
	Female	3.3692	1.08811	13	3.4857	.64672	14	3.4296	.87126	27
	Total	3.5500	.88465	24	3.3208	.67501	24	3.4354	.78699	48
Self-Confidence	Male	3.6000	.66733	11	3.3067	.67637	10	3.4603	.67162	21
	Female	3.6256	.85355	13	2.9476	.56941	14	3.2741	.78584	27
	Total	3.6139	.75757	24	3.0972	.62846	24	3.3556	.73640	48
Enjoyment	Male	2.9455	.71744	11	2.7200	.48028	10	2.8381	.61194	21
	Female	2.6385	1.14713	13	2.8857	.58685	14	2.7667	.89184	27
	Total	2.7792	.96683	24	2.8167	.54026	24	2.7979	.77501	48
Motivation	Male	3.2000	.87178	11	2.9600	.70427	10	3.0857	.78631	21
	Female	2.7385	1.22579	13	2.9714	.73947	14	2.8593	.99044	27
	Total	2.9500	1.08146	24	2.9667	.70936	24	2.9583	.90479	48

Research Question 3: *Will there be a difference in attitudes toward a mathematics-based GPS activity between males and females?*

Answers to Research Question 3 were sought by analyzing the responses of students assigned to the treatment protocol to a researcher-designed GPS Attitude Survey following the completion of the treatment, i.e., mathematics-based GPS mapping activities. This survey was administered only one time rather than as a pre-treatment/post-treatment component of this research, which was how the ATMI was administered. This decision was based upon the accurate assumption that many students had not previously used a GPS.

The 15-item GPS Attitude Survey employed a Likert-type rating scale from 1 to 5 with 1 being “strongly disagree” and 5 being “strongly agree.” Response data were factor analyzed, which revealed a “best fit” for four factors. A varimax rotation pushed the vectors as far apart as possible resulting in a simple structure of four attitude attributes: Using a GPS, Activities, Motivation, and Mathematics Academics.

Following the factor analysis, a three-way repeated-measures ANOVA was conducted. The Sphericity Assumption was not violated so the Sphericity Assumed measure was used (see Table 16). It revealed a significant difference on the GPS Attitude

Table 16

Repeated-Measures ANOVA Validation for Treatment Protocol Group

Males and Females Using Mauchly's Test of Sphericity

Within-Subjects Effects	Mauchly's <i>W</i>	Approx. Chi-square	<i>df</i>	<i>p</i>	Epsilon		
					Greenhouse-Geisser	Huynh-Feldt	Lower Bound
Factor	.917	2.234	5	.816	.947	1.000	.333

p < .05.

Survey between males and females assigned to the treatment protocol, $F(3, 81) = 4.702$, $p = .004$ (see Table 17). Table 18 presents the group means this survey obtained by the treatment group males and females.

Table 17

Tests of Within-Subjects Effects for Treatment Protocol Group Males and Females

Source		Type III		Mean		
		SS	df	Square	F	p
Category	Sphericity Assumed	3.302	3.000	1.101	4.702	.004*
	Greenhouse-Geisser	3.302	2.841	1.162	4.702	.005*
	Huynh-Feldt	3.302	3.000	1.101	4.702	.004*
	Lower-bound	3.302	1.000	3.302	4.702	.039*
Category * Gender	Sphericity Assumed	1.565	3.000	.522	2.229	.091
	Greenhouse-Geisser	1.565	2.841	.551	2.229	.095
	Huynh-Feldt	1.565	3.000	.522	2.229	.091
	Lower-bound	1.565	1.000	1.565	2.229	.147
Error (Category)	Sphericity Assumed	18.959	81.000	.234		
	Greenhouse-Geisser	18.959	76.718	.247		
	Huynh-Feldt	18.959	81.000	.234		
	Lower-bound	18.959	27.000	.702		

* $p < .05$.

The four discrete factors (i.e., Using a GPS, Activities, Motivation, and Mathematics Academics) revealed by a factor analysis and varimax rotation were analyzed for the males and females assigned to the treatment protocol only. Using a GPS produced a group mean for the males of 3.8810 and 3.6250 for the females. Activities produced group means for males and females of 4.1429 and 4.0833, respectively. Motivation group

Table 18

GPS Attitude Survey Group Means by Gender

Gender	Mean	<i>p</i>
Males	3.891	.004
Females	3.932	

* $p < .05$.

means achieved by males and females were 3.8571 and 4.3125, respectively. GPS Attitude Survey group means of 3.6905 and 3.6875 were obtained respectively by the males and females for the Mathematics Achievement factor (see Table 19).

Table 19

GPS Attitude Survey Group Means and Standard Deviations for Using a GPS, Activities, Motivation, and Mathematics Academics by Gender

Factor	Gender	Mean	Std. Deviation	<i>N</i>
Using GPS	Male	3.8810	.81248	21
	Female	3.6250	.59761	8
	Total	3.8103	.75786	29
Activities	Male	4.1429	.73463	21
	Female	4.0833	.34503	8
	Total	4.1264	.64497	29
Motivation	Male	3.8571	.70963	21
	Female	4.3125	.53033	8
	Total	3.9828	.68768	29
Mathematics Academics	Male	3.6905	.88708	21
	Female	3.6875	.65124	8
	Total	3.6897	.81738	29

Plots of the estimated marginal means of the males and females assigned to the treatment protocol indicate that the males demonstrated a greater group mean than did the females for Using a GPS and a slightly larger mean for the Activities attribute, but a substantially smaller mean for Motivation. Both groups obtained the same mean for the Mathematics Academics factor. (See Figure 6.)

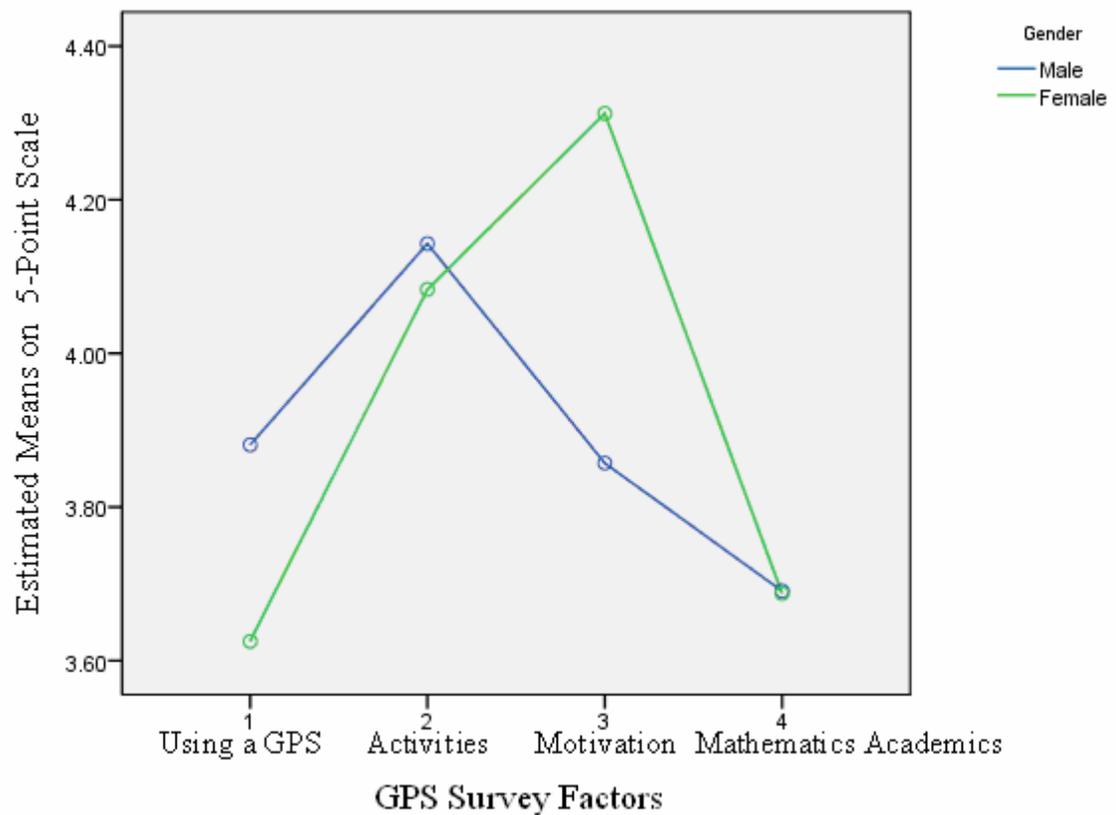


Figure 6. Estimated marginal means of Using a GPS, Activities, Motivation, and Mathematics Academics attributes for males and females assigned to the treatment protocol.

Research Question 4: *What are the attitudes of students toward GPS mapping activities?*

An examination of Research Question 4 was conducted with data used to address Research Question 3. The estimated group mean score (3.891) of the responses of males

assigned to the treatment protocol and the estimated group mean score (3.932) of the females assigned to the treatment protocol indicate that students' attitudes toward mathematics-based GPS mapping activities are relatively positive. In the case of this study, females expressed a more positive attitude than did the males of the treatment group.

Research Question 5: *Will a mathematics-based GPS mapping activity affect students' mathematics achievement as demonstrated by NCE Test scores?*

Pre- and posttest scores of the NCE Test administered to students assigned to either a treatment protocol or a control group were analyzed using an ANCOVA design to address Research Question 5. Group means of the experimental group, which was composed of students assigned to the treatment protocol, were compared to the group means of the control group, i.e., students who did not participate in the mathematics-based GPS mapping activities. A comparison of the treatment and control groups revealed no significant difference in the scores achieved pre- to posttest for these two groups for the NCE Test, $F(1, 47) = .221$, $p = .641$ (see Table 20).

Table 20

Univariate Test for NCE Test Pretest and Posttest Group Means by Group Assignment

	Sum of Squares	<i>df</i>	Mean Square	<i>F</i>	<i>p</i>
Contrast	.163	1	.163	.221	.641
Error	34.659	47	.737		

$p < .05$.

The NCE Test pre- and posttest group means of students assigned to the treatment protocol group were 3.796 and 4.193, respectively, indicating a gain of .397. The NCE

Test pre- and posttest group means of student assigned to the control group were 3.769 and 4.185, respectively, indicating a gain of .416 (see Table 21).

Table 21

Pretest and Posttest NCE Test Group Means by Group Assignment

Group Assignment	Means		Total	Gain/Loss	<i>p</i>
	Pre- Treatment	Post- Treatment			
Treatment	3.796	4.193	3.995	.397	.641
Control	3.769	4.185	3.977	.416	

p < .05.

Summary

An examination of the research data revealed small differences between students assigned to the treatment protocol and students of the control group regarding (a) their attitudes toward mathematics, (b) their attitudes toward the use of mathematics with GPS mapping activities, and (c) their grade-level progress in mathematics skills acquisition as measured by the NCE Test. Treatment group participants demonstrated higher posttest group means overall and greater gains from the pre- to post-treatment surveys (attitudinal shifts) and pre- and posttest NCE Test administrations (mathematics skills attainment).

When gender differences were examined, males assigned to the treatment protocol demonstrated the higher NCE Test posttest group means and higher post-treatment attitude survey group means for most categories. Females assigned to the control group demonstrated higher gains for two ATMI factors.

For the NCE Test pre- and posttests, males assigned to the treatment protocol achieved the highest group means. Females assigned to the treatment protocol achieved the lowest group means for both the pretest and the posttest, but obtained the greatest gains. Although the mean differences were small, there was an indication that the treatment group demonstrated a positive attitudinal shift and academic progress overall, which the control group did not demonstrate.

CHAPTER V

DISCUSSION AND RECOMMENDATIONS

This study examined students' attitudes toward learning mathematics, attitudes toward using a GPS tool while applying mathematical skills, and grade-level progress in mathematics. The purpose of this study was to determine if conducting a mathematics-based GPS mapping activity would have an effect on students' perceptions toward learning mathematics or an effect on their mathematics skills attainment. The effects of gender on attitudes and achievement also were investigated in this study.

The findings did not demonstrate a statistically significant difference overall for mathematics achievement between those students assigned to the treatment protocol and those who were assigned to the control group. However, analyses of specific aspects of the data yielded some interesting information. In addition, informal interactions with students offered valuable information that the survey ratings and achievement scores did not provide. Findings and recommendations are discussed in relation to the research questions posed at the beginning of the study.

A persistent limitation of the study was the small sample population of 75 students enrolled in three algebra 1A classes. Group participation would change dramatically if a single student were not in attendance on a day that a study activity was conducted. A single absentee could create a 2 to 8% decrease in participation that would affect the collection and analyses of data. This was further exacerbated by participants who compromised data by purposely marked their surveys with non-designated letters or nonsense symbols. Those surveys were not counted. However, for the participating school, this type of data gathering represents an initial step toward collecting information that will

assist the administration and staff to better serve the educational needs of the students.

This may be especially so for mathematics, which is, perhaps, the schools weakest subject area.

One *advantage* of the limited sample population was that it allowed the research to remain simple and clean by facilitating the measurement of similar attitudinal attributes and variables across all levels. A clearer assessment of the results may have been yielded since multiple subject areas or grade levels were not compared in this study.

The sample population consisted of entering freshmen. The ninth-grade year is pivotal for students who may be at risk for dropping out of school. For students enrolled in the participating school, mathematics, more than any other subject, is an obstacle to success. Presently, students enrolled in the standard diploma curriculum at this school can finish their mathematics requirements for graduation by the end of the tenth-grade year; however, it is common that some seniors who are on grade level in every other subject are still attempting to finish their mathematics credits.

Five research questions outlined the framework for the study. The first question, *Will a mathematics-based GPS mapping activity affect students' attitudes toward mathematics?* was addressed using data from a survey of attitudes toward mathematics. This survey, titled Attitudes Toward Mathematics Inventory (ATMI), was constructed more than a decade ago by an associate professor of mathematics when she was a doctoral student. It was revised after the initial administration and continues to have a contemporary audience (see Tapia & Marsh, 2004, 2005).

Results, Conclusions, and Discussion

The results of the *F* tests of repeated measures for the ATMI showed a significant difference between the experimental group and the control group. The experimental group had a higher post-treatment mean and a greater pre- to post-treatment gain than did the control group, indicating that the treatment protocol, mathematics-based GPS mapping activities, positively affected students' attitudes toward mathematics. When Tapia administered the ATMI to examine differences between female and male populations, she did so without an intervening variable. The addition of a treatment protocol serves to broaden Tapia's work.

The researcher was unable to locate any published experiments that examined the use of a GPS as a teaching tool in an educational setting, only descriptive accounts of its use. No dissertations written about the subject were identified, although some conference papers were discovered. As a new technology that has recently been introduced as a pedagogical tool, educators who are incorporating the GPS into teaching may be more interested in its applications than in studying its effectiveness. Descriptive or expository articles about using a GPS as a teaching tool included mathematics as well as other core disciplines. Overall, authors described positive responses from students (Broda & Baxter, 2003; Lane, 2004; Matherson et al., 2008). All authors indicated that they intended to continue incorporating the GPS as a teaching tool.

The experimental design of this study provided the researcher with opportunities to parse the data to note the gender differences within discrete attributes identified as components of students' attitudes toward learning mathematics. These predominant factors helped define why students embrace their perceptions of the subject and the study of

mathematics. The four ATMI factors were identified as Value, Self-Confidence, Enjoyment, and Motivation. Table 22 compares the pre- and post-treatment survey group means and indicates the gain or loss in the total group mean for each attribute by group assignment.

Table 22

ATMI Group Means Gains and Losses by Group Assignment for Value, Self-Confidence, Enjoyment, and Motivation

ATMI Factor	Pretest	Posttest	Total	Gain/Loss
Value				
Treatment	3.6606	3.5906	3.6262	-.07
Control	3.5500	3.3208	3.4354	-.2292
Self-Confidence				
Treatment	3.3394	3.2542	3.2974	-.0852
Control	3.6139	3.0972	3.3556	-.5167
Enjoyment				
Treatment	2.9424	3.0094	2.9754	.067
Control	2.7792	2.8167	2.7979	.0375
Motivation				
Treatment	2.9818	3.1187	3.0492	.1369
Control	2.9500	2.9667	2.9583	.0167

The Value factor group mean was the highest for the treatment group and second highest for the control group. The Self-Confidence group mean was the highest for the control group and the second highest for the treatment group. Although the means for both factors decreased for both groups, the decrease was less than that for the treatment

group. The pre-treatment group means for both Enjoyment and Motivation were less than 3, i.e., a “Disagree” rating, which indicates a negative attitude held by students. The post-treatment means were higher than pre-treatment means for the control and treatment groups for both factors, with the treatment group making the greater gain. The post-treatment means were within the “Neutral” response range for both the treatment and control groups.

Using ATMI data, the results of the F tests of repeated measures revealed a significant difference between the treatment group and the control group. In addition to this difference, there were higher gains or at least lower losses in the group means between the pre- and post-treatment ATMI administrations. Conventional wisdom might advance that the desired outcome of a treatment protocol would be a demonstrated improvement greater than that achieved with no treatment (control group). That did occur in this case, but the answers to Research Question 2 may be the greatest contribution of this study.

The second research question investigated the existence of differences in attitudes toward mathematics between males and females. The F tests of repeated measures revealed a significant difference for the ATMI between males and females with males demonstrating a more positive attitude toward mathematics. This outcome mirrors the findings of Tocci and Engelhard (1991) and Lupart et al. (2004) that males tend to have more positive attitudes toward mathematics and science than females do. Females in those studies exhibited a more positive attitude toward language acquisition.

Of the four factors, the pre- and post-treatment means were the lowest for Enjoyment, and the pre- and post-treatment means for Value were the highest. Stated otherwise, students acknowledge an overall value to learning mathematics, but they do not

enjoy doing it! The value aspect of learning mathematics was noted previously (Public Agenda, 2007). Although no student in the sample population had read that article, each achieved consensus with that perception.

The next lowest group mean was attributed to the Motivation factor of the ATMI pre-treatment administration. Although students value learning mathematics, they do not enjoy it and do not want to take any mathematics courses beyond what is necessary to fulfill academic requirements (Neale, 1969; Public Agenda, 2007). This factor did reveal the greatest difference between group means for males and females with females as a group achieving the lower mean (see Table 23).

Since the mid 1970s, Elizabeth Fennema has been a self-proclaimed feminist who believes firmly that educational efforts to encourage females to pursue more general and advanced mathematics courses will lead to a time when there will be no gender differences in mathematics achievement, interest, or participation (Fennema, 1993). The pre- and post-treatment group means for the Motivation factor for females do not bode well for Fennema's beliefs.

Regarding the Self-Confidence factor, the control groups, both males and females, exhibited the highest means on the pre-treatment ATMI. The post-treatment ATMI means were lower than the pre-treatment means for control group females and treatment group females. All group means for the females (pre- and post-treatment, control and treatment groups) were lower than all corresponding group means achieved by males. It is predictable that students who had a low self-confidence regarding mathematics would neither enjoy it nor be motivated to take additional mathematics courses than those required (Tollefson, 2000).

Table 23

ATMI Group Means Gains and Losses by Group Assignment and Gender for Value, Self-Confidence, Enjoyment, and Motivation

Factor	Group	Gender	Pretest	Posttest	Total	Gain/Loss
Value	Treatment	Males	3.4842	3.6722	3.5757	.188
	Treatment	Females	3.9000	3.4857	3.6929	-.4143
	Control	Males	3.7636	3.0900	3.4429	-.6736
	Control	Females	3.3692	3.4857	3.4296	.1165
Means			3.62925	3.4334	3.535275	-.19585
Self-Confidence	Treatment	Males	3.4281	3.4926	3.4595	.0645
	Treatment	Females	3.2190	2.9476	3.0833	-.2714
	Control	Males	3.6000	3.3067	3.4603	-.2933
	Control	Females	3.6256	2.9476	3.2741	-.6780
Means			3.4681	3.1736	3.3193	-.2945
Enjoyment	Treatment	Males	2.9947	3.1056	3.0486	.1109
	Treatment	Females	2.8714	2.8857	2.8786	.0143
	Control	Males	2.9455	2.7200	2.8381	-.2255
	Control	Females	2.6385	2.8857	2.7667	.2472
Means			2.8625	2.8992	2.883	.0367
Motivation	Treatment	Males	3.1158	3.2333	3.1730	.1175
	Treatment	Females	2.8000	2.9714	2.8857	.1714
	Control	Males	3.2000	2.9600	3.0857	-.24
	Control	Females	2.7385	2.9714	2.8857	.2329
Means			2.9635	3.0340	3.0075	.0705

Research outcomes can be indiscriminate and unpredictable. Preferably, the outcome of any research would be that the treatment protocol was successful and the desired results were obtained. In such a case, the data are sufficient to explain the findings.

In other cases, further exploration is required to understand certain outcomes. There are conditions for which explanations are elusive.

For this study, the best justification for otherwise unexplainable results is that the sample population consisted of first-time ninth-graders. Conventional wisdom would indicate that most factors would show an increase in the post-treatment group means. It would be reasonable to assume that the difference in pre- to post-treatment group means for Self-Confidence and Enjoyment might move in a similar direction. In reality, the results are erratic. A “best” explanation for these volatile results could be that students’ responses reflected the sentiments they were feeling that day. Quite possibly, myriad other concerns affected their responses, including a lack of interest in the survey.

The third research question, which was specific to the treatment group, asked if differences in attitudes toward mathematics-based GPS mapping activities were gender-based. Small differences were exhibited between the group means of the males and females assigned to the treatment protocol. Surprisingly, the females achieved a greater mean score than did the males, suggesting that the females enjoyed using the GPS to perform mathematics-based mapping activities more than the males did. However, the small sample may have skewed the outcome of the survey in this situation. Only eight of the 16 females took the GPS Attitude Survey although more than eight girls were present the day the survey was administered. It is not known why more did not participate in this process. In contrast, more than 75% of the males responded to it.

It would be appropriate to incorporate a discussion of the fourth research question with the third research question, due to their interrelatedness. The fourth research question asked, *What are the attitudes of students toward GPS mapping activities?* (see Table 24).

Table 24

GPS Attitude Survey Means by Gender for Using a GPS, Activities, Motivation, and Mathematics Academics

Factor	Gender	Mean
Using a GPS	Male	3.8810
	Female	3.6250
	Total	3.8103
Activities	Male	4.1429
	Female	4.0833
	Total	4.1264
Motivation	Male	3.8571
	Female	4.3125
	Total	3.9828
Mathematics Academics	Male	3.6905
	Female	3.6875
	Total	3.6897

This 15-item survey signified positive attitudes among students for using a GPS. The items were parceled into four factors: Using a GPS, Activities, Motivation, and Mathematics Academics. None of the group means was less than 3.6. Activities demonstrated the highest group mean, indicating that students enjoyed using the GPS and working outside. Responses to Motivation (i.e., students wanted the opportunity to complete additional GPS mapping activities) also were relatively high. Discussions of GPS mapping activities in the literature support the motivational role of a GPS in education (Broda & Baxter, 2003; Lane, 2004; Matherson et al., 2008). This survey as well as the observed actions and comments by students supported and mirrored the available literature.

An informal evaluation of the study represents an important aspect of this discussion and reports remarks made by students about the GPS mapping activities. Those remarks included positive comments about the activities. Several students asked when they would have opportunities to participate in additional GPS mapping activities. Some indicated that they liked using the GPS. One student stated that he liked working with the GPS because he “didn’t have to do math.” When it was revealed to him that he was “doing math” in the activities, he replied that the “GPS type of math was fun.” It is interesting to note that the majority of these comments were made by males. The males also showed more enthusiasm as a group than did females as a group, although most of the females succeeded in completing the GPS mapping activities.

A few females did not appear to enjoy the GPS mapping activities. Several may have been among the eight girls who did not complete the GPS Attitude Survey, but that cannot be ascertained. Logically, it makes more sense to report a disinterest/distaste for an activity rather than to refrain from voicing an opinion, particularly with an anonymous survey.

The final research question addressed whether a mathematics-based GPS mapping activity would affect students’ mathematics skills attainment as demonstrated by scores achieved on the NCE Test. The students who took both the pretest and posttest represented only 73% of the total sample population. The group with the greatest percentage of participants taking the diagnostic test was the males assigned as the control (83%). The group with the smallest percentage of participants taking the diagnostic test was the males assigned to the treatment protocol (61%).

Once again, a small population exposes drawbacks. Several factors could have affected the lack of participation (i.e., small percentages). The pretest NCE Test was administered during the last month of the 2007-2008 school year. Students successfully completing the eighth grade may not have been required to take this test; some might have been absent the day of its administration. Additionally, several students moved into the school district during the interim between eighth and ninth grades. Newly enrolled students did not take the NCE Test (pretest) as eighth-graders. In addition, some students in the total sample population did not take the January administration of the NCE Test (posttest), the reasons for which are unknown.

In the future, the NCE Test will be administered at the beginning of the ninth grade. An administration of the NCE Test was inadvertently overlooked at the beginning of the 2008-2009 school year due to major renovation of the building during the previous summer. Although no students were displaced from regular classrooms during any part of the 2008- 2009 school year as a consequence of this construction, the administration and staff were pushed to have classrooms ready for the first day of school. More time was required for the computer laboratories; therefore, there was no administration of the NCE Test. This one-time mishap is not likely to reoccur. To compensate for the lack of beginning year data, the May 2008 NCE Test scores of eight-graders (i.e., rising freshmen) were obtained from the middle school.

Overall, the results of the study appear to be positive, but do not show a strong relationship to the treatment (see Table 25). The treatment may have been statistically insignificant, but students are making progress in mathematics. Improvement was demonstrated by each group. However, as a group, the students assigned to the control

group outperformed the students assigned to the treatment protocol. If group means are the only data considered, then the treatment protocol was rendered ineffective. Further study of the data revealed information that would disappoint Dr. Tapia, the ATMI designer.

Table 25

NCE Test Group Means and Gains or Losses by Group Assignment and Gender

Group Assignment	Pretest	Posttest	Total	Gain/Loss	<i>p</i>
Treatment Group	3.747	4.1525	3.9498	.4055	.641
Control Group	3.764	4.193	3.9785	.429	
Treatment Males	3.976	4.341	4.1585	.366	
Control Males	3.740	4.230	3.985	.49	
Treatment Females	3.518	3.964	3.741	.466	
Control Females	3.788	4.156	3.972	.279	
All Males	3.889	4.300	4.0945	.411	
All Females	3.678	4.078	3.878	.4	

$p < .05$.

The males, for all factors, outperformed the females on the NCE Test pretest and posttest. The mean scores for the males assigned to the treatment group indicate that the treatment was effective for the males if the overall means are inspected. Even though the posttest group mean was higher for males assigned to the treatment protocol, their pretest group mean also was high. Their overall gain was lower than that achieved by the males assigned to the control group. This outcome would support the theories of Stanley and Benbow (1980) that males are simply better at mathematics than females.

Implications for Educators

Although many of the results supported the desired outcome, it is questionable whether they did as a whole. However, there were observed actions and interactions that showed the activities to be worthwhile. The very first activity was confusing to many students and most needed considerable guidance. These students were comfortable entering a classroom and taking a seat. When they were given a problem and its framework and asked to solve it, they did not have the skills to tackle this new challenge. When the component of removing classroom walls was added, some of the students were even more lost. In addition, this particular set of students is challenging as well. Middle school teachers, as well as that administration, forewarned the high school faculty for the past two years about this group of students. The fact that they pose challenges was affirmed by the ninth-grade teachers during the first month of the school year.

However, for this study, the students posed no major discipline problems. The biggest challenges presented were a poor work ethic and immaturity in their classroom habits. These traits have prevented this class as a whole from being truly ready for high school. There are some very academically focused students in this group, but they are the minority and are unwilling to serve as positive peer leaders. The students do not display an overt ability to problem solve or to take ownership for new learning. Their teachers must chart every step of each process so that they are able to reach just a low level of comprehension. After the first activity with the two classes, this researcher was convinced that this type of activity must be conducted consistently with students of this grade level. Groups of students such as this certainly help to make teachers rethink effective classroom habits.

The students that entered high school in the school year of 2008-2009 were all born after Macintosh introduced its “computer for the rest of us.” The graphical user interface is the only kind of operating system they have known. They have all grown up with television, many of them having cable or satellite service that offer the opportunity to watch in excess of 100 broadcasting stations. Many of the entering high school students have grown up with video games. They have been externally entertained for their entire lives. Schools have now inherited this generation for whom traditional means of teaching are proving to be less effective. Modern-day students are rather bold about wanting to know how certain knowledge will help them. They want justification and proof that the information they are being expected to learn will serve them in some useful way. The act of leaving the classroom and solving a problem that had a three-dimensional solution seemed to be foreign to the students. However, it is this type of problem solving that schools need to be teaching.

Observations that were of concern involved students lacking rudimentary knowledge of such concepts as direction. Although students had maps of the campus that included a number of latitude and longitude markings, i.e., the location of the front door of the school, some had to be guided in the general direction in which to walk. It appeared that some students did not comprehend that if the GPS latitude indicated a marking of 33.13445, then the latitude that had to be discovered was 33.01233 and that they would need to walk south of their location in the direction of the school’s baseball field.

Some students had more difficulty with basic direction. While working on mapping activities with students, the direction of north was identified and indicated by the researcher who stated “that way is north” and pointed in that direction. The students were

reassured that it was a statement of fact and not a type of virtual reality. In several different cases, students would hear that instruction and ask which way a corresponding direction, for example, west, was. This exercise reinforced other basic learning experiences in which the students had been involved, but did not fully comprehend initially. Because “west” suddenly became important for finding the next clue, students quickly comprehended the lesson on direction.

Although most of the students had never used a GPS before, learning how was not a major obstacle. The GPSs are not more complicated than most of the cell phones many of the students own. In addition, only some features of the GPS were used. The students did not mark any waypoints or navigate to any marked waypoints, which simplified the technology. The biggest challenge for the students was consolidating information so that they could solve their mathematics problem to identify the campus locations of certain positions. As students participated in more activities, most of them did become more comfortable with the multiple steps involved to accomplish the tasks required of the mapping activities.

By combining the use of GPSs with activities such as the ones outlined in this dissertation, many of the International Society for Technology in Education (ISTE, 2007) standards for technology can be met. Because of the difficulty some students had with all or parts of the activities, the more they are exposed to multiple objectives of the ISTE standards, the more accomplished they will become.

Because GPS technology is relatively new, many teachers may have had little to no experience with the devices. Some may have used a GPS designed for use in an automobile, but not for recreational purposes such as geocaching. If a teacher wished to

replicate this study, he or she would need to do several basic things. First, he or she would have to become familiar with the basic functions of a GPS. This can be accomplished in several different ways. The first and, perhaps, easiest way would be to ask a friend who participates in the sport of geocaching. Learning to operate a GPS would come quickly after spending some afternoons participating in the sport. In addition, by becoming acquainted with geocaching, the teacher could begin to develop his or her own ideas of incorporating similar activities into classrooms lessons.

Learning how to operate a GPS could be accomplished by reading a book on the subject. Several have been written about the subject, including *GPS for Dummies* (McManara, 2008) and *Geocaching for Dummies* (McManara, 2004). Both are written in the “user friendly” style for which the *Dummies* series is known. Both books are topically thorough that provide the reader with opportunities to extract information as is needed. Several other books on the market offer sound, complete information without the extra comprehensiveness of the *Dummies* books. Local bookstores and libraries are certainly worthy of visits. Also, do not be quick to bypass a book with an older copyright. The book *Using GPS: Finding Your Way with the Global Positioning System* (Grubbs, 1999), which is 10 years old, remains informative. The older books do not contain information on the technology of the newer GPS units but the basic information is still relevant.

Internet websites are another valuable resource. Geocaching.com is one of the more popular sites. Although it requires a membership, the basic level of that membership is free. The popularity of the site stems from its prominence as an internet source for finding cache sites. Geocaches come in various forms. They can range from being small prizes hidden in a camouflaged box with the coordinates listed on the Geocaching.com

website to puzzle caches that require participants to answer questions or solve problems to obtain the cache's location. The puzzle type of geocache is perhaps the one most teachers would be interested in studying.

Another valuable site for GPS information of all types is the GPS section of the U.S. Geological Survey (see USGS, <http://education.usgs.gov/common/lessons/gps.html>). This site has an impressive list of GPS resources and is a "must see" website. Teachers of all disciplines can find interesting information and those in the physical sciences field will find more information than they may be able to use.

The most difficult aspect of incorporating using a GPS in the classroom is cost. An entry level, recreational GPS unit has an average cost of \$100. For a GPS activity to be effective, a maximum of three students need to be assigned to one GPS unit. A class of 30 students requires 10 GPSs. This set of 10 would have a base cost of \$1,000. Although this is a daunting cost there are various ways to obtain this technology. Sets can be accumulated during the course of several years if a teacher obtains a few units each year with classroom materials funds. Smart shopping on the internet can often reveal bargain and discounted prices, especially for GPS models that are being discontinued due to their design or unpopular features. Although these units are not the newest technology, they are perfectly adequate for classroom use. Sometimes, allocated funds must be spend prior to fiscal year's end; the school's technology committee could vote to use some of those funds for GPSs. Grants also can be written to obtain this technology. Innovative teachers can manage to make the impossible, possible.

Each GPS purchase requires a set of decisions. Recreational GPSs can range in cost between \$100 and \$700. For practical use in the classroom the less expensive GPSs

have all of the features that most teachers would need. Extras such as an electronic compass or a barometer, which add to the cost of a unit, are not needed for classroom use. An important decision regarding the purchase of a GPS involves the teacher's desire to transfer information from the GPS unit to a computer. Reasons for interfacing with a PC include keeping track of waypoints that may be marked. Mapping software can be purchased, but must be used with a GPS unit that has the capability to send and receive data. If no data transfer is needed, then GPSs without a computer connectivity features are sufficient. Virtual games are available with some units. Several Garmin Company (see <http://www.garmin.com/garmin/cms/site/us>) models include such games. These games place the player in the physical role of navigating through a maze or smacking the Geko or several other challenges. This is a fun way for children to get physical exercise.

Limitations

One of the problems that occurred was one that was not anticipated. For the past several years, the weather in central Alabama in December has been mild through the end of the fall semester. The weather did turn cool most years, but not until the third week of December. The first day for which an activity had been planned was extremely cold. The temperature was in the mid twenties and puddles of water in the parking lot had frozen. Because one of the treatment protocol groups met during the first scheduling block, both the temperature and ice were a concern. Hence, the activity was postponed until the following Monday. The researcher met with the classes about the situation and informed the students that they would participate in activity after the upcoming weekend. It was predicted that the temperature would remain cold through the following Monday, but it would not be below freezing. The students were told to wear warm coats and gloves on

Monday with a hat or a cap if they wanted (outside only). This appealed to many of the males because wearing caps at schools is against the dress code. The following Monday the students had the option of not doing the activity, but they all chose to participate.

The weather also was a factor for the second activity. School started late on that day due to the threat of icy roads. Although the school began after the first scheduling block ended, the students reported to their first-block class anyway, and the activity was conducted. Because it was later in the day, the temperature was warmer. The students were still given the option of not participating. Several of the students, mostly females, chose not to participate but later changed their minds and joined groups that were already working through the activity. This was the most trouble the researcher had with students for the entire treatment period. One factor could have been that the students were outside of their normal routine. Another factor was that they had a substitute teacher that day. The students who chose not to participate in the activities remained in the classroom and worked on review problems to use their educational time wisely. They may have thought that the absence of their teacher would have yielded them some social time. Regardless, most of the students who chose not to participate that day did eventually participate. The fourth-block class presented none of these issues. The weather for the third activity was not bad, and the fourth activity coincided with weather conditions the researcher had been expecting for the entire 3-week period.

Because this was a structured treatment, the window of opportunity was not very flexible. It is recommended that teachers who choose this type of activity as an instructional tool need to be well organized and equipped with contingency plans (i.e., another day's lesson) in the event that the weather is inclement. Depending upon the

region of the country, cold or rainy weather may not last for long periods. It is conceivable for regions of the country that receive cold weather to conduct this activity regardless because many students living in colder climates may already participate in various outdoor activities and regularly attend school dressed appropriately. A blanket of snow also could yield a larger variety of hiding places.

Another unforeseen challenge was the issue of mugglers. For each activity where clues were hidden, some clues disappeared each time. It is not known if participating students found clues for the other groups and took them or if other students—ones not involved in the study—happened upon them. Also, sometimes a group accidentally found another group's clue and took it, not being careful to read the label. If this was discovered, then the group was asked to carefully replace the clue so the activity would not be ruined for classmates. Both of these issues can be solved if there are several people assisting with the administration of the activities. This could be difficult if it is a classroom activity and the teacher is alone in his or her endeavors. If two teachers from different levels of schools, for example, one high school and one elementary school were working together, then the high school students could assist the teachers with the younger students.

Recommendations for Future Research

Although GPSs are being used in classrooms across the country, the practitioners of this technology are individuals who have a personal interest in it. These individuals are seeing the advantages the use of GPSs can have in the classroom. This dissertation is one of the first on the subject, and whereas it has its limitations, it also is initiating the documentation of using GPSs in the classroom. Future research in this area needs to expand in various directions. Because being competitive internationally in mathematics is

such a national concern for this county, more studies that incorporate a GPS in mathematics should be designed. This particular study could be replicated on a broader scale for a longer time period. A similar study could include qualitative data.

Research studies across the curriculum should be considered. Much of the GPS literature for this research presented activities for disciplines other than mathematics. Geography lends itself naturally to the integration of GPSs. Some of the more advanced activities that were conducted with college students were multidisciplinary. Similar activities can be performed on a local school campus in a smaller format.

A well-designed GPS activity places the student in the position of three-dimensional problem solving. Solving this kind of a task requires not only a base knowledge of the assignment, but the skills and creativity to know how to apply it. All of this commands the student to be an active participant in his or her own learning. Twenty-first century students require twenty-first century teaching strategies.

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APPENDIX A

Informed Consent for Research Study

Office of Research
 Office of the Chair
 Institutional Review Board for the
 Protection of Human Subjects

THE UNIVERSITY OF
ALABAMA
 R E S E A R C H

January 7, 2009

Lisa Buck
 BLPIB
 College of Education
 The University of Alabama

Re: IRB # 09-OR-003 "An Examination of Student Attitudes Towards
 Mathematics and Mathematical Achievement after Completing a GPS
 Mapping Project"

Dear Ms. Buck:

The University of Alabama Institutional Review Board has granted
 approval for your proposed research.

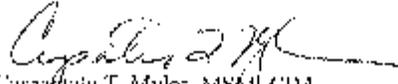
Your protocol has been given expedited approval according to 45 CFR
 part 46. Approval has been given under expedited review category 7 as
 outlined below:

*(7) Research on individual or group characteristics or behavior
 (including but not limited to research on perception, cognition,
 motivation, identity, language, communication, cultural beliefs or
 practices, and social behavior) or research involving surveys, interviews,
 oral history, focus group, program evaluation, human factors evaluation,
 or quality assurance methodologies.*

Should you need to submit any further correspondence regarding this
 proposal, please include the assigned IRB application number. Please use
 reproductions of the IRB approved informed consent form to obtain
 consent from your participants.

Good luck with your research.

Sincerely,


 Carnathan T. Myles, MSW, CIM
 Director & Research Compliance Officer
 Office for Research Compliance
 The University of Alabama



For more information, call 205-
 886-8200
 TDD: 205-886-8200
 205-886-8200
 205-886-8200

Dear Students and Parents,

My name is Lisa Buck and I am working on an advanced degree at the University of Alabama. I am conducting research on using GPS units to teach the concept of area for one of the math classes. The purpose of the research is to determine if the use of GPS devices in the math classroom will improve student achievement and motivation in finding the area of various sites or objects. During the research, the students will be taught how to use and read a GPS (global positioning system) unit. The students will be using these GPS units to calculate the area of different parts of our school campus. They will first take a test on finding the area of triangles. They will then be taught the use of the GPS units and will participate in the activity. They will then take another test on finding the area of triangles. Let me stress, the results of the tests **will not** affect their Algebra grade. They will also be given a short survey regarding their opinions on using the GPS units for learning about area. This entire process will take no more than a total of four class periods to complete.

This study is strictly voluntary for the students. If they elect to participate in the study, they may withdraw from the study at any time without penalty. No grades will be given on any of the activities for the study and their classroom grades will not be affected in any way. In addition, students' names will not be required on the tests or used in reporting the findings as to assure confidentiality. The researcher will be the only individual to have access to the students' original data.

Because GPS units work from satellite signals, they must be used outside. The entire activity will take place on the campus of West Blocton High School. This minimizes the risks of injury that could result from crossing the street or going to a property that is steep or excessively unlevelled. The risks for injuries that could occur from being outside are minimized by staying on the school campus.

If you have any questions, please feel free to contact me, Lisa Buck at 205-938-2825, or my university advisor, Dr. Margaret Rice, 205-348-1165. If you have any questions regarding your rights as a research subject, contact the Institutional Review Board, University of Alabama, Tuscaloosa, AL 35487, (Dr. Tanta Myles, 205-348-5746).

Attached to this letter is an Informed Consent Form for parents and an Informed Assent Form for students. Your signature on the Consent Form indicates that you have read and understand the information provided above and on the Consent Form, that you willingly agree to participate, that you may withdraw your consent at any time and you may choose not to participate without penalty, that you will receive a copy of the Consent Form, and that you are not waiving any legal claims, right or remedies.

Student Assent Form

I am doing a study to try to learn whether the use of GPS units is helpful in teaching the concept of area.

If you agree to be in my study, you will be taught how to use and read a GPS (global positioning system) unit. You will be using these GPS units to calculate the area of different parts of our school campus. You will first take a test on finding the area of triangles. You will then be taught the use of the GPS unit and will participate in the activity. You will then take another test on finding the area of triangles. The results of the tests **will not** affect your Algebra grade. You will also take a short survey regarding your opinions on using the GPS units for learning about area. This entire process will take no more than a total of four class periods to complete.

You can ask questions at any time that you might have about this study. Also, if you decide at any time not to finish, you may stop whenever you want.

Signing this paper means that you have read this or had it read to you and that you want to be in the study. If you don't want to be in the study, don't sign the paper. Remember, being in the study is up to you, and no one will be mad if you don't sign this paper or even if you change your mind later.

Signature of Participant _____ Date _____

Signature of Investigator _____ Date _____

Parental Consent Form

Your child is invited to be in a research study where he/she will be taught how to use and read a GPS (global positioning system) unit. Your child will be using GPS units to calculate the area of different parts of our school campus. Your child will first take a test on finding the area of triangles. Your child will then be taught the use of the GPS unit and will participate in the activity. Your child will then take another test on finding the area of triangles. The results of the tests **will not** affect your child's Algebra grade. They will also be given a short survey regarding their opinions on using the GPS units for learning about area. This entire process will take no more than a total of four class periods to complete.

Your child was selected as a possible participant because your child is in the grade where students learn about the area of objects. We ask that you read this form and ask any questions you may have before agreeing to have your child in this study.

The study: The purpose of this study is to examine whether the use of GPS units improve student achievement and motivation. If you agree to have your child in this study, your child will be asked to complete a pre and posttest on finding the area of triangles and to participate in an activity that involves measuring the area of various places on the school campus. The activity and tests will take approximately four math class periods to complete.

Risks/benefits: The only risks involved with this study involve the students going outside on the school campus. The risks of being outside are minimized because they will stay on the school campus in areas with which they are already familiar. Your child's math grade will be in no ways affected by the tests taken for this study or by any other aspect of the study. Your child's participation is strictly voluntary and your child may withdraw from the study at any time without penalty.

The benefits of the study include the students getting the advantage of participating in a project that would enhance a particular math concept. They will also learn to use a GPS unit. In addition, the students will be contributing to researcher's knowledge on this subject.

Confidentiality: The records of this study will be kept private. Names will not be required on the tests or surveys, so no subjects will be identified by name. Results will be reported as group results. Consent forms will be kept securely along with results for 7 years after completion of this study.

Voluntary nature/questions: Your decision whether or not to allow your child to participate will not affect your current or future relations with the school. If you decide to allow your child to participate, you are free to withdraw your child at any time without affecting your relationship with the school. Furthermore, your child may also discontinue participation at any time. The researcher conducting this study is Lisa Buck. You may ask any questions you have now. If you have any questions later, you may contact her at (205) 938-2825. If you have any questions about your rights as a research participant you may contact Ms. Tanta Myles, The University of Alabama Research Compliance Officer, at 205-348-5152.

Signature of Participant _____ Date _____

Signature of Investigator _____ Date _____

APPENDIX B

Algebra I Course of Study

ALGEBRA I

Algebra I is a formal, in-depth study of algebraic concepts and the real number system. In this course students develop a greater understanding of and appreciation for algebraic properties and operations. Algebra I reinforces concepts presented in earlier courses and permits students to explore new, more challenging content which prepares them for further study in mathematics. The course focuses on the useful application of course content and on the development of student understanding of central concepts. Appropriate use of technology allows students opportunities to work to improve concept development. As a result, students are empowered to perform mathematically, both with and without the use of technological tools.

Because of its importance in the development of mathematical empowerment, Algebra I is required for all students. The content is also a central component of formal state-level assessments at the secondary level. To better meet the needs of students of varying abilities, school systems may offer Algebra I (140 hours/one credit) or Algebra IA and IB (280 hours/two credits). If systems choose to offer Algebra I in the eighth grade, the course must include the minimum required content as prescribed in this course of study.

Number and Operations

Students will:

1. Simplify numerical expressions using properties of real numbers and order of operations, including those involving square roots, radical form, or decimal approximations.

Example: Express $\sqrt{27} + \sqrt{75}$ in simplified form.

- Applying laws of exponents to simplify expressions, including those containing zero and negative integral exponents

Algebra

2. Analyze linear functions from their equations, slopes, and intercepts.
 - Finding the slope of a line from its equation or by applying the slope formula
 - Determining the equations of linear functions given two points, a point and the slope, tables of values, graphs, or ordered pairs
 - Graphing two-variable linear equations and inequalities on the Cartesian plane

3. Determine characteristics of a relation, including its domain, range, and whether it is a function, when given graphs, tables of values, mappings, or sets of ordered pairs.

- Finding the range of a function when given its domain

Example: finding the range of $f(x) = -x^2 + 2x - 3$
when given the domain $\{-4, -2, 0, 2, 4\}$

4. Represent graphically common relations, including $x = \text{constant}$, $y = \text{constant}$, $y = x$, $y = \sqrt{x}$, $y = x^2$, and $y = |x|$.

- Identifying situations that are modeled by common relations, including $x = \text{constant}$, $y = \text{constant}$, $y = x$, $y = \sqrt{x}$, $y = x^2$, and $y = |x|$.

5. Perform operations of addition, subtraction, and multiplication on polynomial expressions.

- Dividing by a monomial

6. Factor binomials, trinomials, and other polynomials using GCF, difference of squares, perfect square trinomials, and grouping.

7. Solve multistep equations and inequalities including linear, radical, absolute value, and literal equations.

Examples: solving for x in problems such as $\sqrt{x} - 4 = 0$, $\sqrt{x-4} < 2$,
 $|x| = 6$, $|x+3| > 10$, and $y = mx + b$

- Writing the solution of an equation or inequality in set notation

Example: finding the solution of $|x+3| > 10$ to be $\{x \mid x > 7 \text{ or } x < -13\}$

- Graphing the solution of an equation or inequality
- Modeling real-world problems by developing and solving equations and inequalities, including those involving direct and inverse variation

8. Solve systems of linear equations and inequalities in two variables graphically or algebraically.

- Modeling real-world problems by developing and solving systems of linear equations and inequalities

9. Solve quadratic equations using the zero product property.
Approximating solutions graphically and numerically

Geometry

10. Calculate length, midpoint, and slope of a line segment when given coordinates of its endpoints on the Cartesian plane.
- Deriving the distance, midpoint, and slope formulas

Measurement

11. Solve problems algebraically that involve area and perimeter of a polygon, area and circumference of a circle, and volume and surface area of right circular cylinders or right rectangular prisms.
- Applying formulas to solve word problems

Example finding the radius of a circle with area 75 square inches

Data Analysis and Probability

12. Compare various methods of data reporting, including scatterplots, stem-and-leaf plots, histograms, box-and-whisker plots, and line graphs, to make inferences or predictions.
- Determining effects of linear transformations of data
- Example: The mean score on an algebra test is 78. If the teacher adds five points to each student's grade, the mean score will be 83.
- Determining effects of outliers
 - Evaluating the appropriateness of the design of a survey
13. Identify characteristics of a data set, including measurement or categorical and univariate or bivariate.
- Example: conducting a survey of 100 students to determine whether boys and girls prefer to watch the same genres of movies to get a bivariate, categorical data set
14. Use a scatterplot and its line of best fit or a specific line graph to determine the relationship existing between two sets of data, including positive, negative, or no relationship.
15. Estimate probabilities given data in lists or graphs.
- Comparing theoretical and experimental probabilities

APPENDIX C

Attitude Toward Mathematics Inventory (ATMI) Items

and GPS Attitude Survey Items

The following document comprises the instructions to students and the items in order of presentation on the Attitudes Toward Mathematics Inventory (ATMI), which was developed and copyrighted in 1996 by Dr. Martha Tapia, and used for this research.

ATTITUDES TOWARD MATHEMATICS INVENTORY

Directions: This inventory consists of statements about your attitude toward mathematics. There are no correct or incorrect responses. Read each item carefully. Please think about how you feel about each item. Enter the letter that most closely corresponds to how each statement best describes your feelings. Please answer every question.

PLEASE USE THESE RESPONSE CODES:

A – Strongly Disagree B – Disagree C – Neutral D – Agree E – Strongly Agree

1. Mathematics is a very worthwhile and necessary subject.
2. I want to develop my mathematical skills.
3. I get a great deal of satisfaction out of solving a mathematics problem.
4. Mathematics helps develop the mind and teaches a person to think.
5. Mathematics is important in everyday life.
6. Mathematics is one of the most important subjects for people to study.
7. High school math courses would be very helpful no matter what I decide to study.
8. I can think of many ways that I use math outside of school.
9. Mathematics is one of my most dreaded subjects.
10. My mind goes blank and I am unable to think clearly when working with mathematics.
11. Studying mathematics makes me feel nervous.
12. Mathematics makes me feel uncomfortable.
13. I am always under a terrible strain in a math class.
14. When I hear the word mathematics, I have a feeling of dislike.
15. It makes me nervous to even think about having to do a mathematics problem.
16. Mathematics does not scare me at all.
17. I have a lot of self-confidence when it comes to mathematics.
18. I am able to solve mathematics problems without too much difficulty.
19. I expect to do fairly well in any math class I take.
20. I am always confused in my mathematics class.
21. I feel a sense of insecurity when attempting mathematics.
22. I learn mathematics easily.

23. I am confident that I could learn advanced mathematics.
24. I have usually enjoyed studying mathematics in school.
25. Mathematics is dull and boring.
26. I like to solve new problems in mathematics.
27. I would prefer to do an assignment in math than to write an essay.
28. I would like to avoid using mathematics in college.
29. I really like mathematics.
30. I am happier in a math class than in any other class.
31. Mathematics is a very interesting subject.
32. I am willing to take more than the required amount of mathematics.
33. I plan to take as much mathematics as I can during my education.
34. The challenge of math appeals to me.
35. I think studying advanced mathematics is useful.
36. I believe studying math helps me with problem solving in other areas.
37. I am comfortable expressing my own ideas on how to look for solutions to a difficult problem in math.
38. I am comfortable answering questions in math class.
39. A strong math background could help me in my professional life.
40. I believe I am good at solving math problems.

GPS Attitude Survey Items

The following items comprise the researcher-designed GPS Attitude Study that was administered to the students assigned to the treatment protocol for this research study. Students were asked to respond to each statement using a 5-point, Likert-type scale that represented level of agreement or disagreement with the item: 1 = Strongly Disagree, 2 = Somewhat Disagree, 3 = No Opinion, 4 = Somewhat Agree, and 5 = Strongly Agree. The instructions to students are included.

Each statement below expresses an opinion about math and using a GPS (Global Positioning System) to do math. You are asked to express the extent to which you agree or disagree with each statement, using the scale at the top of the instrument: Strongly Disagree, Somewhat Disagree, No Opinion, Somewhat Agree, Strongly Agree. Circle the number to the right of each statement which corresponds to how you feel about the statement.

1. I found it easy to learn to use the GPS.
2. I liked doing a GPS activity.
3. I want to do more GPS activities.
4. This would be a good activity for any grade level.
5. I would like to use the GPS for learning other things.
6. I can understand how this activity has “real life” uses.
7. Learning about area was much more fun using a GPS.
8. I understood the concept of finding area better than I would have without using the GPS.
9. Using a GPS helped me better learn how to find areas.
10. I felt more motivated to learn about area while using the GPS.
11. My academic time could have been better spent in the classroom rather than outside using a GPS.
12. I would be more motivated to learn about other math topics if we could use a GPS.
13. Using a GPS helped me learn math better.
14. Using a GPS made me want to do more math problems.
15. I could do better in math if I could do more activities when learning new material.

APPENDIX D
GPS Mapping Activities

Geocache Exercise #1

Make sure your GPS is set to read decimal degrees.

The latitude and longitude degrees have been filled in for you.

Solve the following problems to fill in the numbers for your latitude and longitude. If the answer has more than a single digit answer, then put each number in a different blank.

Answers can have a 1, 2, or 3 digit answer. You should have no 4 or more digit answers. If an answer has a decimal or is negative, ignore the decimal or negative sign for the purpose of this exercise.

All clues are in plastic Easter eggs. The answer to this problem will take you to your next clue. You will find 2 eggs and then your prize. It will be in a zip lock bag. To make sure you have not accidentally found the wrong egg or bag, all of your eggs and bag have the same number on them as your GPS.

Use your map and GPS to guide you. **Do not enter waypoints.**

When you finish, meet back in your classroom.

GPS Activity Answer Key Document

GPS 1 11372/12891 11356/12688 11294/12783 11276/12887

Latitude 33. ____ ____ ____ ____ ____

Longitude 87. ____ ____ ____ ____

Find the difference

$$-95 - 18 = \mathbf{-113}$$

Simplify the following expression.

$$16 \div 4^2 - 1.6 + 3.8 \cdot 2 = \mathbf{7}$$

Divide:

$$6 \div (-3) = \mathbf{-2}$$

Find the product:

$$-32 \cdot 4 = \mathbf{-128}$$

Simplify the following expression.

$$12 \div 2^2 - .5 + 1.3 \cdot 5 = \mathbf{9}$$

Solve

$$10x + 4 = 14 \rightarrow \mathbf{1}$$

Solve:

$$4x + 25 - 2x + 25 = 28 \rightarrow \mathbf{-11}$$

Simplify:

$$-(-4) - (-2) + (-9) = \mathbf{-3}$$

Find the difference

$$-33 - 23 = \mathbf{-56}$$

Divide:

$$24 \div (-2) = \mathbf{-12}$$

Find the product:

$$-17 \cdot 4 = \mathbf{-68}$$

Simplify the following expression.

$$100 \div 5^2 - 6.6 + 2.65 \cdot 4 = \mathbf{8}$$

Find the difference

$$-89 - 23 = \mathbf{-112}$$

Simplify the following expression.

$$12 \div 2^2 - .5 + 1.8 \cdot 5 - 2.5 = \mathbf{9}$$

Divide:

$$8 \div (-2) = \mathbf{-4}$$

Solve:

$$-48 \div 4 = \mathbf{-12}$$

Solve

$$3x + 5 = 239 \rightarrow \mathbf{78}$$

Simplify the following expression.

$$27 \div 3^2 - 8.1 + 2.7 \cdot 3 = \mathbf{3}$$

11276/12887

Solve:

$$8x + 61 - 4x + 39 = 78 \rightarrow \mathbf{-11}$$

Simplify:

$$-(-4) - (-3) + (-9) = \mathbf{-2}$$

Find the difference

$$-43 - 33 = \mathbf{-76}$$

Divide:

$$48 \div (-4) = \mathbf{-12}$$

Find the product:

$$-22 \cdot 4 = \mathbf{-88}$$

Simplify the following expression.

$$16 \div 4^2 - 1.6 + 3.8 \cdot 2 = \mathbf{7}$$

GPS 2 11381/12905 11309/12693 11289/12884 11282/12884Latitude 33. ____ ____ ____ ____ ____Longitude 87. ____ ____ ____ ____

Find the difference

$$-95 - 18 = \mathbf{-113}$$

Simplify the following expression.

$$16 \div 4^2 - 1.6 + 3.8 \cdot 2 = \mathbf{7}$$

Divide:

$$6 \div (-6) = \mathbf{-1}$$

Find the product:

$$-32 \cdot 4 - 1 = \mathbf{-129}$$

Simplify the following expression.

$$12 \div 2^2 - 9.5 + 1.3 \cdot 5 = \mathbf{0}$$

Solve

$$10x + 4 = 54 \rightarrow \mathbf{5}$$

Solve:

$$4x + 25 - 2x + 25 = 28 \rightarrow \mathbf{-11}$$

Find the difference

$$-27 - 3 = \mathbf{-30}$$

Simplify the following expression.

$$12 \div 2^2 - .5 + 1.8 \cdot 5 - 2.5 = \mathbf{9}$$

Divide:

$$24 \div (-2) = \mathbf{-12}$$

Find the product:

$$-23 \cdot 3 = \mathbf{-69}$$

Simplify:

$$-(-4) - (-2) + (-9) = \mathbf{-3}$$

11289/12884

Find the difference

$$-89 - 23 = \mathbf{-112}$$

Simplify the following expression.

$$12 \div 2^2 - 1.5 + 1.8 \cdot 5 - 1.5 = \mathbf{8}$$

Divide:

$$27 \div (-3) = \mathbf{-9}$$

Solve:

$$-48 \div 4 = \mathbf{-12}$$

Solve

$$4x + 5 = 357 \rightarrow \mathbf{88}$$

Simplify the following expression.

$$27 \div 3^2 - 8.1 + 2.7 \cdot 3 = \mathbf{3}$$

Solve:

$$8x + 61 - 6x + 39 = 78 \rightarrow \mathbf{-11}$$

Simplify:

$$-(-4) - (-3) + (-9) = \mathbf{-2}$$

Find the difference

$$-44 - 38 = \mathbf{-82}$$

Divide:

$$48 \div (-4) = \mathbf{-12}$$

Find the product:

$$-22 \cdot 4 = \mathbf{-88}$$

Simplify the following expression.

$$16 \div 4^2 - 4.6 + 3.8 \cdot 2 + 3 = \mathbf{7}$$

GPS 3 11391/12919 11285/12738 11287/12803 11267/12938Latitude 33. ____ ____ ____ ____ ____Longitude 87. ____ ____ ____ ____

Find the difference

$$-95 - 18 = \mathbf{-113}$$

Simplify the following expression.

$$12 \div 2^2 - .5 + 1.3 \cdot 5 = \mathbf{9}$$

Divide:

$$6 \div (-6) = \mathbf{-1}$$

Find the product:

$$-32 \cdot 4 - 1 = \mathbf{-129}$$

Simplify the following expression.

$$16 \div 4^2 - 7.6 + 3.8 \cdot 2 = \mathbf{1}$$

Solve

$$10x + 2 = 92 \rightarrow \mathbf{9}$$

Solve:

$$4x + 25 - 2x + 25 = 28 \rightarrow \mathbf{-11}$$

Simplify:

$$-(-3) - (-4) + (-9) = \mathbf{-2}$$

Find the difference

$$-53 - 32 = \mathbf{-85}$$

Divide:

$$24 \div (-2) = \mathbf{-12}$$

Find the product:

$$-17 \cdot 5 + 17 = \mathbf{-68}$$

Simplify the following expression.

$$100 \div 5^2 - 6.6 + 2.65 \cdot 4 = \mathbf{8}$$

Find the difference

$$-89 - 23 = \mathbf{-112}$$

Simplify the following expression.

$$12 \div 2^2 - 1.5 + 1.8 \cdot 5 - 1.5 = \mathbf{8}$$

Simplify the following expression.

$$16 \div 4^2 - 4.6 + 3.8 \cdot 2 + 3 = \mathbf{7}$$

Solve:

$$-48 \div 4 = \mathbf{-12}$$

Solve

$$3x + 3 = 243 \rightarrow \mathbf{80}$$

Simplify the following expression.

$$27 \div 3^2 - 8.1 + 2.7 \cdot 3 = \mathbf{3}$$

Solve:

$$8x + 61 - 6x + 39 = 78 \rightarrow \mathbf{-11}$$

Simplify:

$$-(-4) - (-3) + (-9) = \mathbf{-2}$$

Find the difference

$$-33 - 34 = \mathbf{-67}$$

Divide:

$$48 \div (-4) = \mathbf{-12}$$

Find the product:

$$-22 \cdot 4 - 5 = \mathbf{-93}$$

Simplify the following expression.

$$16 \div 4^2 - .6 + 3.8 \cdot 2 = \mathbf{8}$$

GPS 4 11419/12897 11283/12708 11242/12794 11272/12936Latitude 33. ____ ____ ____ ____Longitude 87. ____ ____ ____ ____

Find the difference

$$-96 - 18 = \mathbf{-114}$$

Simplify the following expression.

$$16 \div 4^2 - 7.6 + 3.8 \cdot 2 = \mathbf{1}$$

Divide:

$$27 \div (-3) = \mathbf{-9}$$

Find the product:

$$-32 \cdot 4 = \mathbf{-128}$$

Simplify the following expression.

$$12 \div 2^2 - .5 + 1.3 \cdot 5 = \mathbf{9}$$

Solve

$$10x + 4 = 74 \rightarrow \mathbf{7}$$

Solve:

$$4x + 25 - 2x + 25 = 28 \rightarrow \mathbf{-11}$$

Simplify:

$$-(-3) - (-4) + (-9) = \mathbf{-2}$$

Find the difference

$$-63 - 20 = \mathbf{-83}$$

Divide:

$$24 \div (-2) = \mathbf{-12}$$

Find the product:

$$-7 \cdot 10 = \mathbf{-70}$$

Simplify the following expression.

$$100 \div 5^2 - 6.6 + 2.65 \cdot 4 = \mathbf{8}$$

Find the difference

$$-89 - 23 = \mathbf{-112}$$

Simplify the following expression.

$$12 \div 2^2 - 5.5 + 1.8 \cdot 5 - 2.5 = \mathbf{4}$$

Divide:

$$8 \div (-4) = \mathbf{-2}$$

Solve:

$$-36 \div 3 = \mathbf{-12}$$

Solve

$$3x + 2 = 239 \rightarrow \mathbf{79}$$

Simplify the following expression.

$$27 \div 3^2 - 7.1 + 2.7 \cdot 3 = \mathbf{4}$$

Solve:

$$8x + 61 - 6x + 39 = 78 \rightarrow \mathbf{-11}$$

Simplify:

$$-(-4) - (-3) + (-9) = \mathbf{-2}$$

Find the difference

$$-39 - 33 = \mathbf{-72}$$

Divide:

$$48 \div (-4) = \mathbf{-12}$$

Find the product:

$$-22 \cdot 4 - 5 = \mathbf{-93}$$

Simplify the following expression.

$$16 \div 4^2 - 2.6 + 3.8 \cdot 2 = \mathbf{6}$$

GPS 5 11435/12865 11269/12725 11228/12820 11278/12933Latitude 33. ____ ____ ____ ____Longitude 87. ____ ____ ____ ____

Find the difference

$$-96 - 18 = \mathbf{-114}$$

Simplify the following expression.

$$27 \div 3^2 - 8.1 + 2.7 \cdot 3 = \mathbf{3}$$

Divide:

$$15 \div (-3) = \mathbf{-5}$$

Find the product:

$$-32 \cdot 4 = \mathbf{-128}$$

Simplify the following expression.

$$12 \div 2^2 - 3.5 + 1.3 \cdot 5 = \mathbf{6}$$

Solve

$$10x + 4 = 54 \rightarrow \mathbf{5}$$

Solve:

$$4x + 25 - 2x + 25 = 28 \rightarrow \mathbf{-11}$$

Simplify:

$$-(-3) - (-4) + (-9) = \mathbf{-2}$$

Find the difference

$$-33 - 36 = \mathbf{-69}$$

Divide:

$$24 \div (-2) = \mathbf{-12}$$

Find the product:

$$-9 \cdot 8 = \mathbf{-72}$$

Simplify the following expression.

$$100 \div 5^2 - 9.6 + 2.65 \cdot 4 = \mathbf{5}$$

Find the difference

$$-89 - 23 = \mathbf{-112}$$

Simplify the following expression.

$$12 \div 2^2 - 7.5 + 1.8 \cdot 5 - 2.5 = \mathbf{2}$$

Divide:

$$16 \div (-2) = \mathbf{-4}$$

Solve:

$$-36 \div 3 = \mathbf{-12}$$

Solve

$$3x + 5 = 239 \rightarrow \mathbf{78}$$

Simplify the following expression.

$$27 \div 3^2 - 8.1 + 2.7 \cdot 3 = \mathbf{3}$$

Solve:

$$8x + 61 - 6x + 39 = 78 \rightarrow \mathbf{-11}$$

Simplify:

$$-(-4) - (-3) + (-9) = \mathbf{-2}$$

Find the difference

$$-10 - 18 = \mathbf{-28}$$

Divide:

$$48 \div (-4) = \mathbf{-12}$$

Find the product:

$$-22 \cdot 4 \cdot 5 = \mathbf{-93}$$

Simplify the following expression.

$$16 \div 4^2 - 5.6 + 3.8 \cdot 2 = \mathbf{3}$$

GPS 6 11442/12801 11271/12740 11222/12840 11290/12929Latitude 33. ____ ____ ____ ____ ____Longitude 87. ____ ____ ____ ____

Find the difference

$$-96 - 18 = \mathbf{-114}$$

Simplify the following expression.

$$16 \div 4^2 - 4.6 + 3.8 \cdot 2 = \mathbf{4}$$

Divide:

$$6 \div (-3) = \mathbf{-2}$$

Find the product:

$$-32 \cdot 4 = \mathbf{-128}$$

Simplify the following expression.

$$12 \div 2^2 - 0.5 + 1.3 \cdot 5 - 9 = \mathbf{0}$$

Solve

$$10x + 4 = 14 \rightarrow \mathbf{1}$$

Solve:

$$4x + 25 - 2x + 25 = 28 \rightarrow \mathbf{-11}$$

Simplify:

$$-(-3) - (-4) + (-9) = \mathbf{-2}$$

Find the difference

$$-45 - 26 = \mathbf{-71}$$

Divide:

$$24 \div (-2) = \mathbf{-12}$$

Find the product:

$$-17 \cdot 4 - 6 + 17 = \mathbf{-68}$$

Simplify the following expression.

$$100 \div 5^2 - 14.6 + 2.65 \cdot 4 = \mathbf{0}$$

Find the difference

$$-89 - 23 = \mathbf{-112}$$

Simplify the following expression.

$$12 \div 2^2 - 7.5 + 1.8 \cdot 5 - 2.5 = \mathbf{2}$$

Divide:

$$4 \div (-2) = \mathbf{-2}$$

Solve:

$$-48 \div 4 = \mathbf{-12}$$

Solve

$$3x + 5 = 257 \rightarrow \mathbf{84}$$

Simplify the following expression.

$$27 \div 3^2 - 11.1 + 2.7 \cdot 3 = \mathbf{0}$$

Solve:

$$8x + 61 - 6x + 39 = 78 \rightarrow \mathbf{-11}$$

Simplify:

$$-(-4) - (-3) + (-9) = \mathbf{-2}$$

Find the difference

$$-57 - 33 = \mathbf{-90}$$

Divide:

$$48 \div (-4) = \mathbf{-12}$$

Find the product:

$$-22 \cdot 4 - 4 = \mathbf{-92}$$

Simplify the following expression.

$$12 \div 2^2 - .5 + 1.3 \cdot 5 = \mathbf{9}$$

GPS 7 11468/12837 11329/12804 11235/12812 11276/12887Latitude 33. ____ ____ ____ ____Longitude 87. ____ ____ ____ ____

Find the difference

$$-96 - 18 = \mathbf{-114}$$

Simplify the following expression.

$$16 \div 4^2 - 2.6 + 3.8 \cdot 2 = \mathbf{6}$$

Divide:

$$16 \div (-2) = \mathbf{-8}$$

Find the product:

$$-32 \cdot 4 = \mathbf{-128}$$

Simplify the following expression.

$$12 \div 2^2 - 6.5 + 1.3 \cdot 5 = \mathbf{3}$$

Solve

$$10x + 4 = 74 \rightarrow \mathbf{7}$$

Solve:

$$4x + 25 - 2x + 25 = 28 \rightarrow \mathbf{-11}$$

Simplify:

$$-(-4) - (-2) + (-9) = \mathbf{-3}$$

Find the difference

$$-20 - 9 = \mathbf{-29}$$

Divide:

$$24 \div (-2) = \mathbf{-12}$$

Find the product:

$$-20 \cdot 4 = \mathbf{-80}$$

Simplify the following expression.

$$100 \div 5^2 - 10.6 + 2.65 \cdot 4 = \mathbf{4}$$

Find the difference

$$-89 - 23 = \mathbf{-112}$$

Simplify the following expression.

$$12 \div 2^2 - 6.5 + 1.8 \cdot 5 - 2.5 = \mathbf{3}$$

Divide:

$$10 \div (-2) = \mathbf{-5}$$

Solve:

$$-36 \div 3 = \mathbf{-12}$$

Solve

$$2x + 5 = 167 \rightarrow \mathbf{81}$$

Simplify the following expression.

$$27 \div 3^2 - 9.1 + 2.7 \cdot 3 = \mathbf{2}$$

11276/12887

Solve:

$$8x + 61 - 6x + 39 = 78 \rightarrow \mathbf{-11}$$

Simplify:

$$-(-4) - (-3) + (-9) = \mathbf{-2}$$

Find the difference

$$-43 - 33 = \mathbf{-76}$$

Divide:

$$48 \div (-4) = \mathbf{-12}$$

Find the product:

$$-22 \cdot 4 = \mathbf{-88}$$

Simplify the following expression.

$$16 \div 4^2 - 1.6 + 3.8 \cdot 2 = \mathbf{7}$$

GPS 8 11465/12783 11294/12777 11261/12851 11282/12884Latitude 33. ____ ____ ____ ____Longitude 87. ____ ____ ____ ____

Find the difference

$$-96 - 18 = \mathbf{-114}$$

Simplify the following expression.

$$16 \div 4^2 - 2.6 + 3.8 \cdot 2 = \mathbf{6}$$

Divide:

$$15 \div (-3) = \mathbf{-5}$$

Find the product:

$$-32 \cdot 4 + 1 = \mathbf{-127}$$

Simplify the following expression.

$$12 \div 2^2 - 1.5 + 1.3 \cdot 5 = \mathbf{8}$$

Solve

$$10x + 4 = 34 \rightarrow \mathbf{3}$$

Solve:

$$4x + 25 - 2x + 25 = 28 \rightarrow \mathbf{-11}$$

Simplify:

$$-(-3) - (-4) + (-9) = \mathbf{-2}$$

Find the difference

$$-72 - 22 = \mathbf{-94}$$

Divide:

$$24 \div (-2) = \mathbf{-12}$$

Find the product:

$$-17 \cdot 4 - 9 = \mathbf{-77}$$

Simplify the following expression.

$$100 \div 5^2 - 7.6 + 2.65 \cdot 4 = \mathbf{7}$$

Find the difference

$$-89 - 23 = \mathbf{-112}$$

Simplify the following expression.

$$12 \div 2^2 - 3.5 + 1.8 \cdot 5 - 2.5 = \mathbf{6}$$

Divide:

$$8 \div (-8) = \mathbf{-1}$$

Solve:

$$-36 \div 3 = \mathbf{-12}$$

Solve

$$1x + 5 = 90 \rightarrow \mathbf{85}$$

Simplify the following expression.

$$27 \div 3^2 - 10.1 + 2.7 \cdot 3 = \mathbf{1}$$

Solve:

$$8x + 61 - 6x + 39 = 78 \rightarrow \mathbf{-11}$$

Simplify:

$$-(-4) - (-3) + (-9) = \mathbf{-2}$$

Find the difference

$$-44 - 38 = \mathbf{-82}$$

Divide:

$$48 \div (-4) = \mathbf{-12}$$

Find the product:

$$-22 \cdot 4 = \mathbf{-88}$$

Simplify the following expression.

$$16 \div 4^2 - 4.6 + 3.8 \cdot 2 + 3 = \mathbf{7}$$

GPS 9 11429/12716 11300/12776 11266/12869 11267/12938Latitude 33. ____ ____ ____ ____ ____Longitude 87. ____ ____ ____ ____

Find the difference
Simplify the following expression.
Divide:

$$\begin{aligned} -96 - 18 &= \mathbf{-114} \\ 16 \div 4^2 - 6.6 + 3.8 \cdot 2 &= \mathbf{2} \\ 27 \div (-3) &= \mathbf{-9} \end{aligned}$$

Find the product:
Simplify the following expression.
Solve

$$\begin{aligned} -32 \cdot 4 + 1 &= \mathbf{-127} \\ 12 \div 2^2 - 8.5 + 1.3 \cdot 5 &= \mathbf{1} \\ 10x + 4 = 64 &\rightarrow \mathbf{6} \end{aligned}$$

Solve:
Simplify:
Find the difference

$$\begin{aligned} 4x + 25 - 2x + 25 = 28 &\rightarrow \mathbf{-11} \\ -(-40) + (-4) + (-36) &= \mathbf{0} \\ -33 + 33 &= \mathbf{0} \end{aligned}$$

Divide:
Find the product:
Simplify the following expression.

$$\begin{aligned} 24 \div (-2) &= \mathbf{-12} \\ -17 \cdot 4 - 9 &= \mathbf{-77} \\ 100 \div 5^2 - 10.6 + 2.65 \cdot 4 &= \mathbf{6} \end{aligned}$$

Find the difference
Simplify the following expression.
Divide:

$$\begin{aligned} -89 - 23 &= \mathbf{-112} \\ 12 \div 2^2 - 3.5 + 1.8 \cdot 5 - 2.5 &= \mathbf{6} \\ 12 \div (-2) &= \mathbf{-6} \end{aligned}$$

Solve:
Solve
Simplify the following expression.

$$\begin{aligned} -36 \div 3 &= \mathbf{-12} \\ 2x + 5 = 177 &\rightarrow \mathbf{86} \\ 27 \div 3^2 - 2.1 + 2.7 \cdot 3 &= \mathbf{9} \end{aligned}$$

Solve:
Simplify:
Find the difference

$$\begin{aligned} 8x + 61 - 6x + 39 = 78 &\rightarrow \mathbf{-11} \\ -(-4) - (-3) + (-9) &= \mathbf{-2} \\ -33 - 34 &= \mathbf{-67} \end{aligned}$$

Divide:
Find the product:
Simplify the following expression.

$$\begin{aligned} 48 \div (-4) &= \mathbf{-12} \\ -22 \cdot 4 - 5 &= \mathbf{-93} \\ 16 \div 4^2 - .6 + 3.8 \cdot 2 &= \mathbf{8} \end{aligned}$$

GPS 10 11404/12706 11311/12879 11262/12881 11272/12936Latitude 33. ____ ____ ____ ____ ____Longitude 87. ____ ____ ____ ____

Find the difference

$$-96 - 18 = \mathbf{-114}$$

Simplify the following expression.

$$16 \div 4^2 - 8.6 + 3.8 \cdot 2 = \mathbf{0}$$

Divide:

$$16 \div (-4) = \mathbf{-4}$$

Find the product:

$$-32 \cdot 4 + 1 = \mathbf{-127}$$

Simplify the following expression.

$$12 \div 2^2 - 9.5 + 1.3 \cdot 5 = \mathbf{0}$$

Solve

$$10x + 4 = 64 \rightarrow \mathbf{6}$$

Solve:

$$4x + 25 - 2x + 25 = 28 \rightarrow \mathbf{-11}$$

Simplify:

$$-(-4) - (-2) + (-9) = \mathbf{-3}$$

Find the difference

$$-9 - 2 = \mathbf{-11}$$

Divide:

$$24 \div (-2) = \mathbf{-12}$$

Find the product:

$$-21 \cdot 4 - 3 = \mathbf{-87}$$

Simplify the following expression.

$$100 \div 5^2 - 5.6 + 2.65 \cdot 4 = \mathbf{9}$$

Find the difference

$$-89 - 23 = \mathbf{-112}$$

Simplify the following expression.

$$12 \div 2^2 - 3.5 + 1.8 \cdot 5 - 2.5 = \mathbf{6}$$

Divide:

$$8 \div (-4) = \mathbf{-2}$$

Solve:

$$-36 \div 3 = \mathbf{-12}$$

Solve

$$2x + 5 = 181 \rightarrow \mathbf{88}$$

Simplify the following expression.

$$27 \div 3^2 - 10.1 + 2.7 \cdot 3 = \mathbf{1}$$

Solve:

$$8x + 61 - 6x + 39 = 78 \rightarrow \mathbf{-11}$$

Simplify:

$$-(-4) - (-3) + (-9) = \mathbf{-2}$$

Find the difference

$$-39 - 33 = \mathbf{-72}$$

Divide:

$$48 \div (-4) = \mathbf{-12}$$

Find the product:

$$-22 \cdot 4 - 5 = \mathbf{-93}$$

Simplify the following expression.

$$16 \div 4^2 - 2.6 + 3.8 \cdot 2 = \mathbf{6}$$

GPS 11 11390/12708 11305/12883 11247/12914 11278/12933Latitude 33. ____ ____ ____ ____ ____Longitude 87. ____ ____ ____ ____

Find the difference

$$-95 - 18 = \mathbf{-113}$$

Simplify the following expression.

$$100 \div 5^2 - 5.6 + 2.65 \cdot 4 = \mathbf{9}$$

Divide:

$$6 \div (-0) = \mathbf{0}$$

Find the product:

$$-32 \cdot 4 + 1 = \mathbf{-127}$$

Simplify the following expression.

$$12 \div 2^2 - 9.5 + 1.3 \cdot 5 = \mathbf{0}$$

Solve

$$10x + 4 = 84 \rightarrow \mathbf{8}$$

Solve:

$$4x + 25 - 2x + 25 = 28 \rightarrow \mathbf{-11}$$

Find the difference

$$-33 + 33 = \mathbf{0}$$

Simplify:

$$-(-3) - (-1) + (-9) = \mathbf{-5}$$

Divide:

$$24 \div (-2) = \mathbf{-12}$$

Find the product:

$$-44 \cdot 2 = \mathbf{-88}$$

Simplify the following expression.

$$100 \div 5^2 - 11.6 + 2.65 \cdot 4 = \mathbf{3}$$

Find the difference

$$-89 - 23 = \mathbf{-112}$$

Simplify the following expression.

$$12 \div 2^2 - 5.5 + 1.8 \cdot 5 - 2 = \mathbf{4}$$

Divide:

$$8 \div (-2) - 3 = \mathbf{-7}$$

Solve:

$$-36 \div 3 = \mathbf{-12}$$

Solve

$$2x + 5 = 187 \rightarrow \mathbf{91}$$

Simplify the following expression.

$$27 \div 3^2 - 7.1 + 2.7 \cdot 3 = \mathbf{4}$$

Solve:

$$8x + 61 - 6x + 39 = 78 \rightarrow \mathbf{-11}$$

Simplify:

$$-(-4) - (-3) + (-9) = \mathbf{-2}$$

Find the difference

$$-10 - 18 = \mathbf{-28}$$

Divide:

$$48 \div (-4) = \mathbf{-12}$$

Find the product:

$$-22 \cdot 4 - 5 = \mathbf{-93}$$

Simplify the following expression.

$$16 \div 4^2 - 5.6 + 3.8 \cdot 2 = \mathbf{3}$$

Exercise #2

Make sure your GPS is set to read degrees, minutes, and seconds.

Sheet One

The degrees and minutes have been filled in for you since they will not change for this exercise. Find the latitude and longitude for each place listed. Fill in the seconds place; **round this number to the proper whole (2 digit) number.**

When you are finished meet back at the outdoor break area until everyone is finished. We will then return to the classroom.

Sheet Two

When you are back inside, plot the points you have found on your map. You may want to first label each line. Several have already been done for you. Label each point in some way so you will know what you have plotted (ex. Softball home plate can be sbhp).

Sheet Three

Find the area for the listed distances. Remember the formula for finding the area of a triangle – $\frac{1}{2}$ base x height. Remember, each block equals 25 feet. Four blocks equals 100 feet.

Exercise 2
Finding area

Find the Latitude and Longitude of the following points. Record your answer in degrees, minutes, and seconds. Round the seconds to the nearest whole number; for example if the latitude is $33^{\circ} 06' 23.8''$ it will round to $33^{\circ} 06' 24''$. If the latitude is $33^{\circ} 06' 23.3''$ it will round to $33^{\circ} 06' 23''$. Several have been filled in for you.

Location	Latitude	Longitude
School Marquee	$33^{\circ} 06' \underline{53''}$	$87^{\circ} 07' \underline{46''}$
Top of School Exit Drive (Right Side)	$33^{\circ} 06' \underline{\quad}$	$87^{\circ} 07' \underline{\quad}$
Softball Homeplate	$33^{\circ} 06' \underline{\quad}$	$87^{\circ} 07' \underline{\quad}$
Softball Right Field Foul Post	$33^{\circ} 06' \underline{\quad}$	$87^{\circ} 07' \underline{\quad}$
Top of Football Seats North End(Far End)	$33^{\circ} 06' \underline{\quad}$	$87^{\circ} 07' \underline{\quad}$
Door of Football Concession Stand	$33^{\circ} 06' \underline{\quad}$	$87^{\circ} 07' \underline{\quad}$
Baseball Left Field Post	$33^{\circ} 06' \underline{\quad}$	$87^{\circ} 07' \underline{\quad}$
Baseball Homeplate	$33^{\circ} 06' \underline{44''}$	$87^{\circ} 07' \underline{45''}$
Baseball Left Field 330 Post	$33^{\circ} 06' \underline{42''}$	$87^{\circ} 07' \underline{42''}$

Using your marked map, connect the following points by drawing a line between them.

- School Marquee to the Softball Right field Foul Post
- School Marquee to the top of School Exit Drive
- Top of School Exit Drive to Softball Right field Foul Post
- Softball Right field Foul Post to Softball Homeplate
- Softball Right field Foul Post to Door of Football Concession Stand
- Softball Homeplate to Top of Football Seats North End
- Softball Homeplate to Door of Football Concession Stand
- Softball Homeplate to Baseball Homeplate
- Baseball Left Field Post to Softball Homeplate
- Baseball Left Field Post Baseball Homeplate
- Baseball Homeplate to Baseball Left Field Post
- Baseball Homeplate to Baseball Left Field 330 Post

You will see that a number of right triangles are now formed. Using the formula for finding the area of a right triangle — $\frac{1}{2}$ base x height = area — find the areas for the following:

What is the area of the triangle formed by:

1. The School Marquee to the Softball Right field Foul Post to the top of School Exit Drive

Answer: _____

2. The Softball Homeplate to the Softball Right field Foul Post to the Top of Football Seats North End

Answer: _____

3. The Softball Homeplate to the Top of Football Seats North End to the Door of Football Concession Stand

Answer: _____

4. The Baseball Homeplate to Baseball Left Field Post to the Softball Homeplate

Answer: _____

5. The Baseball Homeplate to Baseball Left Field Post to the Baseball Left Field 330 Post

Answer: _____

Activity 3

Get into your groups of 3. Make sure your GPSs are set to decimal degrees. Solve the following problems. Each of the problems will give you an ordered pair. Plot your answers on your map. Remember, if the answer is a plus or minus IS important in this exercise. Go to this place on campus to retrieve your next clue. You have a hint of the latitude and longitude for each. After you have found your prize, return to the classroom.

GPS 1Divide: $-25 \div (-5)$ Find the difference: $-62 - 31 + 86$ **Hint 12776/12887****GPS 1**Divide $-16 \div (-8) =$ Evaluate $2j + 3k$ when $j = 2$ and $k = 1$ =**Hint 11285/12777****GPS 1**Find the product: $-3 \cdot 3 =$ Evaluate $2j + 3k$ when $j = 5$ and $k = 3$ =**Hint 11363/12701****GPS 2**Find the product: $-6 \cdot -2 =$ Simplify: $-(-4) - (-2) + (-9) =$ **Hint 11226/12878****GPS 2**Evaluate the expression $(3g-h)^2$ when $g = 2$ and $h = 5$. =Evaluate $2j + 3k$ when $j = 2$ and $k = 1$ =**Hint 11294/12777****GPS 2**Solve: $-7 \cdot 2 + 3 =$ Evaluate $2j + 3k$ when $j = 5$ and $k = 3$ =**Hint 11390/12708**

GPS 3

Solve the equation. Round your result to the whole number.

$$2.5x + 1.2 = 21.7 =$$

$$\text{Simplify: } -(-4) - (-2) + (-10) =$$

Hint 11247/12914

GPS 3

Solve the equation. Round your result to the whole number.

$$2.5x + 1.2 = -3.6 =$$

$$\text{Divide: } -25 \div (-5) =$$

Hint 11265/12804

GPS 3

$$\text{Solve: } -7 \cdot 2 =$$

Solve the equation. Round your result to the whole number.

$$\text{Evaluate } 2j + 3k \text{ when } j = 5 \text{ and } k = 3$$

Hint 11404/12706

GPS 4

Solve the equation. Round your result to the whole number.

$$2.5x + 1.2 = 21.7 =$$

$$\text{Simplify: } -(-4) - (-2) + (-9) =$$

Hint 11247/12914

GPS 4

$$\text{Simplify: } -(-4) - (-2) + (-10) =$$

$$\text{Divide: } -25 \div (-5) =$$

Hint 11330/12810

GPS 4

$$\text{Divide: } 36 \div (-2) =$$

$$\text{Solve: } -7 \cdot 2 - 3 =$$

Hint 11438/12730

GPS 5

Evaluate $2j + 3k$ when $j = 2$ and $k = 1$

$$2.5x + 1.2 = -3.6 \quad =$$

Hint 11263/12868

GPS 5

Find the difference: $-62 - 31 + 93 =$

$$2.5x + 1.2 = 23.7 \quad =$$

Hint 11251/12784

GPS 5

Simplify: $-(-9) - (-4) - (-9) =$

Solve the equation. Round your result to the whole number.

$$2.5x + 1.2 = 21.7 \quad =$$

Hint 11457/12778

GPS 6

Evaluate the expression $(3g-h)^2$ when $g = 3$ and $h = 6$. =

Find the difference: $-62 - 31 + 93 =$

Hint 11281/12853

GPS 6

Find the difference: $-62 - 31 + 93 =$

Find the product: $-5 \cdot -2 = 1$

Hint 11251/12779

GPS 6

Simplify: $-(-9) - (-4) - (-9) =$

Divide $-24 \div (-4) =$

Hint 11448/12792

GPS 7

Solve: $-7 \cdot -2 - 1 =$

Divide $-16 \div (-8) =$

Hint 11222/12840**GPS 7**

Find the difference: $-62 - 31 + 97 =$

Solve the equation. Round your result to the whole number.

$2.5x + 1.2 = 37.6 =$

Hint 11271/12740**GPS 7**

Solve: $-9 \cdot 2 - 6 =$

Evaluate the expression $(3g-h)^2$ when $g = 2$ and $h = 5$. $=$ **Hint 11468/12837****GPS 8**

Solve: $-9 \cdot -2 - 7 =$

Find the difference: $-62 - 31 + 97 =$

Hint 11228/12820**GPS 8**

Divide $-24 \div (-4) =$

Evaluate $2j + 3k$ when $j = 2$ and $k = 4 =$

Hint 11264/12725**GPS 8**

Simplify: $-(-4) - (-5) - (-10) =$

Simplify: $-(-4) - (-2) + (-9) =$

Hint 11435/12865

GPS 9

Find the product: $-5 \cdot -2 =$

Solve the equation. Round your result to the whole number.

$$2.5x + 1.2 = 21.7 =$$

Hint 11251/12784

GPS 9

Simplify: $-(-11) - (-2) + (-10) =$

$$\text{Solve: } -7 \cdot -2 + 3 =$$

Hint 11277/12706

GPS 9

Simplify: $-(-4) - (-5) - (-10) =$

Find the difference: $-62 - 31 + 86 =$

Hint 11419/12897

GPS 10

Solve the equation. Round your result to the whole number.

$$2.5x + 1.2 = 21.7 =$$

$$\text{Divide } -24 \div (-4) =$$

Hint 11253/12807

GPS 10

$$\text{Divide } -16 \div (-8) =$$

$$2.5x + 1.2 = 23.7 =$$

Hint 11285/12738

GPS 10

Find the product: $-8 \cdot 2 =$

$$\text{Solve: } -7 \cdot 2 + 3 =$$

Hint 11391/12919

GPS 11

Find the difference: $-62 - 31 + 97 =$

Simplify: $-(-8) - (-6) + (-10) =$

Hint 11284/12813

GPS 11

Find the difference: $-62 - 31 + 93 = -1$

Solve the equation. Round your result to the whole number.

$$2.3x + 1.2 = 47.6 =$$

Hint 11309/12693

GPS 11

Solve: $-7 \cdot 2 =$

Find the product: $-3 \cdot 3 =$

Hint 11381/12905

Activity 3 Answer Sheet

GPS 1

Divide: $-25 \div (-5) = 5$

Find the difference: $-62 - 31 + 86 = -7$

Divide $-16 \div (-8) = 2$

Evaluate $2j + 3k$ when $j = 2$ and $k = 1$ **=7**

Find the product: $-3 \cdot 3 = -9$

Evaluate $2j + 3k$ when $j = 5$ and $k = 3$ **=19**

GPS 2

Find the product: $-6 \cdot -2 = 12$

Simplify: $-(-4) - (-2) + (-9) = -3$

Evaluate the expression $(3g-h)^2$ when $g = 2$ and $h = 5$. **=1**

Evaluate $2j + 3k$ when $j = 2$ and $k = 1$ **=7**

Solve: $-7 \cdot 2 + 3 = -11$

Evaluate $2j + 3k$ when $j = 5$ and $k = 3$ **=19**

GPS 3

Solve the equation. Round your result to the whole number.

$2.5x + 1.2 = 21.7$ **= 8.2 or 8**

Simplify: $-(-4) - (-2) + (-10) = -4$

Solve the equation. Round your result to the whole number.

$2.5x + 1.2 = -3.6$ **= 1.92 or -2**

Divide: $-25 \div (-5) = 5$

Solve: $-7 \cdot 2 = -14$

Solve the equation. Round your result to the whole number.

Evaluate $2j + 3k$ when $j = 5$ and $k = 3$ **=19**

GPS 4

Solve the equation. Round your result to the whole number.

$2.5x + 1.2 = 21.7$ **= 8.2 or 8**

Simplify: $-(-4) - (-2) + (-9) = -3$

Simplify: $-(-4) - (-2) + (-10) = -4$

Divide: $-25 \div (-5) = 5$

Divide: $36 \div (-2) = -18$

Solve: $-7 \cdot 2 - 3 = -17$

GPS 5

Evaluate $2j + 3k$ when $j = 2$ and $k = 1$ **=7**

$$2.5x + 1.2 = -3.6 \quad \mathbf{= 1.92 \text{ or } -2}$$

Find the difference: $-62 - 31 + 93 = \mathbf{-1}$

$$2.5x + 1.2 = 23.7 \quad \mathbf{= 9}$$

Simplify: $-(-9) - (-4) - (-9) = \mathbf{-22}$

Solve the equation. Round your result to the whole number.

$$2.5x + 1.2 = 21.7 \quad \mathbf{= 8.2 \text{ or } 8}$$

GPS 6

Evaluate the expression $(3g-h)^2$ when $g = 3$ and $h = 6$. **=9**

$$\text{Find the difference: } -62 - 31 + 93 = \mathbf{0}$$

Find the difference: $-62 - 31 + 93 = \mathbf{-1}$

$$\text{Find the product: } -5 \cdot -2 = \mathbf{10}$$

Simplify: $-(-9) - (-4) - (-9) = \mathbf{-22}$

$$\text{Divide } -24 \div (-4) = \mathbf{6}$$

GPS 7

$$\text{Solve: } -7 \cdot -2 - 1 = \mathbf{13}$$

$$\text{Divide } -16 \div (-8) = \mathbf{2}$$

Find the difference: $-62 - 31 + 97 = \mathbf{4}$

Solve the equation. Round your result to the whole number.

$$2.5x + 1.2 = 37.6 \quad \mathbf{= 15.04 \text{ or } 15}$$

$$\text{Solve: } -9 \cdot 2 - 6 = \mathbf{-24}$$

Evaluate the expression $(3g-h)^2$ when $g = 2$ and $h = 5$. **= 1**

GPS 8

$$\text{Solve: } -9 \cdot -2 - 7 = \mathbf{11}$$

Find the difference: $-62 - 31 + 97 = \mathbf{4}$

$$\text{Divide } -24 \div (-4) = \mathbf{6}$$

Evaluate $2j + 3k$ when $j = 2$ and $k = 4$ **= 16**

Simplify: $-(-4) - (-5) - (-10) = \mathbf{-19}$

Simplify: $-(-4) - (-2) + (-9) = \mathbf{-3}$

GPS 9

Find the product: $-5 \cdot -2 = \mathbf{10}$

Solve the equation. Round your result to the whole number.

$$2.5x + 1.2 = 21.7 \quad = \mathbf{8.2 \text{ or } 8}$$

Simplify: $-(-11) - (-2) + (-10) = \mathbf{3}$

$$\text{Solve: } -7 \cdot -2 + 3 = \mathbf{17}$$

Simplify: $-(-4) - (-5) - (-10) = \mathbf{-19}$

$$\text{Find the difference: } -62 - 31 + 86 = \mathbf{-7}$$

GPS 10

Solve the equation. Round your result to the whole number.

$$2.5x + 1.2 = 21.7 \quad = \mathbf{8.2 \text{ or } 8}$$

$$\text{Divide } -24 \div (-4) = \mathbf{6}$$

$$\text{Divide } -16 \div (-8) = \mathbf{2}$$

$$2.5x + 1.2 = 23.7 \quad = \mathbf{9}$$

Find the product: $-8 \cdot 2 = \mathbf{-16}$

$$\text{Solve: } -7 \cdot 2 + 3 = \mathbf{-11}$$

GPS 11

Find the difference: $-62 - 31 + 97 = \mathbf{4}$

Simplify: $-(-8) - (-6) + (-10) = \mathbf{4}$

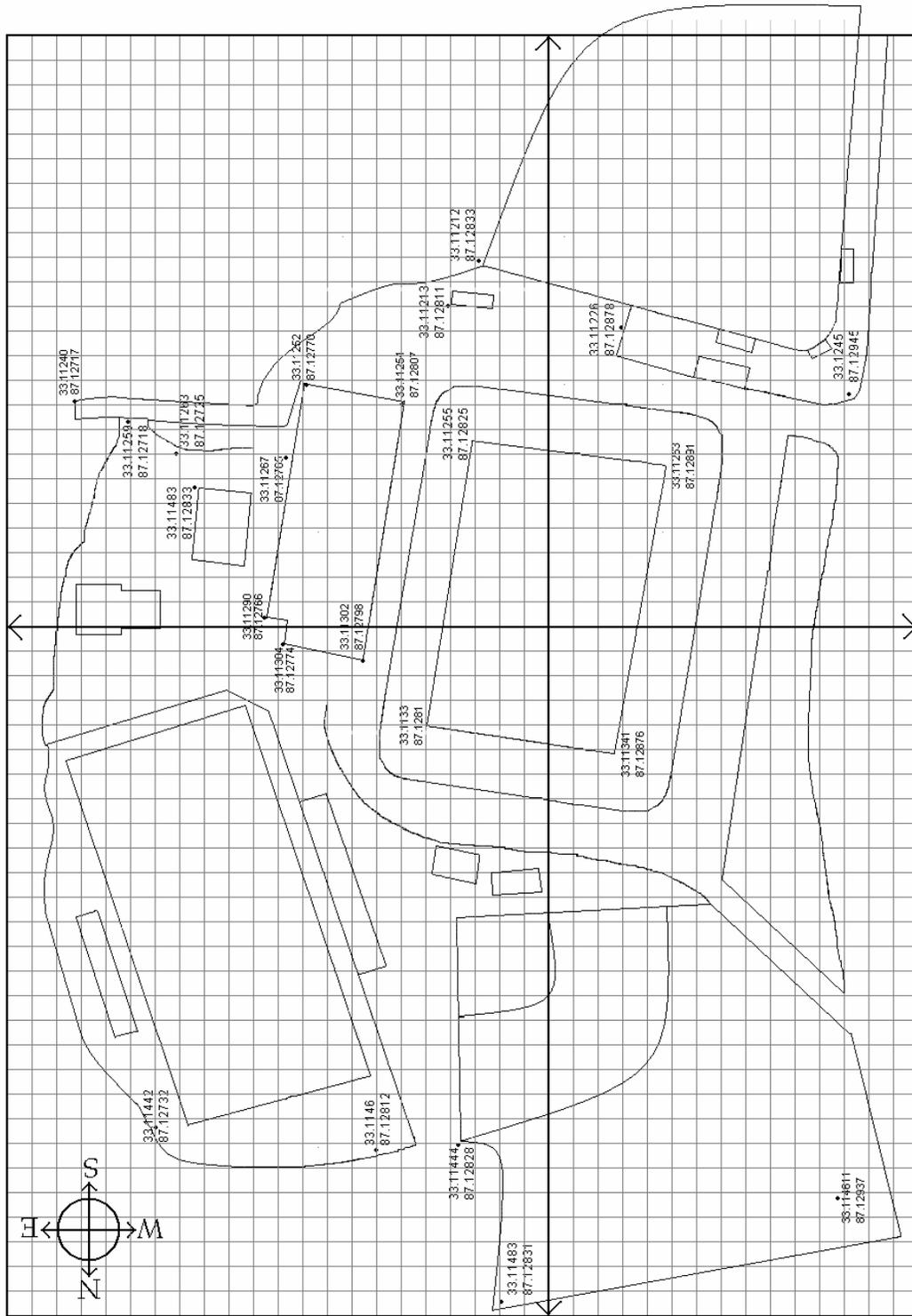
Find the difference: $-62 - 31 + 93 = \mathbf{-1}$

Solve the equation. Round your result to the whole number.

$$2.3x + 1.2 = 47.6 \quad = \mathbf{20.17 \text{ or } 20}$$

$$\text{Solve: } -7 \cdot 2 = \mathbf{-14}$$

$$\text{Find the product: } -3 \cdot 3 = \mathbf{-9}$$



West Blocton High School Area Map

Mapping Activity #4. The ultimate finish.

The final GPS activity will consist of a combination of the first three activities. The students will have to solve algebra problems to find three locations on campus. These three locations will be permanent locations, such as a football goal post. These locations will be sequential with each clue leading to the next clue. In finding the third cache, the instructions in it will instruct each team to plot the three locations on their map and find the area of the triangle that will be formed. That number will then become an ordered pair that they will graph. This clue will lead them to their final clue. This clue will instruct them to return to “break area”. This exercise will focus on speed as well as accuracy as the team to finish first will get the first pick of the prizes. The prizes for this exercise will follow a stair-step progression with the first place team getting a better prize than the other teams. The team that finishes last will still get candy.

The first three places will be locations that form a right triangle. The problems that the students will work will give them the second’s location. The first number will be the latitude mark and the second will be the longitude mark. The students will then find the area of the triangle by plotting the places on their map and counting squares to determine distance. They will then use that number in 2 other problems to come up with an ordered pair, which they will then plot on their map. That will lead them to an envelope with instructions to return to their classroom to claim their prize. In order for them to get any prize they must have their envelope.

Answer Sheet

GPS 1

Work the following problems. Each set will be the seconds of a latitude and longitude marking. Go to that place to determine which place on your location sheet it is. When you find the 3rd place, mark each on your map. This activity is like the second one we did. Once you have all 3 locations marked, use the formula for finding the area of a triangle ($1/2$ base times height). Once you have that number use it in the 2 problems to make an ordered pair. Plot this point on your map. Go to that place to get your final clue.

Make an input-output table for the following functions: use the numbers from the box. For the value of x .

$$y = 4x - 50$$

$$y = 7x - 13$$

$$y = 9x - 21$$

Input, x	25	9	8
Output, y (Latitude)			

Complete the input-output table for the following functions: use the numbers from the box. For the value of x .

$$2x + 2 = y$$

$$5x + 5 = y$$

$$10x + 22 = y$$

Input, x	Output, y (Longitude)
20	
6	
2	

Put your latitude and longitude numbers in this chart, then plot them on your first map.

Latitude			
Longitude			

What is the area of the right triangle that is formed? _____

Use that number for the x value of the following:

$$2x + 25 - 2x - 13 =$$

$$2x + 25 - 2x - 28 =$$

Plot this ordered pair on your second map. Go there for your next clue.

50 42 50 41 51 42 5000 12, -3

GPS 2

Work the following problems. Each set will be the seconds of a latitude and longitude marking. Go to that place to determine which place on your location sheet it is. When you find the 3rd place, mark each on your map. This activity is like the second one we did. Once you have all 3 locations marked, use the formula for finding the area of a triangle ($1/2$ base times height). Once you have that number use it in the 2 problems to make an ordered pair. Plot this point on your map. Go to that place to get your final clue.

Make an input-output table for the following functions: use the numbers from the box. For the value of x .

$$y = 4x - 50$$

$$y = 7x - 13$$

$$y = 9x - 23$$

Input, x	25	9	8
Output, y (Latitude)			

Complete the input-output table for the following functions: use the numbers from the box. For the value of x .

$$2x+2 = y$$

$$5x+5 = y$$

$$10x+21 = y$$

Input, x	Output, y (Longitude)
20	
6	
2	

Put your latitude and longitude numbers in this chart, then plot them on your first map.

Latitude			
Longitude			

What is the area of the right triangle that is formed? _____

Use that number for the x value of the following:

$$2x + 25 - 2x - 10 =$$

$$2x + 25 - 2x - 17 =$$

Plot this ordered pair on your second map. Go there for your next clue.

50 42 50 41 49 41 10, 8

GPS 3

Work the following problems. Each set will be the seconds of a latitude and longitude marking. Go to that place to determine which place on your location sheet it is. When you find the 3rd place, mark each on your map. This activity is like the second one we did. Once you have all 3 locations marked, use the formula for finding the area of a triangle ($1/2$ base times height). Once you have that number use it in the 2 problems to make an ordered pair. Plot this point on your map. Go to that place to get your final clue.

Make an input-output table for the following functions: use the numbers from the box. For the value of x .

$$y = 4x - 50$$

$$y = 9x - 21$$

$$y = 7x - 13$$

Input, x	25	8	9
Output, y (Latitude)			

Complete the input-output table for the following functions: use the numbers from the box. For the value of x .

$$2x + 1 = y$$

$$5x + 6 = y$$

$$10x + 22 = y$$

Input, x	Output, y (Longitude)
20	
6	
2	

Put your latitude and longitude numbers in this chart, then plot them on your first map.

Latitude			
Longitude			

What is the area of the right triangle that is formed? _____

Use that number for the x value of the following:

$$2x + 5 - 2x - 19 =$$

$$2x + 25 - 2x - 6 =$$

Plot this ordered pair on your second map. Go there for your next clue.

50 41 51 42 50 42 -14, 19

GPS 4

Work the following problems. Each set will be the seconds of a latitude and longitude marking. Go to that place to determine which place on your location sheet it is. When you find the 3rd place, mark each on your map. This activity is like the second one we did. Once you have all 3 locations marked, use the formula for finding the area of a triangle ($1/2$ base times height). Once you have that number use it in the 2 problems to make an ordered pair. Plot this point on your map. Go to that place to get your final clue.

Make an input-output table for the following functions: use the numbers from the box. For the value of x .

$$y = 4x - 50$$

$$y = 7x - 13$$

$$y = 9x - 23$$

Input, x	25	9	8
Output, y (Latitude)			

Complete the input-output table for the following functions: use the numbers from the box. For the value of x .

$$2x + 2 = y$$

$$5x + 5 = y$$

$$10x + 21 = y$$

Input, x	Output, y (Longitude)
20	
6	
2	

Put your latitude and longitude numbers in this chart, then plot them on your first map.

Latitude			
Longitude			

What is the area of the right triangle that is formed? _____

Use that number for the x value of the following:

$$2x + 15 - 2x - 26 =$$

$$2x + 25 - 2x - 6 =$$

Plot this ordered pair on your second map. Go there for your next clue.

50 42 50 41 49 41 -11, 19

GPS 5

Work the following problems. Each set will be the seconds of a latitude and longitude marking. Go to that place to determine which place on your location sheet it is. When you find the 3rd place, mark each on your map. This activity is like the second one we did. Once you have all 3 locations marked, use the formula for finding the area of a triangle ($1/2$ base times height). Once you have that number use it in the 2 problems to make an ordered pair. Plot this point on your map. Go to that place to get your final clue.

Make an input-output table for the following functions: use the numbers from the box. For the value of x .

$$y = 9x - 21$$

$$y = 4x - 50$$

$$y = 7x - 6$$

Input, x	8	25	8
Output, y (Latitude)			

Complete the input-output table for the following functions: use the numbers from the box. For the value of x .

$$2x + 2 = y$$

$$5x + 6 = y$$

$$10x + 21 = y$$

Input, x	Output, y (Longitude)
20	
6	
2	

Put your latitude and longitude numbers in this chart, then plot them on your first map.

Latitude			
Longitude			

What is the area of the right triangle that is formed? _____

Use that number for the x value of the following:

$$2x + 15 - 2x - 24 =$$

$$2x + 25 - 2x - 6 =$$

Plot this ordered pair on your second map. Go there for your next clue.

51 42 50 42 50 41 -9, 19

GPS 6

Work the following problems. Each set will be the seconds of a latitude and longitude marking. Go to that place to determine which place on your location sheet it is. When you find the 3rd place, mark each on your map. This activity is like the second one we did. Once you have all 3 locations marked, use the formula for finding the area of a triangle ($1/2$ base times height). Once you have that number use it in the 2 problems to make an ordered pair. Plot this point on your map. Go to that place to get your final clue.

Make an input-output table for the following functions: use the numbers from the box. For the value of x .

$$y = 4x - 50$$

$$y = 7x - 13$$

$$y = 9x - 23$$

Input, x	25	9	8
Output, y (Latitude)			

Complete the input-output table for the following functions: use the numbers from the box. For the value of x .

$$2x+2 = y$$

$$5x+5 = y$$

$$10x+21 = y$$

Input, x	Output, y (Longitude)
20	
6	
2	

Put your latitude and longitude numbers in this chart, then plot them on your first map.

Latitude			
Longitude			

What is the area of the right triangle that is formed? _____

Use that number for the x value of the following:

$$2x + 25 - 2x - 22 =$$

$$2x + 25 - 2x - 8 =$$

Plot this ordered pair on your second map. Go there for your next clue.

50 42 50 41 49 41 3, 17

GPS 7

Work the following problems. Each set will be the seconds of a latitude and longitude marking. Go to that place to determine which place on your location sheet it is. When you find the 3rd place, mark each on your map. This activity is like the second one we did. Once you have all 3 locations marked, use the formula for finding the area of a triangle ($1/2$ base times height). Once you have that number use it in the 2 problems to make an ordered pair. Plot this point on your map. Go to that place to get your final clue.

Make an input-output table for the following functions: use the numbers from the box. For the value of x .

$$y = 4x - 50$$

$$y = 7x - 13$$

$$y = 9x - 21$$

Input, x	25	9	8
Output, y (Latitude)			

Complete the input-output table for the following functions: use the numbers from the box. For the value of x .

$$2x + 2 = y$$

$$5x + 5 = y$$

$$10x + 22 = y$$

Input, x	Output, y (Longitude)
20	
6	
2	

Put your latitude and longitude numbers in this chart, then plot them on your first map.

Latitude			
Longitude			

What is the area of the right triangle that is formed? _____

Use that number for the x value of the following:

$$2x + 25 - 2x - 19 = 25 =$$

$$2x + 25 - 2x - 29 =$$

Plot this ordered pair on your second map. Go there for your next clue.

50 42 50 41 51 42 6, -4

GPS 8

Work the following problems. Each set will be the seconds of a latitude and longitude marking. Go to that place to determine which place on your location sheet it is. When you find the 3rd place, mark each on your map. This activity is like the second one we did. Once you have all 3 locations marked, use the formula for finding the area of a triangle ($1/2$ base times height). Once you have that number use it in the 2 problems to make an ordered pair. Plot this point on your map. Go to that place to get your final clue.

Make an input-output table for the following functions: use the numbers from the box. For the value of x .

$$y = 4x - 50$$

$$y = 9x - 23$$

$$y = 7x - 13$$

Input, x	25	8	9
Output, y (Latitude)			

Complete the input-output table for the following functions: use the numbers from the box. For the value of x .

$$2x+1 = y$$

$$5x+5 = y$$

$$10x+22 = y$$

Input, x	Output, y (Longitude)
20	
6	
2	

Put your latitude and longitude numbers in this chart, then plot them on your first map.

Latitude			
Longitude			

What is the area of the right triangle that is formed? _____

Use that number for the x value of the following:

$$2x + 25 - 2x - 16 =$$

$$2x + 25 - 2x - 25 =$$

Plot this ordered pair on your second map. Go there for your next clue.

50 41 49 41 50 42 9, 0

GPS 9

Work the following problems. Each set will be the seconds of a latitude and longitude marking. Go to that place to determine which place on your location sheet it is. When you find the 3rd place, mark each on your map. This activity is like the second one we did. Once you have all 3 locations marked, use the formula for finding the area of a triangle ($1/2$ base times height). Once you have that number use it in the 2 problems to make an ordered pair. Plot this point on your map. Go to that place to get your final clue.

Make an input-output table for the following functions: use the numbers from the box. For the value of x .

$$y = 4x - 50$$

$$y = 9x - 21$$

$$y = 7x - 13$$

Input, x	25	8	9
Output, y (Latitude)			

Complete the input-output table for the following functions: use the numbers from the box. For the value of x .

$$2x+1 = y$$

$$5x+6 = y$$

$$10x+22 = y$$

Input, x	Output, y (Longitude)
20	
6	
2	

Put your latitude and longitude numbers in this chart, then plot them on your first map.

Latitude			
Longitude			

What is the area of the right triangle that is formed? _____

Use that number for the x value of the following:

$$2x + 25 - 2x - 12 =$$

$$2x + 25 - 2x - 23 =$$

Plot this ordered pair on your second map. Go there for your next clue.

50 41 51 42 50 42 13, 2

GPS 10

Work the following problems. Each set will be the seconds of a latitude and longitude marking. Go to that place to determine which place on your location sheet it is. When you find the 3rd place, mark each on your map. This activity is like the second one we did. Once you have all 3 locations marked, use the formula for finding the area of a triangle ($1/2$ base times height). Once you have that number use it in the 2 problems to make an ordered pair. Plot this point on your map. Go to that place to get your final clue.

Make an input-output table for the following functions: use the numbers from the box. For the value of x .

$$y = 9x - 23$$

$$y = 4x - 50$$

$$y = 7x - 6$$

Input, x	9	25	8
Output, y (Latitude)			

Complete the input-output table for the following functions: use the numbers from the box. For the value of x .

$$2x + 1 = y$$

$$5x + 6 = y$$

$$10x + 21 = y$$

Input, x	Output, y (Longitude)
20	
6	
2	

Put your latitude and longitude numbers in this chart, then plot them on your first map.

Latitude			
Longitude			

What is the area of the right triangle that is formed? _____

Use that number for the x value of the following:

$$2x + 7 - 2x - 29 =$$

$$2x + 25 - 2x - 19 =$$

Plot this ordered pair on your second map. Go there for your next clue.

49 41 50 42 50 41 22, 6

GPS 11

Work the following problems. Each set will be the seconds of a latitude and longitude marking. Go to that place to determine which place on your location sheet it is. When you find the 3rd place, mark each on your map. This activity is like the second one we did. Once you have all 3 locations marked, use the formula for finding the area of a triangle ($1/2$ base times height). Once you have that number use it in the 2 problems to make an ordered pair. Plot this point on your map. Go to that place to get your final clue

Make an input-output table for the following functions: use the numbers from the box. For the value of x .

$$y = 9x - 21$$

$$y = 4x - 50$$

$$y = 7x - 13$$

Input, x	8	25	9
Output, y (Latitude)			

Complete the input-output table for the following functions: use the numbers from the box. For the value of x .

$$2x + 2 = y$$

$$5x + 6 = y$$

$$10x + 21 = y$$

Input, x	Output, y (Longitude)
20	
6	
2	

Put your latitude and longitude numbers in this chart, then plot them on your first map.

Latitude			
Longitude			

What is the area of the right triangle that is formed? _____

Use that number for the x value of the following:

$$2x + 7 - 2x - 29 =$$

$$2x + 25 - 2x - 17 =$$

Plot this ordered pair on your second map. Go there for your next clue.

51 42 50 42 50 41 22, 8

Congratulations. You are finished.
Go back to the classroom to claim your prize.