INTEGRATION OF GEOSPATIAL TECHNOLOGIES INTO K-12 CURRICULUM:

AN INVESTIGATION OF TEACHER AND STUDENT PERCEPTIONS AND

STUDENT ACADEMIC ACHIEVEMENT

by

Donna L. Goldstein

A Dissertation Submitted to the Faculty of

The College of Education

In Partial Fulfillment of the Requirements for the Degree of

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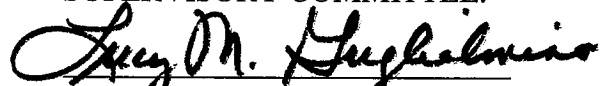Boca Raton, Florida

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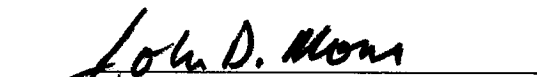
STUDENT ACADEMIC ACHIEVEMENT

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Donna L. Goldstein

This dissertation was prepared under the direction of the candidate's dissertation advisor, Dr. Lucy M. Guglielmino, Department of Educational Leadership, and has been approved by the members of her supervisory committee. It was submitted to the faculty of the College of Education and was accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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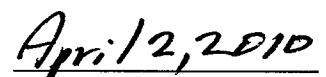
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ABSTRACT

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                     Curriculum: An Investigation of Teacher and

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The purpose of this study was to explore outcomes of a GIS/GPS integration process: to (a) examine student responses to GIS and GPS inclusion in their curriculum, (b) determine whether a relationship exists between inclusion of GIS into existing K-12 curriculum and student achievement, (c) examine the effectiveness of GIS professional development for teachers, and (d) evaluate teacher perceptions of the value of integrating GIS into their existing curricula.

This study was quantitative and quasi-experimental in design. The samples consisted of 1,425 students from one middle school and 62 teachers from Palm Beach County School District. Two instruments were used in this study: student surveys and

teacher feedback forms. Data from the student surveys indicated that students perceive their learning is enhanced by inclusion of GIS and GPS. Data from the teacher feedback forms revealed positive perceptions of the GIS/GPS program as an integrative tool for their existing curricula and a positive assessment of the GIS professional development training.

The relationship between GIS instruction and student academic achievement was evaluated, measured by FCAT reading scores and final grades in science and social studies. The findings support the constructivist theory that students learn best when actively engaged in the process. In this study standardized FCAT reading test results and science and social studies grades corroborate the students' perceptions that GIS and GPS integration enhances their learning.

Study results show FCAT reading scores were higher for GIS students than for non-GIS students. The research further indicated a significant increase in FCAT reading scores for non-native English speaking GIS students and a significantly higher average science grade for non-White GIS students. The findings also show that students who had a greater frequency of GIS instruction had higher averages in science and social studies grades.

Education reform requires bold initiatives and an organizational culture supportive of innovative ideas. The structured model for development and implementation of GIS in the K-12 public school system presented at the end of this study includes collaboration between district leadership, administrators, and teachers and a comprehensive approach to professional development.

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CHAPTER 1 - INTRODUCTION

The Mandate for Education Reform

The elusive goal of raising student achievement has led us on a path toward

educational reform, a path fraught with unfulfilled promises and seemingly

insurmountable obstacles. As legislators and administrators set mandates and policies,

ultimately the teacher in the classroom is responsible for educating our students to

become successful members of society. The aggressive nature of No Child Left Behind

(NCLB) (U.S. Department of Education, 2009), tight budget constraints, and little time

for deviation from the prescribed curriculum has put our school systems in a precarious

position. Teachers are continuously asked to do more with less, administrators are forced

to make hard choices, and the results regarding the effectiveness of these mandates and

policies are mixed.

Engagement of Students in Learning through GIS

A growing body of evidence suggests that inclusion of Geographic Information

Systems (GIS) into school curricula will promote learning, including enhancement of

students' critical thinking skills, analytical abilities, and communication skills. GIS is a

software application that combines graphic features and images of anything on the earth

with database information, which makes it a very powerful decision-making tool. This

application is utilized in many industries, and implementation in the classroom is a

promising opportunity for enhancing education. As noted in *USGS Science for a*

Changing World (U.S. Geological Survey, [USGS], 2005), GIS can address the finding

identified by the U.S. Labor Secretary's Commission on Achieving Necessary Skills

(SCANS) that the most effective way to teach is in context. SCANS competencies

include identifying resources, working with others, and understanding complex and

changing inter-relationships; the GIS is an appropriate medium to encourage student

growth in each of these competencies. The visual nature and technology component of

the GIS program is also viewed as a way to engage and motivate students in the learning

process. Bloom and Palmer-Moloney (2004) present findings regarding the integration of

GIS into middle school curriculum based on qualitative results. Their assessment

revealed that students generally embraced the challenge of GIS technology and viewed

this hands-on enhancement to learning as fun, thus providing motivation for students to

learn. Less conclusive is the available data regarding transfer between students' increased

spatial literacy and increased performance on standardized testing. The authors

acknowledge that this aspect requires further research.

Development of Career Skills

Pang (2006) suggests that the learner-centered approach to delivering curriculum

through GIS enhances the overall learning experience for students and encourages

students to actively participate in manipulating data and constructing and presenting

information. Pang further states that "the skills and knowledge students acquire through

GIS use in school may also enhance their future career prospects**"** (p. 1). Her comment

supports the necessity to educate our students with the skills they will need to compete in

the global marketplace.

In addition, in 2004 the U.S. president identified geospatial technologies (GIS/GPS) as one of the top three emerging fields, following biotechnology and nanotechnology. The worldwide geospatial market was expected to grow to over $30 billion in 2005, (Gewin, 2004), creating the necessity for trained GIS/GPS staff to fill the growing void and to replace retiring personnel. The payback of teaching GIS in the classroom extends beyond the pedagogical benefits to career opportunities for students as well.

GIS and Transformative Learning

The goal of educational reform legislation is to raise student achievement. While measuring students' achievement is a necessary function, we must find the balance of teaching required curriculum while creating an environment where students' knowledge is enhanced by encouraging interest in the subject matter. One way to accomplish this may be by integrating geospatial technology into the K-12 curriculum. The application can be infused in most subjects, but is especially well-suited to social studies and science. With the proper professional development and adequate support, the often-cited steep technology learning curve for teachers can be minimized. (Acheson, 2004; Alibrandi & Palmer-Moloney, 2001; Bloom & Palmer-Moloney, 2004; Brodie, 2006; Hagevik, 2003; Haymore-Sandholtz & Reilly, 2004; Johansson, 2003; Kerski, 2001; McClurg & Buss, 2007; McInerney, 2006; Milson & Alibrandi, 2008; Yuda & Itoh, 2006; Wilder, Brinkerhoff, & Higgins, 2003).

Alibrandi and Palmer-Moloney (2001) point out that "As a technology for conducting social studies, GIS offers new ways of viewing, representing and analyzing information for transformative learning and teaching" (p. 2). The study of transformative

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learning began in the late 1970's with the work of Jack Mezirow (as cited in Merriam, Caffarella, & Baumgartner, 2007). Essentially, transformative teaching and learning create a shift in the way we view ourselves and the world.

The result of providing teachers with a transformational learning experience is that they may embark on a path of transformational teaching; that is, a learning experience that alters their views and possibilities may in turn affect the way they teach. By learning how to use a GIS, teachers gain a level of confidence in technology, become empowered to leverage the subject matter they teach, and provide an interesting and creative educational environment for their students. Teaching with GIS changes teachers' competency levels in their own classrooms and builds bridges to other disciplines. In addition to elevating their teaching experience, teachers also gain 21st century technology skills that broaden their horizons.

By educating teachers in the use of GIS and allowing them the opportunity to experience and see the value of this application as an educational tool, we can transform the educational process to both comply with mandated legislation and bring the joy of teaching and learning back into the classroom. The residual effect of providing teachers with a transformative experience is that student learning may be transformed.

For students, using a GIS system can also be instrumental to the transformative learning process, as it may be utilized to teach about world events, population, conservation, and a host of issues that students can relate to. Using this technology, students incorporate the "four main components of the transformative learning process; experience, critical reflection, reflective discourse, and action" (Merriam et al. 2007, p. 134). Although Mezirow's research during the 1970s was focused on adult learning, the

theory is applicable to pedagogy. While engaged in a GIS class, K-12 students draw from their own experience; they are prompted to critically reflect on the information presented based on their analysis; they are encouraged to define new solutions; and, finally, to take action.

Teaching New Skills

In 2006, the National Research Council published *Learning to Think Spatially: GIS as a Support System in the K-12 Curriculum*, which identified the importance of promoting spatial thinking skills across the curriculum. As indicated by the report, GIS has the potential to successfully cultivate spatial skills through integrating the use of GIS into existing curriculum. For teachers who simply do not have the luxury of time to teach material that may not be directly aligned with mandated high-stakes tests (including new computer technology skills), integrating GIS and GPS (Global Positioning System) into the existing curriculum allows them the ability to engage students, promote critical thinking and spatial skills, and incorporate integrated learning. As noted by Bloom and Palmer-Moloney (2004), the issue to be addressed is how to integrate this instruction in such a way that teachers do not view it as a burden as additional curriculum.

Teacher Reluctance

Pre-Service GIS

A common theme regarding teacher interest and acceptance of integrating GIS into existing curriculum becomes evident through the literature. Teacher reluctance is recognized as a barrier by Yuda and Itoh (2006) in their evaluation of the potential for GIS in educational reform. The authors state, "One of the reasons why GIS hasn't been accepted widely in education might be that many of the teachers have neither studied it

before when they were students nor had experiences to use GIS as an educational tool before" (p. 100). Alibrandi and Palmer-Moloney (2001) support the contention that in most cases GIS has not been integrated into teacher education programs, stating: "Generally, in teacher education programs, GIS technology has not been integrated into content-area methods classes nor would teachers expect to use GIS in the classroom" (p. 5). The result of GIS not being incorporated into pre-service classes for teachers-to-be during their college education is that they are unlikely to incorporate it into their lessons when they begin to teach. If more teachers were educated on the use of GIS while enrolled in teacher education programs, the likelihood that they would embrace incorporating this technology into their own classrooms would increase tremendously. The residual effect of including GIS in teachers' pre-service classes is that grade school students would reap the benefits.

Johansson (2003) conducted a study regarding teacher readiness of secondary geography teachers to use GIS in their curricula involving 198 teachers in 149 secondary schools in Finland. While the results were similar to those reported by Kerski's (2001) regarding national assessment of GIS in American high schools, the Finnish analysis indicated that a fifth of the respondents identified lack of in-service teacher training as the largest barrier.

In-Service GIS Professional Development

One possible antidote for the lack of pre-service GIS classes for teachers is to develop in-service professional development training in geospatial technologies for teachers already in the field. Educating teachers who are already in the classroom in GIS can accelerate GIS classroom integration, filling the gap while waiting for the pre-service

teachers to move into the actual classroom. McClurg and Buss (2007) explain this approach in their article *Professional Development: Teachers' Use of GIS to Enhance Student Learning,* which studies the experiences of grade school teachers using GIS over a five-year time period. The authors note, "While initial users of GIS were often self-taught, it is not realistic to assume that most teachers, while working full time in demanding jobs, will be able to incorporate strategies using these new tools into their professional repertoires" (p. 80). They report key components that help facilitate success of the professional development workshop such as "time for practice and application of knowledge and skills, including a conceptual introduction to GIS" and "providing relevant, accessible data sets, developing skill in file management, using relevant examples to introduce skills" (p. 86). Meltzer (2006) expands on recommendations for effective professional development to include the overall strategy. She notes that in addition to planning and conducting the professional development, collaboration and participation from administrators and teachers for developing long term goals is essential.

<center>Continued Research</center>

While the consensus is that inclusion of GIS into grade school curricula is beneficial, substantial data is lacking to back up whether this instruction increases student test scores. In addition, although the subject of including GIS into existing curriculum has been discussed and researched, few studies have provided conclusive results regarding the barriers and benefits.

Prior research included a study by Johansson (2003), which indicated that one of the greatest obstacles concerning teachers implementing GIS in their classroom was lack of teacher training. Kerski's (2001) survey of 1500 American high schools revealed that

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although 5% of the high schools had the GIS software only 2% actually used the program; and only 20% of the 2% owning the GIS software had utilized the program more than once for classroom instruction. Furthermore, Hagevik (2003) reports in her research that 75% of the teachers continued implementation of the GIS program a year after initial training. While this percentage is encouraging, a limitation to this study may be that the sample population of teachers numbered 12, and the sample of students numbered 68.

There is a need to expand research regarding the implementation of GIS into K-12 curriculum and to further explore the impediments to widespread use. Further study is required to evaluate the effects of GIS on student learning and the development of GIS professional development training for educators. In addition to teacher training, the aspect of incorporating GIS into required competencies and standards needs to be addressed. With the current time constraints placed upon teachers the prospect of teaching with GIS may be viewed as auxiliary if teachers do not make the connections between GIS processes and current required competencies.

Problem Statement

Serious challenges face the kindergarten through 12th grade (K-12) system, including federal and state policy pressures (standardized testing and school finance) as well as the achievement gap and increasing dropout rates (Ediger, 2007; Soublis-Smyth, 2008; Sunderman & Kim, 2007; Weaver, 2007). The literature suggests that some technological applications, specifically Geographic Information Systems (GIS) may have a positive impact on students' information and computer literacy, learning, academic achievement, and career preparation (Bloom & Palmer-Moloney, 2004; Goldstein, 2008;

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Johansson, 2003; Kerski, 2008; Pang, 2006; U.S. Department of Labor Employment & Training Administration, 2009; White, 2005).

There are competency standards identified by the Florida Department of Education (DOE) that substantiate this position. Florida's DOE established the framework for a GIS Career Academy in 2008, recognizing the value of this application in education and the future career opportunities for students (Florida Department of Education, 2009). In addition there are number of GIS lesson plan books currently in publication that identify a correlation of activities in the GIS lessons to national standards concerning social studies, science, technology and math (Malone, Palmer, Voight, Napoleon, & Feaster, 2005).

Public K-12 school systems are struggling to find ways to improve student achievement. While research indicates that integrating geospatial technologies into the curriculum is beneficial, there are no conclusive studies regarding the impact this instruction has on raising academic achievement test scores. Furthermore, additional research is needed to evaluate whether students perceive that their learning is enhanced by inclusion of GIS and GPS and to determine whether a relationship exists between inclusion of GIS into existing K-12 curriculum and student achievement.

The success of integrating GIS into the classroom is dependent on several factors including a structured implementation model and on teachers' ability to apply the program to curricular goals. Subsequently, the aspect of teacher training in the use of geospatial technology tools requires further exploration. The literature indicates lack of data concerning structured models for GIS professional development. Wilder et al. (2003) state, regarding GIS, "Research on strategies and models for effective teacher

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professional development is limited" (p. 255). While a number of models for professional development and program planning for adults exist including those cited by Caffarella (2002), Galbraith, Sisco, and Guglielmino (2001), Merriam and Simpson (2000) and Meltzer (2006), there is limited research regarding the application of these models to GIS.

Purpose of the Research

The purpose of this study was to explore outcomes of a GIS/GPS integration process: to (a) examine student responses to GIS and GPS inclusion in their curriculum, (b) determine whether a relationship exists between inclusion of GIS into existing K-12 curriculum and student achievement, (c) examine the effectiveness of GIS professional development for teachers, and (d) evaluate teacher perceptions of the value of integrating GIS into their existing curricula.

Research Questions

1. Do students perceive that their learning is enhanced by inclusion of GIS and GPS?

2. Do students perceive that inclusion of GIS and GPS into curriculum enhances their computer literacy skills?

3. How do students evaluate the GIS/GPS program implementation, which includes both teacher instruction and environmental factors?

4. Does academic achievement differ for students who had GIS instruction and those who did not?

5. * Is the change in FCAT reading scores from 2008 to 2009 different for those students who had GIS instruction and those who did not?

6a. Do FCAT reading scores differ between White students who had GIS instruction and those who did not, and between non-White students who had GIS instruction and those who did not

6b. Is the difference in FCAT reading scores between White students who had GIS instruction and White students who did not have GIS instruction different from the difference in FCAT reading scores between non-White students who had GIS instruction and non-White students who did not have GIS instruction?

7. Is the difference in academic achievement for those who received GIS instruction and those who did not receive GIS instruction moderated by gender, race, SES, or primary language?

8. * Is there a difference in academic achievement of students receiving different frequency of GIS instruction (twice a week or five times a week)?

9. How do teachers evaluate the GIS professional development training workshops?

10. Do teachers perceive incorporation of GIS into their K-12 curricula as beneficial to the students' learning experience?

* Only research question 5 and 8 use 2008 and 2009 data for student academic achievement analyses, all other research questions concerning academic achievement use 2009 data.

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

Null Hypothesis 1: The distribution of students' perceptions of the extent to which their learning is enhanced by inclusion of GIS and GPS is symmetric.

Null Hypothesis 2: The distribution of students' perceptions that inclusion of GIS and GPS into curriculum enhances their computer literacy skills is symmetric.

Null Hypothesis 3: The distribution of students' evaluation for the GIS/GPS program implementation, which includes both teacher instruction and environmental factors, is symmetric.

Null Hypothesis 4: There is no significant difference in academic achievement of students who had GIS instruction and those who did not.

Null Hypothesis 5: There is no significant difference in the change of FCAT scores from 2008 to 2009 for students who had GIS instruction and those who did not.

Null Hypothesis 6a: There is no significant difference in FCAT reading scores of White students who had GIS instruction and those who did not, and between non-White students who had GIS instruction and those who did not.

Null Hypothesis 6b: The difference in FCAT reading scores between White students who had GIS instruction and White students who did not have GIS instruction is not significantly different from the difference in FCAT reading scores between non-White students who had GIS instruction and non-White students who did not have GIS instruction.

Null Hypothesis 7: The difference in academic achievement of those who receive GIS instruction and those who do not is not moderated by gender, race, SES, or primary language.

Null Hypothesis 8: There is no significant difference in academic achievement of students receiving different frequency of GIS instruction (twice a week or five times a week).

Null Hypothesis 9: The distribution of teachers' evaluations of the GIS professional development training is symmetric.

Null Hypothesis 10: The distribution of teachers' perceptions of incorporating GIS into their K-12 curricula as beneficial to the students' learning experience is symmetric.

Significance of the Study

There is an urgent need to find solutions for the expanding achievement gap in K-12 education and to increase computer literacy in our youth. The high school dropout rate and existing apathy among some students indicate that public school systems must find better ways to engage students in the learning process. New educational tools and creative program planning are necessary for schools to elevate students' learning experience. The integration of these new programs needs to not only enhance their academic achievement but also provide students with real-world 21st century skills, preparing them to compete in the global market place.

GIS has the potential to engage students in a variety of subjects, to motivate their learning and enhance their classroom experience. Another benefit of integrating GIS into the classroom lies in the capacity to increase students' computer literacy. Increasing computer literacy for all students is an issue that public education continues to grapple with, and the matter of educating our youth with competitive technological skills is a national interest. GIS may be an option to help close the digital divide, that widening gap that exists between students from various socioeconomic lifestyles. Those who may not have the technology at home are at a greater disadvantage. Public schools, with the help of integrating GIS, may level the playing field by promoting computer literacy for all students. A residual effect of engaging students may be increased test scores. This quantitative research study may provide academic results that will convince legislators and other stakeholders to support expanded use of GIS in K-12 public school systems.

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This study adds to the research on students' learning, as well as their evaluation of the GIS program implementation, and assists in determining if GIS is a viable tool for education reform. By assessing student's perceptions regarding their learning and computer literacy, the research evaluated whether this tool can assist in providing our next generation of students with skills identified as those needed to compete in the 21st century (Lang, 2009).

Research concerning GIS professional development for teachers also adds to the body of knowledge concerning benefits to educators, and their classroom experience. Insights gained regarding teacher's perceptions of the effectiveness of the GIS/GPS professional development can be used to improve future instructional designs that promote integration of GIS/GPS. In addition a significant indicator of teachers' readiness to accept the GIS technology as a viable teaching aid may be gleaned by evaluating their perceived merit of integrating GIS into their existing curricula.

Definitions

Academic achievement - Academic achievement in this study refers to the standardized FCAT reading scores and final grades in science and social studies.

Achievement gap - The achievement gap refers to the inequality between the performance of groups of students on educational measures, especially groups defined by gender, race or ethnicity, ability, and socioeconomic status (National Education Association, 2006).

AYP - The term stands for *Adequate Yearly Process* and is a measure under the NCLB Act. AYP is an individual state's measure of progress toward the goal of 100 percent of students achieving to state academic standards in at least reading/language arts and math. It sets the minimum level of proficiency that the state, its school districts, and schools

must achieve each year on annual tests and related academic indicators. Parents whose children are attending Title I (low-income) schools that do not meet AYP over a period of years are given options to transfer their child to another school. Also schools that do not make AYP for two consecutive years may face sanctions (Ediger, 2007; Soublis-Smyth, 2008; Sunderman & Kim, 2007; Weaver, 2007).

Constructivism - Constructivism posits that learners do not passively absorb information, but construct it based on their prior learning within a social context (Alibrandi, 2003; Duffy & Kirkley, 2004; Merriam et al. 2007).

Digital divide - The term digital divide refers to the gap between people with access to information technology and those with very limited or no access at all. In this document the term is used to describe the gap between K12 students who have access to computer technology at home and those who do not (Organization for Economic Cooperation and Development, 2002).

ESOL - English Speakers of Other Languages - The term is used when a non-native-English speaker is studying English in an English-speaking country.

FCAT - Florida Comprehensive Achievement Test.

Geospatial technology - Technology based on geography and spatial relationships. The technology is comprised of various hardware and software applications such as GIS, GPS and Remote Sensing (Southwestern Indian Polytechnic Institute, n.d.).

GIS - Geographic Information Systems (GIS) are computerized systems that allow the user to work with, interrelate, and analyze virtually all forms of spatial data. Typically a GIS consists of three major components: a database of geospatial and thematic data and

information, a capability to spatially model or analyze the data sets, and a graphical display capability (American Society for Photogrammetry and Remote Sensing, 2006).

GPS - Global Positioning System, a system comprised of satellites that circle the earth and transmit signals back to receivers on earth. GPS was developed and is operated by the U.S. Department of Defense. Before its civilian applications, GPS was used to provide all-weather round-the-clock navigation capabilities for military ground, sea, and air forces. GPS has applications beyond navigation and location determination and can be used for cartography, forestry, mineral exploration, wildlife habitation management, monitoring climate change and movements of people, products and other observable activities on the planet (U. S. Geological Survey, 2000).

High-stakes testing - High-stakes tests are used to determine a wide range of critical outcomes. Results may determine which students progress to the next grade level or receive a diploma, which teachers receive bonuses, or whether a school receives rewards or sanctions (Ediger, 2007; Soublis-Smyth, 2008; Sunderman & Kim, 2007; Weaver, 2007).

In-service - Professional development courses that teachers participate in while employed as teachers.

Inquiry-Based learning - It is a student or learner-centered learning approach where students are actively involved in the investigation and problem-solving process. Students take the initiative to observe and question phenomena; pose explanations of what they see; devise and conduct tests to support or contradict their theories; analyze data and draw conclusions (Acheson, 2004; Duffy & Kirkley, 2004; Gewin, 2004; Johansson, 2003; Pang, 2006).

Multiple intelligences - A theory developed by Howard Gardner and first published in his book, *Frames Of Mind,* that posits additional human intelligence factors that influence the way we learn, including verbal, quantitative, spatial, musical, kinesthetic, interpersonal, and intrapersonal (as cited in Bloom & Palmer-Moloney, 2004).

NASA - National Aeronautics and Space Administration – This independent agency of the United States government is responsible for aviation and spaceflight.

NCLB - No Child Left Behind - NCLB is federal legislation that enacts the theories of standards-based education reform, which is based on the belief that setting high standards and establishing measurable goals can improve individual outcomes in education. President Bush signed it into law on January 8, 2002 (Sunderman & Kim, 2007).

Pre-service - For the purpose of this document, pre-service refers to the coursework required at the college or university level toward earning teacher licensure.

Problem-Based learning - Problem Based Learning (PBL) is a term used within education for a range of pedagogic approaches that encourage students to learn through the structured exploration of a research problem (Johansson, 2003; Kierski, 2008).

Remote sensing - Digital images or models of an area on the earth generated by special cameras from airplanes or satellites. Either the sun's reflections or the earth's temperature is turned into digitally imaged maps of the area. In order to view the results, the data must be rendered by specialized image processing software (National Aeronautics and Space Administration, 2009).

 SCANS - Secretary's Commission on Achieving Necessary Skills - In the 1990s, the U.S. Secretary of Labor, Lynn Martin, convened the Secretary's Commission on Achieving Necessary Skills (SCANS) with the intention of transforming academic standards. The

U.S. Labor Secretary's Commission on Achieving Necessary Skills (SCANS) stated that the most effective way to teach skills is "in context" (U.S. Department of Labor 1991, p.16). SCANS competencies include identifying resources, working with others, using information, and understanding complex and changing inter-relationships (Gewin, 2004; U.S. Geological Survey, 2005).

SES - Socio-economic status is based on income, education, and occupation. It is an economic and sociological combined total measure of an individual's or family's economic and social position.

Student or learner-centered learning - In student or learner-centered learning, students are active participants in their learning; they learn at their own pace and use their own strategies; they are more intrinsically than extrinsically motivated. Student or learner-centered learning develops learning-how-to-learn skills such as problem solving, critical thinking, and reflective thinking (Acheson, 2004; Duffy & Kirkley, 2004; Pang, 2006).

Transformative learning - The transformative learning theory resulted from studies by Jack Mezirow during the 1970's. It refers to a way of teaching and learning that transforms us, causing a shift in the way we view ourselves and the world. Merriam et al. (2007) identify the "four main components of the transformative learning process: experience, critical reflection, reflective discourse, and action" (p. 134).

<p align="center">Delimitations</p>

The sample is limited to teachers and students in the Palm Beach County School District, Florida. Furthermore, student data is limited to one middle school where the GIS is taught.

Limitations

The GIS program is not designated as a core component for instruction; integration of the GIS/GPS program is restricted by the desire of the teacher and can only be undertaken with the principal's approval. Therefore, only limited members of classrooms were available for this study. Furthermore, evaluation of schools choosing to implement this program that are under restructuring is prohibited by the School District. Schools in restructuring mode cannot engage in additional surveying or testing, which may interfere with the corrective academic efforts in place. Additional limiting factors involve the hardware constraints facing the school district. Many schools have only one PC lab or Media center, and often the system requirements of the GIS software necessitate upgrades to the technology infrastructure. Also, data to address some of the research questions is based on self-reporting by teachers or students. The findings may be affected by a desire to provide the expected response or some other type of response bias.

The primary researcher was also the primary force in the integration of GIS and GPS technologies into the K-12 curriculum. This involvement is detailed in chapter 3.

Summary

The mandate for education reform has challenged school systems across the nation to develop methods that will result in greater student achievement. The prospect of incorporating GIS into the curricula is promising regarding this goal; however, there are a host of obstacles and challenges. While the premise is that GIS engages students and enhances their learning experience, data is lacking to quantify if teaching GIS influences test scores. The issue of teacher reluctance to learn and incorporate new technology also

presents challenges. Another obstacle is the aspect of developing successful GIS professional development and creating a sustained model for implementing GIS in K-12.

Continued research is needed to evaluate whether students' perceive that GIS enhances their learning, and whether integration of GIS into existing curricula elevates student achievement. Previous studies also indicate that further research is necessary to assess professional GIS development practices for teachers and to investigate the development for a structured model to GIS integration into K-12.

Overview of the Chapters

This chapter introduces the nature of the study, the purpose for the research, and the research questions. The significance of the study is also defined within this chapter as well as definitions and the delimitations and limitations.

The literature review found in chapter 2 provides in-depth discussion regarding legislative mandates, the quest for academic achievement and potential for GIS integration into the K-12 curriculum. The evolution of Geographic Information Systems from business to educational areas is also explored. Further review includes the pedagogical and economic benefits of GIS.

Chapter 3 details the methodology for conducting the research. Included within this chapter is a description of the pilot study in addition to the research setting and background for the study. This chapter also includes the research design, samples, and procedures. Chapter 4 includes descriptive information on the samples and the results of the analyses. Chapter 5 includes conclusions and discussion drawn from the findings. Implications from the findings and suggestions for further research are also found in this chapter.

CHAPTER 2 – LITERATURE REVIEW

A review of the literature concerning GIS in K-12 education indicates that addressing the growing need for academic achievement in public school systems is a multi-faceted issue which requires both a holistic view and a detailed approach. The pressing concerns of our lagging ranking in the world standing regarding academic achievement coupled with the elevated high school dropout rates have been the impetus for a number of legislative educational reforms. The continuing educational reform crisis seems to have the effect of suppressing potential economic and human capital growth. Three questions arise: "Is what we're doing working?" "Are we doing enough?" and "How can we improve our efforts?"

Technology tools and software programs designed for particular areas of pedagogy are abundant, including classroom tools to advance reading literacy and math programs. There is, however, an instructional technology that spans many core curricula and can be integrated into most subject areas. Geospatial technology, including the use of GPS and software such as GIS can be implemented into virtually any topic in the K-12 environment, while advancing students' computer literacy skills. In addition, the literature also suggests that integrating this application into the curriculum can assist with closing the digital divide and the achievement gap. While continued advancement in the development and use of geospatial technologies in K-12 persists progress has been slow.

Research indicates there are a number of reasons why the educational community has been slow to embrace these tools.

This review will detail the current educational reform legislation and the effectiveness of the reforms that have been attempted. Exploration through existing literature will also provide insight regarding the potential benefits of incorporating GIS into K-12 curriculum and the potential economic and societal impact of that integration. GIS professional development for teachers will be addressed, as well as an examination of the barriers to implementing GIS in K-12 and successful implementation efforts.

Academic Achievement

Legislative Mandates

The fabric of K-12 (grade school) education in the U.S. was altered dramatically with the onset of the No Child Left Behind Act (NCLB), which was signed into law on January 8, 2002. While the premise of NCLB is to ensure sufficient education for all students, the federally mandated legislation never delivered on promised funding. From 2002 until 2008, the cumulative funding gap between what was promised and actual dollar amounts allocated was $54.7 billion (see Figure 1). These actions placed each state in the precarious position of funding the many initiatives directed in this mandate or facing the ramifications of school failure. If a school fails to pass for two years in a row, sanctions are levied, which can include reduction in funding and, at the extreme, a take-over of the school from the local school district.

A research study conducted by Sunderman and Kim (2007) examined three factors influencing implementation and illustrates the increasing tension between federal,

state and local authorities concerning the implementation and success of NCLB. Through discussion of NCLB's evolution, the literature is clear in outlining the present quagmire.

> As implementation proceeded, dissatisfaction with the law reverberated within states where policymakers voiced concerns about local control and the costs of implementing NCLB. These issues cut across political and ideological lines. Lawmakers, including many who initially had supported the goals of NCLB, now saw the law as overly punitive and lacking in adequate funding. (Sunderman & Kim, 2007, p. 1065)

The authors further stipulate that since NCLB is the largest education program targeting disadvantaged youth in our country, it is imperative that we adjust the program and build cooperative relationships between federal, state and local officials.
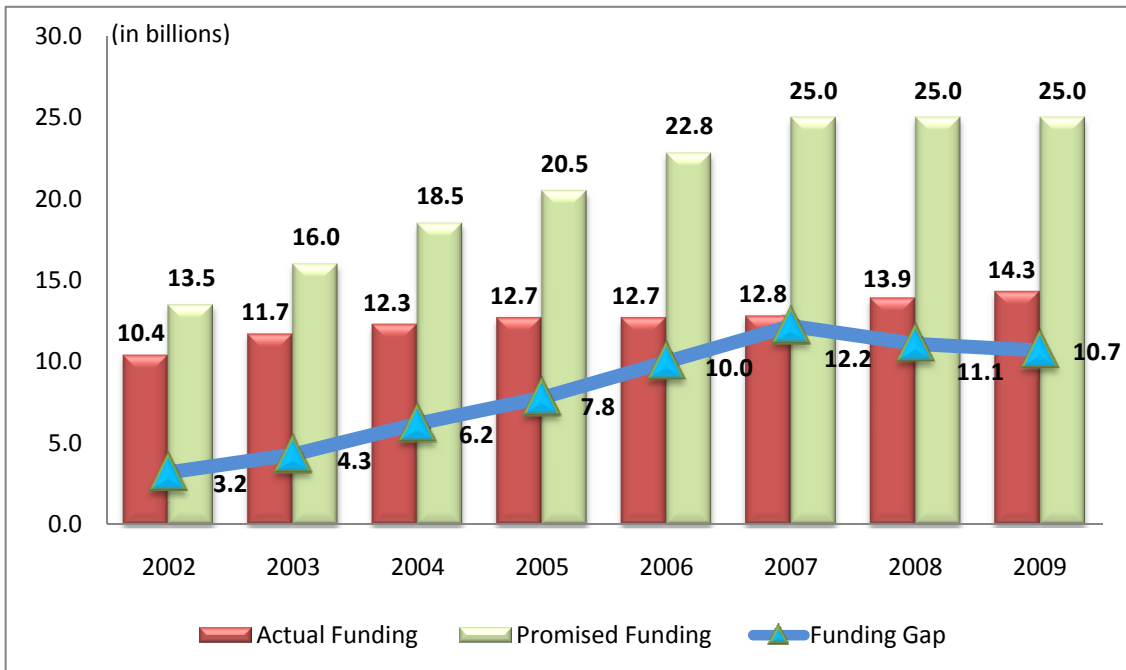
Figure 1. Funding gap NCLB Title 1-A grants, promised funding vs. actual.

Source: Zembar, T. (2008). Used with permission.

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As a result of NCLB and Adequate Yearly Progress (AYP) directives, teachers are forced to spend much of their valuable time teaching their students to take high-stakes tests. While students do gain valuable instruction, all too often there simply is not enough time to teach them necessary subject matter that is not required on the high-stakes tests such as civics, social studies, history, and computer literacy. As Weaver (2007) so aptly states, "Accountability systems should reward success and support educators to help students learn" (p. 45). The mechanism of accountability needs to actually support student learning and assist, not hinder, teacher efforts to reach this goal.

Interestingly, the NCLB legislation emphasizes the significance of leveraging the use of technology in K-12 education. Computer literacy, however, is not necessarily included in the high-stakes testing and many smaller school districts lack the funds for high tech software and hardware. There seem to be two conflicting choices: focus on the high-stakes testing to ensure funding from the state for education at the school or comply with initiatives from NCLB that require teaching components that are not tested. As we focus on the measures outlined in NCLB and the overwhelming importance of high-stakes testing, the effects these initiatives have had on the U.S. students' academic achievement has been mixed.

Testing and World Ranking

Testing to measure student achievement is nothing new; and, when used appropriately, testing is a valuable instrument to gauge a student's growth and ability to retain the instructional content. The literature overwhelmingly identifies that one of the greatest current flaws in the K-12 educational high-stakes testing is the drill down method of teaching students to take the test.

In *Teacher Observation to Assess Student Achievement*, Ediger (2007) points out one critical factor that may be what is lacking in the current NCLB law. What the author suggests is that "Systematic teacher observation of students in the classroom is vital" (p. 137), stating that many real assessments regarding students' growth are determined by observing their ability to grasp the content with which they are presented. Soublis-Smyth (2008) concurs with Ediger's remarks concerning the importance of observation. In her article, *Who is No Child Left Behind Leaving Behind*, the author expresses the notion of observation as a viable mechanism for assessment and portrays a systematic plan for education reform which includes school self-evaluations and site visits. Soublis-Smyth further states, regarding NCLB, that "Students from low socioeconomic backgrounds, minorities, students with special needs, and second language learners are adversely affected by this legislation" (2008, p. 135). This sentiment is observed throughout the literature, adding to the frustration with NCLB felt by politicians, educators and the public.

Roger Schank's work at the Institute for the Learning Sciences at Northwestern University prompted the development of Engines for Education, a nonprofit organization whose goal is to radically change our perceptions of how teaching and learning occurs at schools. In Schank and Cleary's book, *Engines for Education* (1995), learning is described as satisfaction of an innate curiosity that humans are born with. Unfortunately, as stated by the authors, once students enter the classroom, they are no longer prompted to be curious; they are, in fact, often reduced to rote learning and memorization. Simply stated, the fun has been removed from the learning experience. As do many other constructivists, the authors deliberate on the fact that, as human beings, we learn best by

doing. We remember those elements of knowledge that we can relate to in our own reality by connecting to what is relevant in our lives and constructing new knowledge with prior experiences. The book also provides remarks on the inherent benefits of incidental learning, learning by exploring and learning by reflection.

Schank and Cleary (1995) refer to "natural learning" as the antithesis of lockstep classroom instruction, the prescription in practice today. The notion of natural learning is a result of the Progressive Movement, whose tenets are that education should promote and cultivate natural interests and spur intrinsic motivation. Integrating GIS in the classroom can be the springboard to enhance learning and cultivate students' interests. The authors imply the primary impediments to the widespread implementation of the theories of the Progressive Movement are based in our steadfast love affair with standardized testing and curriculum, the one-size-fits-all education system.

This implication is reiterated by Soublis-Smyth (2008), who states, "Teaching to the test reduces teacher creativity, innovative instruction, the use of varied strategies for diverse students, and teacher and student motivation" (p. 134). Throughout the literature, the underlying tone suggests that students are more engaged and motivated to learn when they are involved with the topic in a contextualized way. The rote learning that has been popularized by NCLB assessments does not appear to be effective in motivating students or promoting teacher satisfaction. As Soublis-Smyth indicates, when teachers are excluded from the decision making their profession is marginalized, stating that "NCLB is leaving the teaching profession behind" (p. 134).

Fletcher (2006) argues that an effort should be made to enable all our students to acquire the necessary content to excel on high-stakes testing while also expanding their

educational horizons to include much-needed technology skills. Fletcher (2006) noted in the article, *A Plan Without a Plan*, that the Department of Education still had not defined technological literacy or how to access technological literacy, nor did the agency provide funding for this assessment. Learning technology skills and relevant content is not only necessary; it is the axis on which our students' success pivots. The Partnership for 21st Century Skills recognized this void and has made great strides advocating for the integration of 21st century skills into core K-12 academic subjects including social studies, English, math, science and geography. The 21st Century Skills Map for geography, developed in June of 2009, provides educators and administrators with examples and leads a way to infuse GIS into curriculum (Partnership for 21st Century Skills, 2009).

The Alliance for Excellent Education (2008) is a national policy and advocacy organization whose primary focus is to ensure that each child graduates high school and is prepared for college, work, and to be a contributing member of society. They report that the U.S. is falling short globally on test scores and academic ranking. According to their report, the U.S. ranks 15th of 30 Organization for Economic Cooperation and Development (OECD) countries in reading literacy, 21st out of 29 in science literacy, 25th out of 30 in math literacy, and 24th out of 29 in problem solving. The countries participating in the academic testing represent close to 90% of the world's economy.

The educational curriculum in the U.S. can be an arena where students flourish, absorbing contextualized information that is both engaging and meaningful. Teaching GIS and GPS (geospatial technologies) in our public K-12 school systems may help our youth acquire competitive learning skills and stem our plummeting world standing in

student achievement. GIS can motivate student learning and help to improve technology skills. This view is illustrated in the national report *Learning to Think Spatially: GIS as a Support System in the K-12 Curriculum* (Committee on Support for Thinking Spatially, 2005). One key element of this effort is to engage teachers in utilizing geospatial technologies in their curricula.

<div align="center">GIS (Geographic Information System)</div>

<div align="center">*What is GIS*</div>

Geographic Information Systems (GIS) are information systems with a locational component, making it possible to combine visual graphic features of anything that lies on the earth, such as lakes and rivers, road networks, zip code and city boundaries, or schools and libraries with the power of database records that can contain many pieces of information about a specific feature, including demographic data (see Figure 2).
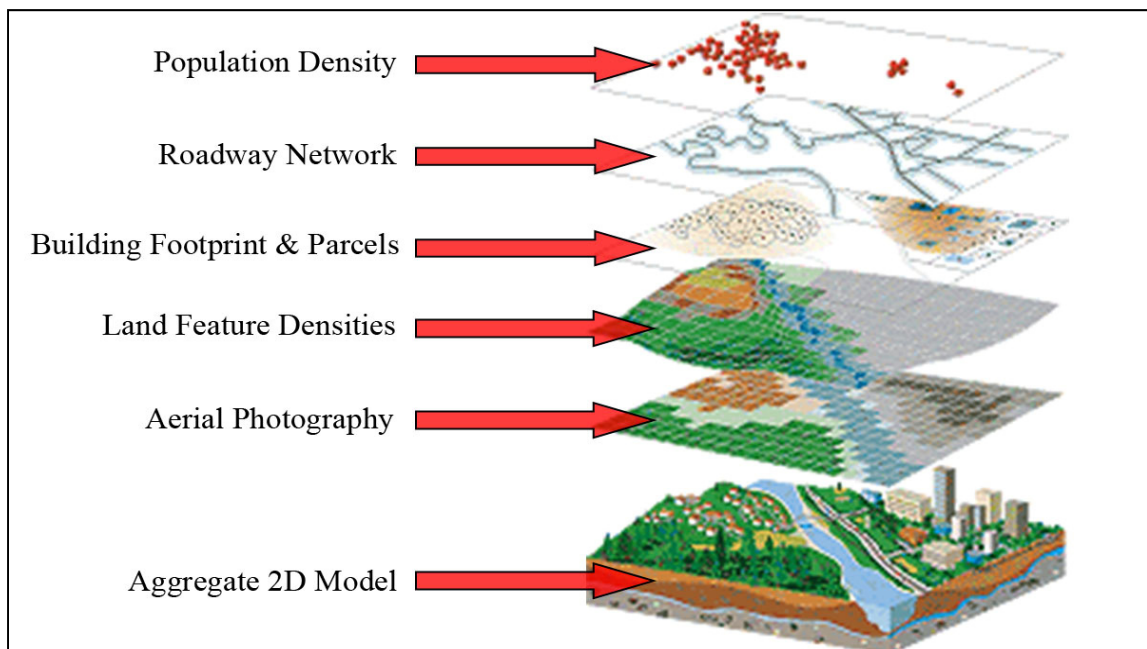
Figure 2. GIS layers image.

Source: ESRI (n.d. a). Copyright © ESRI. All rights reserved. Used by permission.

The power of the GIS lies in the ability to perform functions such as spatial querying and statistical analysis with the visualization and geographic analysis provided by maps. Nearly 80% of all data has a spatial component. The GIS provides the tools for spatially analyzing these data, their relationships, patterns and impact. The results of the analysis can be displayed in a report or visually as a map. The impact of utilizing GIS in the classroom can be evidenced in its applicability in a wide range of topics; for example, integrating GIS into a civics class can make the lesson come alive for students as they can visually see and understand the relationships between economic growth and mortality between countries.

Evolution of GIS

GIS was originally conceived during the 1960s in Canada, then further developed at a Harvard University Lab, and subsequently was utilized by the Defense Department and the Census Bureau through the 1970s. In the early 1980s a GIS software application was developed for commercial use, primarily for the environmental and scientific communities. Through the 1980s and 1990s GIS flourished in local government agencies and gained widespread use at this level. The business world realized the power and potential of GIS during the late 1990s. At present, the use of this technology is found in virtually every industry.

> GIS analysts, like other geospatial technology professionals, can be found
> working in various local, state, and federal government agencies, as well as in a
> wide range of related scientific and technical fields, such as agriculture, soils
> archaeology, biology, cartography, ecology, environmental sciences, forestry and
> range, geodesy, geography, geology, hydrology and water resources, land

appraisal and real estate, medicine, transportation, urban planning and development, and more. (U.S. Department of Labor, n.d.)

Geography education awareness was heightened in 1985 with the advent of the Geographic Education National Implementation Project (GENIP). The organization is comprised of several geographic associations, including the Association of American Geographers, the American Geographical Society, the National Council for Geographic Education, and the National Geographic Society. These groups were "committed to improving the status and quality of geography education in the United States" (GENIP, n.d.). The use of GIS tools in K-12 education seems to have made an entrance during the 1990s; however, integration has been slow to emerge in mainstream classrooms.

Benefits of Incorporating Geospatial Technologies in Academic Instruction

Pedagogical Benefits

Critical Thinking Skills

"Problem-based-learning and inquiry-based-learning" (Pang, 2006, p. 2), are instructional methods grounded in the constructivist theory that we scaffold new information upon prior knowledge. The GIS is an educational tool that capitalizes on the constructivist theory of learning. According to Johansson (2003), "GIS has the potential to facilitate problem-based-learning and inquiry-based-learning if the techniques are incorporated into secondary school curricula" (p. 2). Johansson presents information regarding Finland's National Curriculum mandate that GIS is incorporated into upper secondary schools.

As indicated by much of the literature reviewed, integration of GIS into curriculum subject matter can have broad-reaching educational benefits for students.

Most school age children have not known a world without computers; they are not intimidated by the technology and naturally gravitate to the visual and interactive platform of GIS. The U.S. Labor Secretary's Commission on Achieving Necessary Skills (SCANS) has indicated that teaching skills within context is a most effective approach for engaging students (U.S. Department of Labor Employment & Training Administration, 2006). There is abundant literature to support this aspect of integrating GIS into the curriculum, including publications from the Partnership for 21st Century Skills (Lang, 2009) and *USGS Science for a Changing World,* which recognizes that "SCANS competencies include identifying resources, working with others, using information, and understanding complex and changing inter-relationships" (U.S. Geological Survey, 2005, p. 1). All of the SCANS competencies are addressed when utilizing a GIS as an instructional tool. Pang (2006) refers to the scientific visualization and inquiry-based learning of GIS as one of the main reasons for utilizing this tool in an educational setting. Pang contends that "the anchoring of geographic data in real-life phenomena provides many possibilities for implementing problem-based learning approaches in rich, authentic, educationally productive contexts" (Pang, 2006, p. 2). This assertion is further supported by Goldstein (2008), who states;

> GIS is a perfect vehicle to deliver necessary content and contextualize a lesson, so students are engaged and motivated to gain the knowledge presented. Using GIS in the classroom enhances computer skills, increases the range of students' learning styles, promotes critical thinking skills, and hones communication and presentation skills. (Goldstein, 2008, p. 20)

Essentially, GIS is a critical thinking tool that helps students learn methodologies to carry out and test hypotheses of research projects based on real-world problems that incorporate real-world data. Students are excited about projects; GIS education provides exposure to the effects of geography on the world's problems and provides a conduit for students to engage in inquiry on issues that interest them. The software program is a great foundation for interdisciplinary projects and can be integrated into lessons for multiple subject areas. For example, in social studies, the class can explore demographic information for countries of the world; visualize historical events; and explore natural change over time (Alibrandi & Baker, 2008). Science education can include exploring natural phenomena such as earthquakes and volcano locations, exploring habits of animals, and the impact of humans (White, 2004).

Addressing Multiple Intelligences and the Achievement Gap

The very nature of the GIS and GPS facilitates tapping into various students' "multiple intelligences" as defined by Gardner (as cited in Bloom & Palmer-Moloney, 2004). These intelligences, which influence the various ways in which we learn and retain information, form the basis for understanding and relating to the world around us. Multiple intelligences are a theory of learning styles developed by Gardner and first presented in *Frames Of Mind*. "This theory posits that intelligence is not uniform, and that people possess at least eight exclusive intelligences including the musical, bodily kinesthetic, logical mathematical, linguistic, spatial, interpersonal, intrapersonal and naturalistic" (p. 2). Infusing GIS into instruction incorporates many of these intelligences, thus broadening the spectrum of students that can be reached academically and exposing a larger population to a meaningful way of learning.

These geospatial tools can be particularly advantageous for students who speak

English as a second language, as many of the GIS lessons span world-wide data. These

students are more inclined to be motivated for learning when the content-rich material

can be tied to their home countries and heritage. It is a widely held belief that when

teaching ESOL (English Speakers of Other Languages) students, inclusion of their

backgrounds, culture, and heritage is extremely advantageous to their instructional

comprehension. One of the five standards for student achievement developed by Tharp,

Estrada, Dalton and Yamauchi (as cited in Doherty, Hilberg, Pinal, & Tharp, 2003) is

based on socio-cultural tenets that "instructional activities are meaningfully connected to

students' prior experience and knowledge" (p. 4). As noted by Reed and Railsback

(2003) in *Strategies and Resources for Mainstream Teachers of English Language*

Learners, culture studies can be combined with other strategies such as project-based

learning, cooperative learning, and accessing a student's prior knowledge. To integrate

various cultural aspects into a GIS project is a relatively easy task to accomplish given

the plethora of worldwide data and lesson plans available.

The Digital Divide and the New Knowledge Gap

In addition to supporting the narrowing of the achievement gap for non-native

English speakers and other at-risk groups, GIS and GPS also address the concept of

closing the digital divide. The digital divide is the technological expanse between those

who have access to technology and those who do not. For those students who may be at

the lower end of the socioeconomic scale, teaching GIS and GPS in grade school exposes

them to technology and provides them with a venue to acquire much-needed computer

literacy skills. For many disadvantaged youths, having access to computers and learning

valuable, marketable skills can be a ticket out of poverty. "In the old days, the only way to get out of the ghetto was sports. The new way is technology" (Belcher, 2001, p. 1). Pang (2006) reinforces this sentiment by stating "GIS use in education will develop students' information and media literacy, preparing them well for the digital age" (p. 3). The literature suggests that as we reflect upon our past, there is an urgent need to review the flawed educational policies we have implemented.

Spatial Literacy

The entire platform of GIS is built on spatial understanding and analysis. "Given the increasing need for lifelong learning skills in a technologically challenging world, all students can benefit from learning to think spatially, as it is an integrator and facilitator for problem solving across many subjects" (Committee on Support for Thinking Spatially, 2005, p. 3). The literature further contends that this effort will only come to fruition if there is a systematic shift in our educational system, one that embraces spatial literacy. The report provides a remedy for the current deficiencies by including spatial elements into our national standards for K-12 curriculum. In addition, federal and state grants are recommended to provide assistance for implementation of GIS into the educational system. Spatial literacy extends beyond promoting critical thinking and problem solving to enabling students to better understand the world around them by promoting geographic literacy, a somewhat forgotten topic in today's school system.

While students in foreign countries are becoming equipped with understanding geography at the local, national and global levels, our current mandated curriculum does not allow for adequate instruction on this critical topic. This lack of geographic literacy coincides with deepening concern over what is defined in the *Last Child in the Woods* as

the "nature deficit disorder" (Louv, 2005). This term refers to the fact that today's children no longer play outside, are losing an understanding of and respect for nature and have become geographically inept. Not only do these trends have an ill effect on individual knowledge but may have serious ramifications for protecting our environment and utilizing our natural resources wisely. The fact is if our next generation does not understand geography and nature, they will be more likely to exploit the environment, which may have disastrous results; and they will be ill equipped to face the challenges of the future.

> The problems we face in the 21st Century—natural hazards, crime, terrorism, water availability and quality, biodiversity loss, climate change, urban sprawl, energy needs, and many more—are becoming more serious and are growing in geographic extent, affecting individuals' everyday lives. Each of these problems has a geographic component. Education in spatial analysis using GIS as the tool is the important skill that must be promoted if we hope to grapple with these issues. (Kerski, 2006, p.11)

The decrease in geographic knowledge of current students is evidenced throughout the literature (Bloom, & Palmer-Moloney, 2004; Committee on Support for Thinking Spatially, 2005, 2006; Louv, 2005). A number of researchers indicate that due to the emphasis on high-stakes testing, geography, which is not included in the NCLB testing requirements, is left behind. Unfortunately, this leaves our students lacking much-needed knowledge. Incorporating aspects of GIS into standards and adding them to the criteria of measurement in high-stakes testing may impact the value of these tools, and help to restore spatial and geographic literacy.

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Economic Benefits

Geospatial Job Market

Social and financial implications of GIS prompted the U.S. Department of Labor in 2004 to identify GIS as one of the three most important emerging and evolving fields (Gewin, 2004, p. 376). Geospatial technology skills have become more prominent in various industries and "employment growth of 18 percent is expected for geoscientists and hydrologists between 2008 and 2018, which is faster than the average for all occupations" (U.S. Department of Labor. 2009, p. 4). With the aging of our many professionals there are a number of organizations seeking to recruit the next generation. There is an imminent shortage of geospatial professionals prepared to enter the workforce as "many employers still report difficulties finding qualified graduates possessing strong preparation in geography and spatial analysis" (Richardson, 2008, p. 1). Richardson suggests that "having strong academic preparation in geography and GIScience will only expand the career opportunities available to students, allowing graduates to enter the job market at a higher level and advance more rapidly through the ranks after being hired" (p. 1). "NASA says that 26% of their most highly trained geotech staff is due to retire in the next decade, and the National Imagery and Mapping Agency is expected to need 7,000 people trained in GIS in the next three years" (Gewin, 2004, p. 376). Approximately one fourth of our present engineering and science workforce is due to retire by 2010; and according to Jackson (2007), "Nearly 70 percent of the civilian scientific and technical workforce at the Department of Defense could be eligible to retire in seven years" (p. 26). These are staggering numbers for the exodus of skilled geospatial workers in the U.S.

A Call to Arms

The article "*Waking up to the 'Quiet Crisis' in the United States*" (Jackson, 2007), was the result of a major report authored by Jackson in 2002, which addressed the national interest aspects of education reform. In her article, Jackson (2007) discusses the dire need for educational reform in the U.S. This literature outlines the directive in 1961 by President Kennedy to place a man on the moon as the catalyst that propelled the nation to embrace the educational efforts to reach this goal. These educational efforts were directed at K-12 and included intensive training for both teachers and students. It was, in effect, a type of educational reform fueled by the national desire to succeed. As the author states, "The young Americans who responded in record numbers to Kennedy's appeal became the engineers, mathematicians and scientists who have comprised the backbone of our innovative economy for the last 40 years" (p. 26). This call to arms drew out the best and brightest, those who prepared this nation for entrance into the digital era. At the present juncture however, many of these highly skilled workers are approaching retirement and a huge knowledge gap is looming in our workforce.

Nationally and Individually

The economic benefits of infusing GIS into K-12 curriculum extend far beyond the classroom. From a macro economic perspective, GIS integration will provide our youth with the technology tools needed to compete in an ever-growing global marketplace. With the emergence of geospatial technology in virtually every industry, students with GIS experience will be well-equipped to enter a myriad of careers or vocational trades. Industries and businesses are no longer tied to a country; the world is truly becoming "flat" (Friedman, 2005), and competition for high-paying technology jobs

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is greater than ever before. The educational system in the U.S. is doing our youth a disservice by not ensuring that their education includes high tech skills. Friedman noted in *The World is Flat* that "The rate at which our students enter Engineering and Science programs has fallen from 3rd in the world to 17th in the past three decades and applications to American graduate schools dropped by 28% in 2004" (p. 257). In order for the U.S. to remain a viable source for innovation and participation as a world leader, we must prepare our future workforce with the knowledge and skills needed. If we are remiss in providing opportunities for our teachers and students, we will be left behind in this technological age. By focusing on high-stakes testing and ignoring the accelerated rate at which countries such as China and India are producing technically savvy citizens, we are putting our nation's future at risk.

From the individual outlook, the economic benefit of integrating GIS into K-12 curriculum enables students who may not have the funding or desire to continue towards higher education, or those who economically are forced to enter the workforce directly after high school, an alternative to minimum wage jobs. By providing hands-on experience with geospatial technology, we open a door for students to compete that may have otherwise been sealed shut.

Projected Growth

Political factors supporting the promotion of GIS include the Florida State Department of Education's new initiative for expansion of geospatial technology in K-12 with the creation of a Geospatial Career Academy beginning in 2008. In addition, at the federal level, the *President's High Growth Job Training Initiative* includes geospatial technology as one of its top ten training initiatives. "The demands for geospatial skills are

growing worldwide, but the job prospects reflect a country's geography, mapping history and even political agenda. In the United States, the focus on homeland security has been one of many factors driving the job market. Another is its vast, unmapped landscape" (Gewin, 2004, p. 376).

"In September, 2004, U.S. Secretary of Labor Elaine L. Chao announced a series of investments totaling more than $6.4 million to address the workforce needs of the geospatial technology industry" (U.S. Department of Labor Employment & Training Administration, 2010, p. 1). In addition the U.S. military has spent more than $1 billion on commercial remote sensing and GIS in the past several years (Gewin, 2004).

The accelerated pace for the use of GIS in business and government has been recognized by the DOL's Employment and Training Administration. The administration has supported "comprehensive business, education, and workforce development partnerships that have developed innovative approaches that address the workforce needs of business while also effectively helping workers find good jobs with good wages and promising career pathways in the geospatial technology industry" (U.S. Department of Labor Employment & Training Administration, 2010, p. 1).

"Because the uses for geospatial technology are so widespread and diverse, the market is growing at an annual rate of almost 35 percent, with the commercial subsection of the market expanding at the rate of 100 percent each year" (U.S. Department of Labor Employment & Training Administration, 2009, p.1). Clearly, the U.S. government recognizes the tremendous growth and urgent need to develop a workforce aptly skilled in geospatial technologies. Educational reform can be adjusted to address the future

economic and business requirements, thus ensuring our ability to compete at the global level.

Career Pipeline

To address the imminent shortfall of skilled geospatial workers, several methods for recruiting young workers through apprenticeship programs with companies and government agencies are available. This type of hands-on experience may provide students who cannot afford to attend college an entry level career opportunity that otherwise would not be available. As noted, the use of geospatial technologies is abundant at all levels of government and the opportunity for local government agencies to work collaboratively with school districts in providing youth with internships and apprenticeships is one reasonable approach. In addition, high school/college dual-enrollment, dual-credit agreements can be negotiated between school districts and local universities and colleges. There are a number of ways that geospatial technologies can be promoted and marketed to young people, including involvement by professionals in the field to work with schools wishing to include this technology in the curriculum. Professionals can provide assistance to teachers by showing them the real world connections with their lessons using GIS. And they can perform educational presentations to students who are eager to learn about how the technology is utilized in the global marketplace. A new program introduced in 2009 by Environmental Scientific Research Institute (ESRI), the Geo Mentor program, is designed to offer educators assistance from GIS professionals. In this effort a GIS professional volunteers to adopt a school or class and assist them in using the GIS tools.

Career Opportunities for Students

Not only does integrating GIS into K-12 curriculum provide students with a tangible learning experience in which the instruction is contextualized, but exposure to GIS may provide some with a foundation for a career in the fast-growing field of geospatial technologies.

For individuals who do not wish to pursue an advanced degree, there are many 2-year academic and technical institutions that offer education and training in geospatial technologies, including GIS. Associate degree and certificate programs in geographic information systems (GIS), surveying, photogrammetry, and similar curricula provide a sound foundation for work experience or for transfer to other academic institutions for further education. Most local government agencies in mid to large size urban areas utilize GIS in many of their departments. There are potential opportunities for apprenticeship or internship programs with these agencies for high school students who have used GIS while in school. There are also local engineering, architecture and survey firms who may be interested in providing these types of opportunities to students skilled in GIS (U.S. Department of Labor Employment & Training Administration, 2009).

Implementation of Geospatial Technologies in K-12 Public School Systems

District, School, and Classroom Implementation

Hagevik (2003) notes the gap in research regarding the learning of K-12 students using GIS. In her dissertation, *The Effects of Online Science Instruction Using Geographic Information Systems to Foster Inquiry Learning of Teachers and Middle School Science Students*, Hagevik explored two different methods of instruction; the experimental group used a web-based GIS curriculum (MOSS) and the comparison group

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utilized a site-based GIS curriculum (CITYgreen) to see if GIS could be used to enhance student learning. The study was mixed method and involved 12 teachers and 164 students (131 in the experimental group and 33 in the comparison group). Hagevik (2003) concluded that GIS curricula should encourage open-ended inquiry. This finding fortifies additional literature that suggests the use of GIS encourages higher order problem solving and motivates students' learning. The findings from this study also substantiate the common belief that student learning can thrive in a collaborative environment such as the one that can be established while integrating GIS into the classroom. While significant results were indicated between and within the groups, the study is limited in sample size, and to a specific subject comparing two different delivery systems of GIS. The need for greater sample size in future studies to validate results is also recognized by Bloom and Palmer-Moloney (2004) who state, "Successful transfer between spatially based performance and performance on standardized tests remains to be empirically validated" (p. 7).

Yuda and Itoh (2006) discuss the topic of GIS in K-12 in their literature regarding educational reform in Japan. While they extol the benefits of integrating GIS into the curriculum, they also point out that widespread use of GIS is slow to emerge. Yuda and Itoh contend that "One of the reasons why GIS has not been distributed in K-12 education might be that the National Curriculum Standards have not forced schools to use GIS in a class" (2006, p. 99). This is also true in the U.S., as Kerski (2001) points out in his article, *A National Assessment of GIS in American High School*s. He notes that "GIS faces stiff competition in the curriculum, particularly with the emphasis on teaching to national and state content standards" (p. 74). The Partnership for 21st Century Skills is

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attempting to address this by providing science and geography maps which can present educators with teacher-created models of how 21st century skills can be integrated into core subject areas (Lang, 2009).

Emerging Classroom Technology

Most of the study-based research regarding the use of GIS in the K-12 classroom has indicated a slow emergence worldwide. A commonality throughout the literature is discussion regarding the snail's pace implementation of GIS into our classrooms. Many researchers suggest that future studies need to reflect the impact of GIS instruction on standardized test scores in an effort to gain widespread attention and support for infusing GIS into curriculum. There seems to be the underlying tone that if GIS is viewed merely as an add-on function for instruction, the pace will remain status quo; however, if there is government influence or pressure for spatial and technology learning, the implementation will increase exponentially.

Another common theme indicates that globally, many nations view education reform as integral and recognize the need to promote future career opportunities to students in high growth industries such as geospatial. At Pimlico State High School in Queensland, Australia, the governing state education authority encouraged integrating technology throughout the curriculum, thus providing the opportunity to incorporate GIS. The introduction of GIS into the curriculum was a methodically structured process and included addressing technology resource issues and staff development. The program has been in place for 11 years now and Jenner (2006) states, "One of the great benefits to date of integrating GIS into the curriculum has been the change of 'culture' where teachers now actively seek new opportunities to further extend the integration of GIS within their

teaching" (p. 282). This is not to say that Pimlico staff did not have hurdles to overcome; the recurrent obstacles were experienced in this study as well as most of the other literature examples, including teacher resistance to change. One resource that was provided to teachers was that local GIS officers volunteered to assist with training and provided demonstrations to teachers on how the application is used in industry. This effort made GIS tangible for teachers and they could see how to integrate the tool into their lessons.

There are a host of reasons why GIS has been slow to emerge as a tool for education: lack of funding for technology, lack of support and directives from leadership, insufficient professional development for teachers and the overall resistance by teachers to implement yet one more element into their already overcrowded mandated curricula load (Acheson, 2004; Alibrandi & Palmer-Moloney, 2001; Bloom & Palmer-Moloney, 2004; Brodie, 2006; Hagevik, 2003; Haymore-Sandholtz & Reilly, 2004; Johansson, 2003; Kerski, 2001; McClurg & Buss, 2007; McInerney, 2006; Milson & Alibrandi, 2008; Yuda & Itoh, 2006; Wilder et al. 2003.)

Funding and School Budget Decisions

Many larger school districts already use GIS for their demographic analysis and busing. One solution to the funding issue is to explore a GIS site license. Depending on the current license use for GIS administrators, the cost to increase licensing for district-wide use may be minimal. For example, if the school district planning and transportation departments are already using GIS and paying for single licenses, they can purchase a site license from ESRI for $25,000.00, which allows the district to put the GIS software on any and every PC the district owns. Staff and teachers are also authorized load the GIS

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software onto their home PC's. The site license also includes all of the GIS software that the vendor develops, including GIS server and web applications. In addition, the site license provides access to numerous virtual GIS classes that can be taken on the internet.

New Internet-accessible GIS tools that have recently been released can ease some pressures of insufficient hardware. White (2008) contends that the GIS internet environment "is one approach that potentially may aid in the diffusion of GIS as an innovative educational resource" (p. 176). For example, ArcGIS Online is a web-based GIS outlet, or repository where users can share GIS data and maps and use free desktop viewers or web-based GIS tools to access this data. While use of internet GIS applications is not as robust as the traditional desktop tools, this venue provides access and exposure to GIS for teachers and students.

White (2008) discusses Everett Rogers' work regarding the Diffusion of Innovators theory as it relates to school district decision making and the adoption of GIS technologies. What White suggests is that the early adopters of the GIS innovation spread their knowledge and gain support through social networks. Her assertion is that "these innovators and early adopters function as a collective voice against the resistance of schools to move forward with the innovation" (p. 173). Essentially, the innovator champions the notion of implementing GIS in the K-12 curriculum and spreads the enthusiasm to ensure all stakeholders have buy-in and are included in the decision making. To move forward there must be a collaborative effort to successfully introduce new instructional technologies such as GIS into the classroom.

Stakeholder Buy-in and Leadership Endorsement

"Working in collaboration, GIS system designers, educational IT specialists, and teachers should develop guidelines for a model GIS-enabled school" (Committee on Support for Thinking Spatially, 2006, p. 10). The report further contends that guidelines need to be developed for pre and in-service teacher training regarding GIS and that these guidelines be developed in a collaborative effort with representatives from colleges of education and GIS educators. As with most new initiatives, a champion must emerge who can engage and motivate leadership. This includes encouraging administrators, curriculum planners and teachers to embrace the GIS as an educational tool. The process must be supported from the top down and from the bottom up; this means leadership must endorse these efforts, provide sufficient staff development and include all parties in the decision making. From the bottom up teachers must be willing to step out of their traditional comfort zone and look to incorporate the GIS as a new technology tool that will not only engage their students but provide greater teaching satisfaction. The model should be developed as a structured guide to implementation and the team of stakeholders should meet on a regular basis to review the status of implementation and the procedures.

As White (2005) indicates, there is a significant awareness issue when it comes to mainstreaming the use of GIS into K-12 curriculum. "Administrator, teacher, student and parent awareness of GIS as a technology is a major factor in making the decision whether to include GIS in curriculum or as an instructional technology" (p. 244). White further illuminates the invisibility of GIS in general and the perception that this technology is cloaked in self-contained industry uses. For mainstream academic acceptance, the public must be educated on the benefits of GIS and the role it can play in K-12 education.

Perception of New Technologies and Professional Development

Hagevik (2003) suggests that for technology to take root in the K-12 environment, "Teachers must change from teacher-centered to more student-centered teaching approaches such as problem or project based learning" (p. 172). In addition, many teachers need to embrace technology, not avoid it. The goal is to make the GIS easy to integrate into existing curricular demands. One way to accomplish this is to use ready-made GIS lesson plans that incorporate national standards. There are several GIS lesson plan books available that provide step-by-step instructions, teacher notes, student worksheets, rubrics, and data sets and are available for both primary and secondary grades (Malone et al., 2005).

Brodie (2006), discusses a case in which GIS was introduced at a Diocesan school for Girls in Auckland, New Zealand. The GIS was introduced in 2005 as part of an existing unit and the teachers utilized the GIS lesson plan book, *Mapping Our World*. Brodie contends, "The success of the project in 2005 depended on making the implementation easy for staff, particularly those who were not GIS enthusiast[s]" (p. 272). While the project was successful and expanded in 2006, Brodie found that, while working with younger teachers, many were reluctant to utilize the GIS, noting that "In most cases this was because they had not enjoyed the GIS component of a university course" (p. 273).

Another case study regarding the impact of computers on teaching and learning was conducted by Haymore-Sandholtz and Reilly (2004). The article, *Teachers Not Technicians: Rethinking Technical Expectations for Teachers*, takes a comprehensive

look at technical expectations of teachers and the growing need to infuse computer literacy into the K-12 environment. The authors state, "The ability of teachers to use technology in classroom instruction lags behind access to technology in schools" (p. 487). The study involved implementing technology in a K-8 school district with 260 teachers and 4600 students near San Diego. The project was implemented with support from state and federal Technology Innovation Challenge grants and provided hands-on training for teachers. A concluding factor was that teachers do not necessarily need to become technology experts; they need to become comfortable with using the technology. An analogy is made that in order to drive a car one does not have to have the skills of a mechanic. The authors note that their findings "suggest that a more productive approach is to begin with teachers' strengths – thinking about curriculum and instruction – rather than putting them in the uncomfortable and unfamiliar role of technicians" (p. 507). This research supports the use of GIS in curriculum from the standpoint that use of the technology is based on the curriculum, the lessons themselves. Learning the technology is a by-product of conducting the content-rich, curriculum-based GIS lessons.

McClurg and Buss (2007) conducted a study involving six separate GIS/GPS professional development workshops over five years involving 130 teachers. In their article *Professional Development: Teachers' Use of GIS to Enhance Student Learning*, the authors discuss obstacles teachers encounter concerning incorporating GIS into their existing classroom, including learning and achieving a comfort level with the technology.

Teacher acceptance of new technologies often relies on the support they receive. Successful implementation of GIS into K-12 requires development of pre-service GIS coursework for teachers-to-be and in-service professional development sessions for

teachers already in the field. For practicing teachers to embrace the use of this new

technology, Johansson (2003) suggests that professional development focus on a

pedagogical perspective rather than a technical one. Johansson indicates through the

results of her survey that, "Teachers do not feel that GIS is easily incorporated into their

curricula and in-service training therefore must focus on the pedagogical rather than

technical part of GIS" (p. 8). This comment reflects the notion that acquisition of the

necessary hardware, software and support from administration to utilize the program is

not enough. Teachers will require professional development that provides them a comfort

level with the software and illustrates effectively the pedagogical benefits of integrating

the GIS into their curriculum for their students.

However, even with extensive professional development teachers do not always

integrate the training into their everyday practice. Notable themes include the necessity

for hands-on training during the professional development, adequate hardware at the

training facility, follow-up training and administrative support. Meltzer (2006) also

highlights the importance of addressing teacher apprehension about new technology.

Meltzer's (2006) study, *An Analysis of Professional Development in Technology for*

Elementary School Teachers provides some insight on this topic. Her findings indicated

that the recommended practices for effective staff development fell into planning,

implementation and follow up including support. The key elements were the involvement

of the administration, the collaborative effort concerning shared vision and goals with

faculty and staff, the long term strategic plan developed with teacher involvement, the

flexible training plans that were developed, and the use of the needs assessment

instrument for the process. Through a compilation and evaluation of best practices

Meltzer (2006) developed a model of effective professional development in technology. The components of this model can be applied when developing a GIS professional development program for teachers.

Shin (2008), states, "The integration of technology is not an exception to the notion that teachers are 'gatekeepers' who make instructional and curricular decisions" (p. 273). The development of GIS professional development workshops that incorporate best practices for these "gatekeepers" is essential to establish a sustained foundation for integrating GIS into curriculum and enhance student learning.

Redefining Curricular Needs for Teacher Programs

Yuda and Itoh (2006) posit another explanation for the phenomenon of the slow emergence of GIS in the educational environment: "One of the reasons why GIS hasn't been accepted widely in education might be that many of the teachers have neither studied it before when they were students nor had experiences to use GIS as an educational tool" (p. 100). Ultimately, it is the teacher who has the power to successfully implement GIS into the classroom. The fact is that even though the application may hold great promise for education reform, if teachers are not motivated and interested, the integration will not occur. To that end, efforts have been made to incorporate GIS at the university level.

Many colleges of business have included GIS coursework as part of the college curriculum, noticing the growing use of GIS in industry and recognizing the increasing global employment need for geospatially educated individuals (ESRI, n.d. b; Gewin, 2004; U.S. Department of Labor, n.d.). There is a need, however to engage colleges of education to incorporate GIS into their teaching programs as well. If we are to impact

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education reform in a meaningful way, the reform must start at the root. To better educate our youth, the reform must start at the beginning – with our teachers.

Conclusion

The success of NCLB and our educational reform program centers on the way we as a nation view our educational system, and whether or not legislators recognize that adjustments must be made. The detailed approach to implementing these adjustments may be realized by incorporating technology programs such as GIS into the curriculum. If we do not address our present educational crisis, the suppression of potential economic and human capital growth may be staggering. Our current approach to education is not working well enough to keep the U.S. competitive. One way we can improve our efforts is to design college programs for teachers that include GIS coursework, for instance integrating GIS into coursework for pre-service teachers. This may provide the trickledown effect of GIS integration into our K-12 educational system.

At this time, we can only speculate as to the societal benefits of implementing GIS into K-12 curriculum, based on the positive outcomes indicated by available studies. The full impact may not be realized for some time to come, as school districts are slow to embrace the paradigm shift from traditional teacher-centered pedagogy to newer technology-assisted approaches driven by learner-centered learning. The longer we wait to educate our students in technologies that promote learning and competitive skills, the further we will trail those countries who are embracing these educational initiatives.

The literature reviewed is consistent in identifying the challenges and barriers to implementing GIS in the K-12 environment. The most noted characteristic that hinders implementation is teacher resistance and lack of a structured implementation model.

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There is also a general consensus regarding the gap in research as it relates to the impact of integrating GIS into the curriculum and high-stakes academic achievement tests. A comprehensive research study is needed that will incorporate quantitative data gathering and analysis, including both student and teacher samples.

The next chapter presents a research methodology for exploring GIS integration into K-12 curriculum, incorporating both student and teacher perspectives.

CHAPTER 3 - METHODOLOGY

This chapter will describe the proposed research study and provide a brief background concerning introduction of GIS into the K-12 curriculum at Palm Beach County School District. The research design includes a description of the samples proposed in this study and illustrates the procedures for collecting data. The proposed methods for data analysis are delineated. In addition, a narrative is provided regarding the pilot study, which was conducted with student and teacher data from 2007 – 2008. The function for this pilot study was to explore the purpose of the research and to adjust instruments for future use.

Purpose of the Research

The purpose of this study was to explore outcomes of a GIS/GPS integration process: to (a) examine student responses to GIS and GPS inclusion in their curriculum, (b) determine whether a relationship exists between inclusion of GIS into existing K-12 curriculum and student achievement, (c) examine the effectiveness of GIS professional development for teachers, and (d) evaluate teacher perceptions of the value of integrating GIS into their existing curricula.

This study was quasi-experimental in design, in that the "experiments lack random assignment of units to conditions but that otherwise have similar purposes and structural attributes to randomized experiments" (Shadish, Cook, & Campbell, 2002, p. 104). This study includes, along with data gathered from a pilot study, an expanded

sample of both teachers and students. This study builds upon the research conducted in the pilot study regarding the influence of GIS instruction on students' motivation and engagement concerning learning, and whether the students believe the program implementation was effective. Results of this research enhance and continue the discussion on evaluating professional development in geospatial technologies for teachers already in the field, to assess their acceptance and readiness to integrate these new tools into their existing curriculum.

Eleven research questions and hypotheses guide this study. They are listed in chapter one and in the procedures section of this chapter.

<center>Research Setting</center>

Palm Beach County School District is located in the Southeastern region of Florida and is the 11th largest school district in the nation. The county's population is comprised of a mostly middle and lower socioeconomic class. The school district, which encompasses the entire county, more than a 2000 square mile geographic area, has a very diverse student population. There are over 170,000 students speaking "149 languages and dialects" (Palm Beach County School District, 2009, p. iv) other than English and over 48% qualify for free and reduced meals (a breakfast and lunch program sponsored by the government for lower SES children) (Goldstein, 2008).

The importance of utilizing Palm Beach County School District for this study lies in the diversity of the population, which reflects national trends. The county has been viewed as a microcosm of the nation in terms of demographic data, as indicated in the National Coalition of Advocates for Students report, *A Gathering Storm: How Palm Beach County Schools Fail Poor and Minority Children,* (Carmona, Wheelock, & First,

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1998). As Figure 3 indicates, the percentage of minority students has increased over the past 20 years (Palm Beach County School District, 2009, p. v)
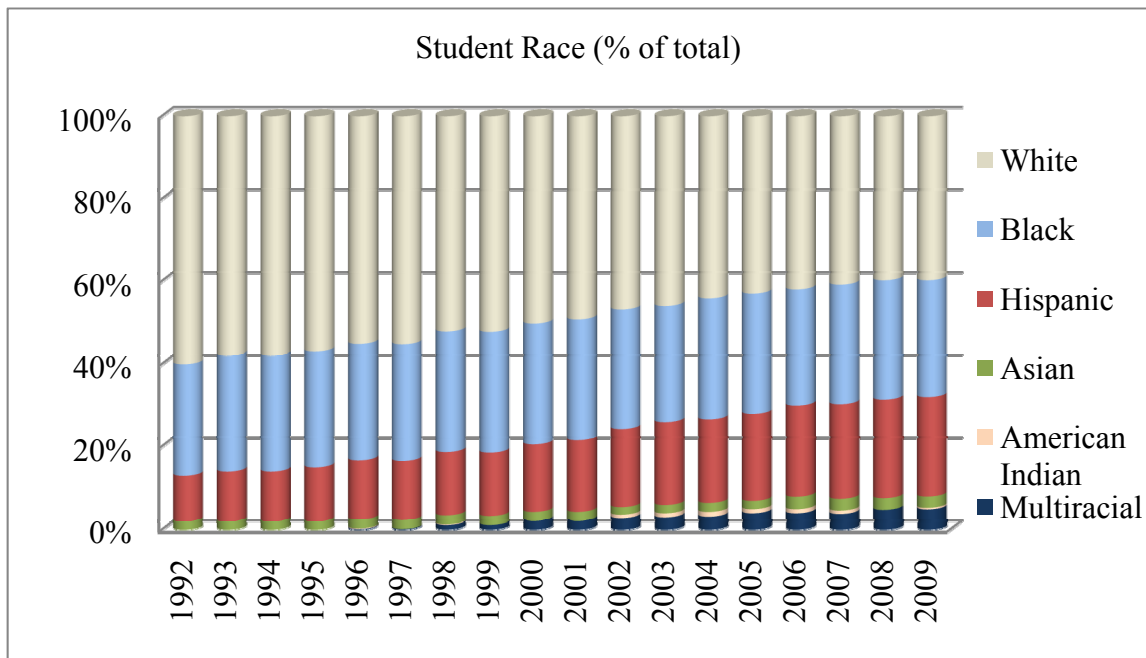
Figure 3. Palm Beach School District: Increasing Hispanic and multiracial students.

Source: School District of Palm Beach County Mainframe

Traditionally the GIS system was used at the district in the operational or administrative levels in departments such as the facility management planning department for demographic analysis, student population projections, boundary assignments and school loading. With the need to expand the existing GIS licenses for users in other departments such as Choice Programming and School Police, a site license was acquired. The cost of this site license was less than purchasing individual licenses of the software for those departments who requested the GIS to assist in their administrative duties. In addition the site license provided access to all of the GIS software applications and offered the school district the ability to put the software on every PC the district owned, including those in classrooms. The site license also permitted staff and teachers to

load the application on their home PC's. Recognizing the powerful potential of GIS as a teaching aid and the overwhelming marketability of GIS skills, the GIS Coordinator and Planning Director pursued the prospect of integrating GIS into the curriculum. A first step was the formation of a GIS Steering Committee and a model project charter. Once the team was in place a strategic plan was developed and the process of implementing GIS into the classroom began. Upon completion of the initial professional development for teachers and the first year of GIS inclusion at one middle school, a pilot study of student responses to GIS integration and teacher responses to a training workshop was conducted.

GIS Educational Model Project Charter (GEM)

A business model approach to developing a collaborative team was utilized to promote broad involvement and to begin expanding use of the available GIS technology (see Figure 6). In 2007 a GIS Steering Committee was formed which included membership from Career Academies, Curriculum Planning, Educational Instruction, Information Technology, Facilities Management, School Police, and others. At the initial meeting the committee was presented with the outline for the project charter, which aligned school district goals and objectives with the integration of GIS into existing curricula. Discussion ensued, milestones were identified and members were assigned roles and responsibilities.

Upon committee agreement the charter was presented to Academic Team Leadership, which includes the Superintendent and the Chief Academic Officer (CAO). Both the superintendent and the CAO had been presented with the background and benefits of implementing GIS into the existing curriculum and endorsed the effort. With

the Chief Academic Officer signing off on the GIS Project Charter, the program was fully sanctioned for use in the K-12 school system. The GIS Educational Model (GEM) has been developed and implemented in the Palm Beach County School District. Appendix E constitutes the text of the charter.

<center>Researchers' Role</center>

The principal investigator for this study was involved in the initiation of the integration of the GIS and GPS technology in Palm Beach County K-12 school system. Initiating actions included discussions with administrators to obtain commitment to the project and selection of individuals from key areas to be involved in the GIS Steering Committee. The researcher also designed and implemented teacher training and developed the instruments for student and teacher surveys.

Recognizing the researchers' integral involvement in the K-12 integration of geospatial technologies, all efforts were made to maintain complete integrity of data. In addition, the methods of analyses were quantitative, reducing any potential for researcher bias in the interpretation of the results.

<center>Pilot Study</center>

A pilot study was conducted to explore the effectiveness of GIS as a classroom tool by measuring motivation and classroom engagement of 75 middle school students who received GIS instruction as integrated into their existing social studies curriculum twice a week. An analysis of the effectiveness of the GIS professional development workshops for 27 social studies teachers from Palm Beach County School District was also included in this pilot. The IRB submitted for this research was deemed exempt.

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Students were instructed to fill out a survey anonymously at the end of the semester during which they received the GIS instruction. Although the results for the first portion of the survey did not meet the requirements of the fidelity scale, the findings, as shown in Table F1 and Figure F1 (see Appendix F) indicated that the majority of students were more engaged and motivated in the learning process when provided with the opportunity to use the GIS software program application. "The fidelity scale provides an objective, structured way to give feedback about program development" (Palm Beach County School District, 2008). A series of survey question results by participants is evaluated by administrators to determine if a program should be recommended for implementation or if it is not supported. Rating of each question is based on a positive response of 50% or greater. The fidelity scale for program implementation ranges from full implementation (>75%), to good (66% – 74%), to fair (65%-56%), and to not supported (<56%). The range of implementation is based on the number of statements in the survey that exceed 50% in positive responses. For the school years 2007, 2008, and 2009, twenty-two programs were evaluated with twelve designated for full implementation. While the fidelity scale is used to measure school district programs, implementation does not relate to teacher quality or the quality of instruction in the classroom.

The student survey results also revealed that students looked forward to classes that included GIS in the instruction by a ratio of almost 2 to 1; 56.7% of students agreed, 13.3% were undecided and 30% did not look forward to the GIS class. Approximately the same 2-1 ratio of students stated that they would recommend the GIS class to others. Over 60 percent of students believed that their computer literacy skills had improved due

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to the skills they learned while using the GIS software program. Furthermore, the students' responses regarding their evaluation of the GIS program implementation as shown in Table G1 and Figure G1 (see Appendix G) indicated, based on the school district's fidelity scale, that the program was viable for implementation at Palm Beach County School District.

The professional development GIS training workshop was held on June 26th 2007. Attendance included 27 social studies teachers, 14 from middle schools and 13 from high schools. The teacher feedback form was developed in accordance with the district's professional development protocol. The responses from the feedback form indicated that the majority of teachers believed GIS was a valuable tool that should be incorporated into curriculum instruction. Recommendations from participants included providing follow-up sessions and additional training workshops. In addition several Likert-type questions have been summarized below. These questions were aimed at evaluating teachers' perceptions of GIS and its application in the classroom.

Prior to the professional development, understanding of GIS was relatively low, an average of 1.5 on a five point scale. Following the staff development, understanding was greatly enhanced to an average of 4.0. The overall quality of the GIS professional development training was rated relatively high, with an average score of 4.1. Additionally teachers found the topic and material utilized in the hands–on exercises interesting, as demonstrated by the average score of 4.0.

The average rating for the length of time to complete the lessons was 4.0, indicating that teachers believed the timeframe for the staff development workshop was adequate. The teachers also rated the usefulness of GIS as a tool to complement lesson

planning highly, with an average of 4.6. The overall GIS training program was rated at a difficulty average of 3.4, indicating that most found implementing the GIS program relatively easy. They also indicated a high average rating (4.5) for the usefulness of GIS lessons plans in the *Mapping Our World* book that was used in the workshop and provided to each teacher. Most of the attending teachers stated that they were likely to implement GIS in their classrooms (average score of 4.2) and on their home PC's (average score of 3.9).

The greatest interest in additional GIS information was for supplementary lesson plans (average 4.5); however, there was also interest in a GIS newsletter for educators (average 4.1), industry-wide newsletters and/or books (average 4.1) and contact with other teachers and agencies utilizing GIS (average 4.3).

Research Design

This research explored the potential benefits for including GIS/GPS into curriculum by examining data from two groups: first, research was performed to determine whether inclusion of GIS in middle school curriculum had a significant effect on student achievement and motivation and by analyzing test scores and student survey results. In addition, results of the study indicated whether the students believe the program implementation was effective.

The second group of data, the professional development feedback forms, assisted in determining teachers' perceptions of the GIS/GPS program as an integrative tool for their existing curricula and their assessment of the GIS professional development training. The research included previously collected data from the pilot study for research questions 8, 9 and 10.

Samples

Teacher Sample

Three groups of teachers were included in the study. Sample 1 is from the pilot study and represented 27 teachers who attended a one day hands-on staff development workshop in June of 2007, Sample 2 represented 9 teachers who attended a one-half-day hands-on staff development workshop in December of 2007, and Sample 3 represented 26 teachers who attended a one week GIS and GPS hands-on staff development workshop June 30th – July 3rd 2008.

Student Sample

The student sample included two groups from the same middle school. Both groups have the same teacher. Sample 2007-2008 is from the pilot study and is comprised of 75 students who received GIS instruction twice a week as part of their social studies class for one semester, with 60 completing the survey. Sample 2008-2009 represented 181 students who received both GIS and GPS instruction five times a week as part of the elective GIS class for one semester, with 144 completing the GIS survey, and 140 completing the GPS survey. Due to space constraints students are often placed in electives out of convenience. While the GIS class was an elective, students do not necessarily get their first choice. For the fall semester of 2008 approximately 50% of the students actually selected the GIS class as their elective, but for the spring 2009 semester, approximately 10% of students who were in the GIS elective course had selected it as their preferred elective. All students at this school filled out the GIS survey at the end of the semester.

Instruments

Two student surveys, one for Sample 2007-2008 (see Appendix A) and one for Sample 2008-2009 (see Appendix B) and the teacher feedback forms (see Appendix C and D) are utilized in this study. Data from the student surveys assisted in determining whether students perceived their learning was enhanced by inclusion of GIS and GPS. Data from the teacher feedback forms were used to evaluate the professional development training.

Student Survey 2007-2008

This survey was developed into two sections; the first five questions were developed to assess whether inclusion of GIS instruction influenced students' learning and is based on a Likert-type scale of five possible selections: Strongly Agree = 2, Agree = 1, Undecided =0, Disagree = -1 and Strongly Disagree = -2.

The second section of this survey was designed to evaluate students' perception of the teacher's delivery of the instruction and the overall program implementation. Questions six through ten were developed based on the school district's fidelity scale, which is a measurement utilized to determine whether a program should be fully implemented. This series of questions provided three possible options for the students to select from: Yes = 2, Sometimes = 1, and No = 0.

Student Survey 2008-2009

This survey included identical questions for instruction concerning the GIS program and GPS technology. The survey was developed into two sections; the first five questions were developed to assess whether or to what degree inclusion of GIS and GPS instruction influenced students' learning and is based on a Likert-type scale of five

possible selections: Strongly Agree =2, Agree = 1, Undecided = 0, Disagree= -1 and

Strongly Disagree = -2.

The second section of this survey was designed to evaluate students' perception of

the teacher's delivery of the GIS and GPS instruction and the overall program

implementation. Questions six through ten were developed based on the school district's

fidelity scale, which is a measurement utilized to determine whether a program should be

fully implemented. For the purpose of continuity the selections for the series of questions

in this survey is also based on a Likert-type scale of five possible selections: Strongly

Agree =2, Agree = 1, Undecided = 0, Disagree= -1 and Strongly Disagree = -2.

Teacher Feedback Form 2007

Completion of this survey was a requirement for teachers to obtain in-service

points for professional development. Questions 1A, 1B, 1C, 2A, 2B, 2C, 2D, 4A and 4B

are based on a Likert-type scale with five possible selections ranging from 1, the least

favorable response, to 5, the most favorable response. These questions pertained to

teachers' evaluation of the professional development training workshop. Question 5A is

also a Likert-type scale with five possible selections ranging from 1, the least favorable

response, to 5, the most favorable response and indicates whether teachers perceive

incorporation of GIS into their curricula is beneficial to students' learning experience.

Teacher Feedback Form 2008

This survey was a requirement for teachers to obtain in-service points for

professional development. Questions 1A, 1B, 1C, 2A, 2B, 2C, 2D, 6A and 6B are based

on a Likert-type scale with five possible selections ranging from 1, the least favorable

response to 5, the most favorable response. These questions pertained to teacher's

evaluation of the professional development training workshop. Question 7A is also a

Likert-type scale with five possible selections ranging from 1, the least favorable

response, to 5, the most favorable response and indicates whether teachers perceive

incorporation of GIS into their curricula is beneficial to students' learning experience.

Procedures

Teacher feedback forms did not require confidentiality. Student participants'

confidentiality was protected. No student survey form contained any identifying

elements. For the student-related research a consent document from both the teacher and

the principal of participating school was acquired, consistent with Palm Beach County

School District protocols for research involving minor students. All identifying fields for

the student grades and demographic data gathered were stripped prior to any analysis.

Data Collection

The needed data were obtained from Palm Beach County School District records.

Teacher feedback forms were gathered after each of the professional development

training sessions. The participating middle school delivered the completed student survey

forms at the end of each semester. At the end of the school year, the student grades and

demographic data were extracted from the school district student database for those

students from the middle school, both those who received GIS instruction in their

coursework and those who did not receive GIS instruction at all.

Data Analysis

Data analysis methods are presented by research question.

Research question 1. Do students perceive that their learning is enhanced by

inclusion of GIS and GPS?

Null hypothesis 1. The distribution of students' perceptions of the extent to which their learning is enhanced by inclusion of GIS and GPS is symmetric.

Responses of 144 students on the GIS student surveys for the school year 2008-09 were used to test the hypothesis. Statistical analysis was performed on two items from the student survey (see Appendix B):

Item 5: *The GIS program can help improve my learning in topics such as social studies, science and math.*

Item 10: *Using the GIS gives me a better understanding of the social studies or science topic that is covered in the lessons.*

For the second part of research question 1, responses of 140 students on the GPS student surveys for the school year 2008-09 were used to test the hypothesis. Statistical analysis was performed on two items from the student survey (see Appendix B):

Item 5: *The GPS program can help improve my learning in topics such as social studies, science and math.*

Item 10: *Using the GPS gives me a better understanding of the social studies or science topic that is covered in the lessons.*

Student responses were entered into electronic format, and the Likert-type items were coded and totaled based on the following numeric values for each response: Strongly Agree = 2, Agree = 1, Undecided = 0, Disagree = -1, Strongly Disagree = -2. An inferential test (symmetry test) was performed.

Research question 2. Do students perceive that inclusion of GIS and GPS into curriculum enhances their computer literacy skills?

Null hypothesis 2. The distribution of students' perceptions that inclusion of GIS and GPS into curriculum enhances their computer literacy skills is symmetric.

Responses of 144 students on the GIS student surveys for the school year 2008-09 were used to test the hypothesis. Statistical analysis was performed on one item from the student survey (see Appendix B):

Item 4: *Learning GIS has improved my prior computer skills.*

For the second part of research question 3 responses of 140 students on the GPS student surveys for the school year 2008-09 was used to test the hypothesis. Statistical analysis was performed on one item from the student survey (see Appendix B):

Item 4: *Learning GPS has improved my prior computer skills.*

Student responses were entered into electronic format, and the Likert-type items were coded and totaled based on the following numeric values for each response: Strongly Agree = 2, Agree = 1, Undecided = 0, Disagree = -1, Strongly Disagree = -2. An inferential test (symmetry test) was performed.

Research question 3. How do students evaluate the GIS/GPS program implementation, which includes both teacher instruction and environmental factors?

Null hypothesis 3. The distribution of students' evaluation for the GIS/GPS program implementation, which includes both teacher instruction and environmental factors, is symmetric.

Responses of 144 students on the GIS student surveys for the school year 2008-09 were used to test the hypothesis. Statistical analysis was performed on four items from the student survey (see Appendix B):

Item 6: *I am often told what we are going to learn at the beginning of each module in the GIS lesson.*

Item 7: *My teacher often makes a connection about what I'm learning now and what I have already learned in relation to GIS.*

Item 8: *During GIS class in the PC Lab I am able to follow the instructions from my own binder of GIS lesson plans to complete the assignment.*

Item 9: *In the GIS Lab classroom I have a computer to myself.*

For the second part of research question 3 responses of 140 students on the GPS student surveys for the school year 2008-09 was used to test the hypothesis. Statistical analysis was performed on four items from the student survey (see Appendix B):

Item 6: *I am often told what we are going to learn at the beginning of each the GPS lesson.*

Item 7: *My teacher often makes a connection about what I'm learning now and what I have already learned in relation to GPS.*

Item 8: *During GPS class I am able to follow the instructions from the assignment.*

Item 9: *I have access to the GPS unit during the lesson.*

Student responses were entered into electronic format, and the Likert-type items were coded and totaled based on the following numeric values for each response: Strongly Agree = 2, Agree = 1, Undecided = 0, Disagree = -1, Strongly Disagree = -2. An inferential test (symmetry test) was performed.

Research question 4. Does academic achievement differ for students who had GIS instruction and those who did not?

Null hypothesis 4. There is no significant difference in academic achievement of students who had GIS instruction and those who did not.

Student data were obtained for final class grades in social studies, science and FCAT reading from 2009. The number of student samples for each test performed varied depending on the availability of scores.

The three dependent variables are FCAT reading scores and final class grades in science and social studies from the 2009. The independent variable is group (GIS instruction or not).

To test the null hypothesis, three *t*-tests were used to compare student FCAT reading scores and final class grades in science and social studies between students who had GIS instruction and those who did not. To avoid an increase in the risk of a type I error (making a false claim that the null hypothesis should be rejected when it is true in the population) when multiple hypotheses are tested, the Bonferroni correction, which is an adjustment of the alpha level for the individual hypothesis tests, was applied to maintain an overall .05 alpha level. An adjusted alpha level of .0167 was used to assess statistical significance for each of the three *t*-tests. To assess practical significance, η^2 was chosen as the effect size measure and .10 (10%) was selected as the critical effect size.

Research question 5. Is the change in FCAT reading scores from 2008 to 2009 different for those students who had GIS instruction and those who did not?

Null hypothesis 5. There is no significant difference in the change of FCAT scores from 2008 to 2009 for students who had GIS instruction and those who did not.

Student data were obtained for FCAT reading scores from the 2008 and 2009 school year. Data analysis was performed to determine the difference in score results from 2008 to 2009 for the 146 students who had scores available and received GIS instruction and the difference in score results from 2008 to 2009 for remainder of the school population, 1,138 students who did not have GIS instruction and had scores available. A comparison of the two groups (GIS vs. no GIS) and the two time periods (2008 vs. 2009) as well as consideration of the interaction effect (is the difference in FCAT scores between 2008 and 2009 FCAT scores for GIS students different from the difference in FCAT scores between 2008 and 2009 FCAT scores for non-GIS students) was performed.

To test the hypothesis, a 2 X 2 mixed model factorial ANOVA was used. The between-subjects factor was group (GIS or no GIS). The within-subjects factor was FCAT scores (2008 or 2009).

Research question 6a. Do FCAT reading scores differ between White students who had GIS instruction and those who did not, and between non-White students who had GIS instruction and those who did not?

Null hypothesis 6a. There is no significant difference in FCAT reading scores of White students who had GIS instruction and those who did not, and between non-White students who had GIS instruction and those who did not.

Student data were obtained for FCAT reading scores from 2009 and compared between groups (GIS, Non-GIS) using two independent samples *t*-tests, one for White students and one for non-White students.

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To test the null hypothesis two independent samples *t*-tests were performed to compare White students who had GIS instruction and those who did not and non-White students that had GIS instruction and those who did not. To avoid an increase in the risk of a type I error (making a false claim that the null hypothesis should be rejected when it is true in the population) when multiple hypotheses are tested, the Bonferroni correction, which is an adjustment of the alpha level for the individual hypothesis tests, was applied to maintain an overall .05 alpha level. An adjusted alpha level of .025 was used to assess statistical significance for each of the two *t*-tests. To assess practical significance, η^2 was chosen as the effect size measure and .10 (10%) was selected as the critical effect size.

Research question 6b. Is the difference in FCAT reading scores between White students who had GIS instruction and White students who did not have GIS instruction different from the difference in FCAT reading scores between non-White students who had GIS instruction and non-White students who did not have GIS instruction?

Null hypothesis 6b. The difference in FCAT reading scores between White students who had GIS instruction and White students who did not have GIS instruction is not significantly different from the difference in FCAT reading scores between non-White students who had GIS instruction and non-White students who did not have GIS instruction.

A 2 X 2 factorial ANOVA was used to test the null hypothesis. The dependent variable was FCAT reading from the 2009 school year. The independent variables were group (GIS instruction or not) and race (White or Non-White).

Research question 7. Is the difference in academic achievement for those who received GIS instruction and those who did not receive GIS instruction moderated by gender, race, SES, or primary language?

Null hypothesis 7. The difference in academic achievement of those who receive GIS instruction and those who do not is not moderated by gender, race, SES, or primary language.

Student data were obtained for FCAT reading scores and final class grades in science and social studies from 2009. Data analysis was performed with the score results from students who received GIS instruction and the remainder of the school student population, who did not have GIS instruction. The number of student samples for each test performed varied depending on the availability of scores.

Twelve multiple regressions were used to test the null hypothesis, one for each combination of criterion variable and moderating variable. The criterion variables were the FCAT reading scores and final class grades in science and social studies, from the 2008-09 school year. The independent variable was group (GIS instruction or not), and the moderating variables were the demographic variables (gender, race, socioeconomic status, or primary language).

Research question 8. Is there a difference in academic achievement of students receiving different frequency of GIS instruction (twice a week or five times a week)?

Null hypothesis 8. There is no significant difference in academic achievement of students receiving different frequency of GIS instruction (twice a week or five times a week).

Student data were obtained for FCAT reading scores and final class grades in science and social studies from the 2007-2008 and the 2008-2009 school year. To address the research question, the grades from the 75 students who had GIS twice a week in school year 2007-2008 was compared to the grades from the 180 students who had GIS five days a week during school year 2008-2009.

The dependent variables are average FCAT reading scores and final class grades in science and social studies from the year in which they received GIS instruction. The independent variable is the time period (twice a week or five times a week) in which the students received GIS instruction.

To test the null hypothesis, three t-tests were used to test the null hypothesis (one with social studies grades as the dependent variable, one with science grades as the dependent variable and one with FCAT reading score as the dependent variable). To avoid an increase in the risk of a type I error (making a false claim that the null hypothesis should be rejected when it is true in the population) when multiple hypotheses are tested, the Bonferroni correction, which is an adjustment of the alpha level for the individual hypothesis tests, was applied to maintain an overall .05 alpha level. An adjusted alpha level of .0167 was used to assess statistical significance for each of the three t-tests. To assess practical significance, η^2 was chosen as the effect size measure and .10 (10%) was selected as the critical effect size.

Research question 9. How do teachers evaluate the GIS professional development training workshops?

Null hypothesis 9. The distribution of teachers' evaluations of the GIS professional development training is symmetric.

Responses of 62 teachers to a total of 9 items from both the 2007 GIS staff development feedback form (Appendix C) and the 2008 GIS staff development feedback form (Appendix D) were used to test the hypothesis. The following items were utilized to analyze the results. Please rate your understanding of the staff development presented:

Item 1A: *Prior to the staff development.*

Item 1B: *Following the staff development.*

Item 1C: *Overall quality of the staff development.*

How would you rate the GIS lesson plan utilized in the training session:

Item 2A: *Level of difficulty.*

Item 2B: *Topic material.*

Item 2C: *Length of time to complete the lesson.*

Item 2D: *Length of time for the training session.*

Please rate the following;

Item 4A from the 2007 survey and 6A from the 2008 survey: *Overall GIS program.*

Item 4B from the 2007 survey and 6B from the 2008 survey: *Lesson plans in Mapping Our World.*

Teacher responses were entered into electronic format, and the Likert-type items were coded and totaled based on the following five possible selections ranging from 1, the least favorable response, to 5, the most favorable response. An inferential test (symmetry test) was performed.

Research question 10. Do teachers perceive incorporation of GIS into their K-12 curricula as beneficial to the students' learning experience?

Null hypothesis 10. The distribution of teachers' perceptions of incorporating GIS into their K-12 curricula as beneficial to the students' learning experience is symmetric.

Responses of 62 teachers to one item from the 2007 (Appendix C) GIS staff development feedback form and the identical question on the 2008 (Appendix D) GIS staff development feedback form were used to test the hypothesis. The following items were utilized to analyze the results:

Item 5A and item 7A: *How likely would you be to implement GIS in your classroom?*

Teacher responses were entered into electronic format, and the Likert-type items were coded and totaled based on the following five possible selections ranging from 1, the least favorable response, to 5, the most favorable response. An inferential test (symmetry test) was performed. As indicated in the research design section, the research included sample data

from the pilot study for research question 8 to determine if there was a difference in academic achievement between students receiving GIS instruction twice a week (students from the pilot study in 2007-2008) and those students who received GIS instruction five times a week during the 2008-2009 school year. Data were also included from the pilot study for research questions 9 and 10, which pertain to the teacher professional development.

Personal Statement

The researcher believes lagging student achievement affects everyone. Teachers are left feeling unfulfilled; students develop apathy toward learning and may fail to meet the nation's demands for skilled technicians, jeopardizing the nation's future in a competitive global society. Our goals should include incorporating programs into K-12

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curriculum that return the joy of learning for students and the joy of teaching for teachers. The GIS and GPS programs appeal to students' desire to learn from a variety of aspects. The applications are interactive and promote a more authentic and enthusiastic approach to learning.

For teachers, professional development needs to be timely and integration must be as seamless as possible. It must provide teachers with the ability to utilize what they learn immediately and be easily integrated into their existing curricula. The research described herein will assist in determining whether the GIS professional development meets those requirements and whether students identify GIS as enhancing their learning experience.

CHAPTER 4 - FINDINGS

The purpose of this research was to examine student responses to GIS and GPS inclusion in their curriculum, and to determine whether a relationship exists between inclusion of GIS into existing K-12 curriculum and student achievement. The research further investigated the effectiveness of GIS professional development for teachers, and examined teacher perceptions of the value of integrating GIS into their existing curricula.

Descriptive Information

For this study, 1,425 students from one middle school and 62 science and social teachers from Palm Beach County School District participated. The student sample included 181 students for 2008-09 who had GIS instruction and 1,169 students who did not. The student sample also included data from a pilot study of 75 students who had GIS instruction during the school year 2007-08. The teacher sample included 36 teachers who attended GIS professional development workshops during 2007 and 26 teachers who attended during 2008.

In addition to analyzing the responses to the student and teacher surveys, the researcher evaluated the relationship between GIS instruction and student academic achievement, measured by FCAT reading scores and final grades in science and social studies. Student demographic data, including race, gender, socioeconomic status (SES), and primary language, were used for some of the analyses.

The results are reported in three separate sections. The first section provides results for the analysis regarding students' perceptions of whether they believe GIS and GPS instruction enhances their learning and their perceptions of the GIS and GPS instruction. The second section reports the results of an analysis of GIS and GPS instruction in relation to students' academic achievement. The third section provides results of the analysis of teachers' perceptions of the GIS staff development and the value of integrating GIS into their existing curricula.

<div align="center">Students' Perceptions of GIS and GPS Instruction</div>

The following section shows the results for the first three research questions. These three research questions pertained to whether the students believe that GIS and GPS instruction enhances their learning and the students' perceptions of the GIS and GPS instruction. Symmetry tests developed by Cooper (1976) and Whitney (1978) were performed using a computer program developed by Morris (1979). The student sample included 144 students who responded to the GIS survey and 140 students who responded to the GPS survey. In the tables, under the column labeled frequencies, SD = students who responded strongly disagree; D = the students who responded disagree; U = those students who were undecided; A = students who responded agree; and SA = students who responded strongly agree.

Research question 1. Do students perceive that their learning is enhanced by inclusion of GIS and GPS?

Null hypothesis 1. The distribution of students' perceptions of the extent to which their learning is enhanced by inclusion of GIS and GPS is symmetric.

Responses of 144 students on the GIS student surveys for the school year 2008-09 were used to test the hypothesis. Statistical analysis was performed on items 5 and 10 from the student survey (see Appendix B):

Item 5: *The GIS program can help improve my learning in topics such as social studies, science and math.*

Item 10: *Using the GIS gives me a better understanding of the social studies or science topic that is covered in the lessons.*

Results presented in Table 1 show that responses were significantly more positive than would be expected in the population if the distribution of responses was symmetric for item 5 and item 10. The null hypothesis of symmetry was rejected. These results support the alternative hypothesis that students perceive that their learning is enhanced by inclusion of GIS.

Table 1

Analysis of Symmetry of Student Survey Responses for Research Question 1

Item	Frequencies					Cooper's Z	p	Whitney's T	p
					GIS Survey ($N = 143$)				
	SD	D	U	A	SA				
5	12	6	28	60	38	6.3	0.00000	7.7	0.00001
10	20	8	29	58	29	4.0	0.00002	4.5	0.00001
					GPS Survey ($N = 139$)				
	SD	D	U	A	SA				
5	14	8	44	39	35	4.4	0.00001	5.1	0.00000
10	15	14	36	40	35	4.0	0.00002	4.4	0.00004

SD=strongly disagree; D=disagree; U= undecided; A=agree; and SA=strongly agree

For the second part of research question 1, responses of 140 students on the GPS student surveys for the school year 2008-09 were used to test the hypothesis. Statistical analysis was performed on two items from the student survey (see Appendix B):

Item 5: *The GPS program can help improve my learning in topics such as social studies, science and math.*

Item 10: *Using the GPS gives me a better understanding of the social studies or science topic that is covered in the lessons.*

Responses were significantly more positive than would be expected in the population if the distribution of responses was symmetric for item 5 and item 10. The null hypothesis of symmetry was rejected. These results support the alternative hypothesis that students perceive that their learning is enhanced by inclusion of GPS.

Research question 2. Do students perceive that inclusion of GIS and GPS into curriculum enhances their computer literacy skills?

Null hypothesis 2. The distribution of students' perceptions that inclusion of GIS and GPS into curriculum enhances their computer literacy skills is symmetric.

Responses of 144 students on the GIS student surveys for the school year 2008-09 were used to test the hypothesis. Statistical analysis was performed on one item from the student survey (see Appendix B):

 Item 4: *Learning GIS has improved my prior computer skills.*

Results presented in Table 2 show that responses were significantly more positive than would be expected in the population if the distribution of responses was symmetric for item 4. The null hypothesis of symmetry was rejected. These results support the

alternative hypothesis that students perceive that their computer literacy skills are enhanced by inclusion of GIS.

For the second part of research question, responses of 140 students on the GPS student surveys for the school year 2008-09 were used to test the hypothesis. Statistical analysis was performed on one item from the student survey (see Appendix B):

Item 4: *Learning GPS has improved my prior computer skills.*

Responses were significantly more positive than would be expected in the population if the distribution of responses was symmetric for item 4. The null hypothesis of symmetry was rejected. These results support the alternative hypothesis that students perceive that their computer literacy skills are enhanced by inclusion of GPS instruction.

Table 2

Analysis of Symmetry of Student Survey Responses for Research Question 2

Item	Frequencies					Cooper's Z	p	Whitney's T	p
			GIS Survey ($N = 143$)						
	SD	D	U	A	SA				
4	15	17	15	55	42	5.5	0.00000	5.9	0.00000
			GPS Survey ($N = 139$)						
	SD	D	U	A	SA				
4	16	19	26	40	39	4.0	0.00002	4.3	0.00001

SD=strongly disagree; D=disagree; U= undecided; A=agree; and SA=strongly agree

Research question 3. How do students evaluate the GIS/GPS program implementation, which includes both teacher instruction and environmental factors?

Null hypothesis 3. The distribution of students' evaluation for the GIS/GPS program implementation, which includes both teacher instruction and environmental factors, is symmetric.

Responses of 144 students on the GIS student surveys for the school year 2008-09 were used to test the hypothesis. Statistical analysis was performed on four items from the student survey (Appendix B):

Item 6: *I am often told what we are going to learn at the beginning of each module in the GIS lesson.*

Item 7: *My teacher often makes a connection about what I'm learning now and what I have already learned in relation to GIS.*

Item 8: *During GIS class in the PC Lab I am able to follow the instructions from my own binder of GIS lesson plans to complete the assignment.*

Item 9: *In the GIS Lab classroom I have a computer to myself.*

Results presented in Table 3 show that responses were significantly more positive than would be expected in the population if the distribution of responses was symmetric for each of the items. The null hypothesis of symmetry was rejected. These results support the alternative hypothesis that students evaluate the GIS program, which includes both teacher instruction and environmental factors, positively.

For the second part of research question 3, responses of 140 students on the GPS student surveys for the school year 2008-09 were used to test the hypothesis. Statistical analysis was performed on four items from the student survey (Appendix B):

Item 6: *I am often told what we are going to learn at the beginning of each the GPS lesson.*

Item 7: *My teacher often makes a connection about what I'm learning now and what I have already learned in relation to GPS.*

Item 8: *During GPS class I am able to follow the instructions from the assignment.*

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Item 9: *I have access to the GPS unit during the lesson.*

Responses were significantly more positive than would be expected in the population if the distribution of responses was symmetric for all of the items. The null hypothesis of symmetry was rejected. These results support the alternative hypothesis that students evaluate the GPS program, which includes both teacher instruction and environmental factors, positively.

Table 3

Analysis of Symmetry of Student Survey Responses for Research Question 3

Item	Frequencies					Cooper's Z	p	Whitney's T	p
			GIS Survey ($N = 143$)						
	SD	D	U	A	SA				
6	3	11	13	56	61	9.5	0.00000	13.5	0.00000
7	9	15	35	56	29	4.8	0.00000	6.1	0.00000
8	15	13	23	58	35	5.0	0.00002	5.7	0.00001
9	7	3	11	61	62	9.9	0.00000	14.0	0.00000
			GPS Survey ($N = 139$)						
	SD	D	U	A	SA				
6	8	12	31	54	35	5.8	0.00000	7.3	0.00000
7	9	13	43	46	29	4.4	0.00000	5.6	0.00000
8	16	4	31	48	41	5.6	0.00000	6.4	0.00000
9	10	11	15	55	49	7.3	0.00000	8.7	0.00000

SD=strongly disagree; D=disagree; U= undecided; A=agree; and SA=strongly agree

Influence of GIS and GPS Instruction on Students' Academic Achievement

The following section shows the results for research questions 4, 5, 6a, 6b, 7 and 8. These five research questions pertain to the influence of GIS and GPS instruction on

students' academic achievement. A series of *t*-tests and ANOVAs were performed to test the null hypotheses.

To assess practical significance, a critical effect size of .10 was used. The selection of a critical effect size is a subjective decision. A critical effect size of .10 is considered a small to moderate effect according to Cohen (1992), and .10 is about the smallest effect that might be large enough to warrant a policy change. An effect size of .10 indicates that 10% of the variance in the dependent variable is accounted for by the linear model.

Research question 4. Does academic achievement differ for students who had GIS instruction and those who did not?

Null hypothesis 4. There is no significant difference in academic achievement between students who had GIS instruction and those who did not.

Means were calculated for each of the academic achievement variables by group (GIS and Non-GIS). Descriptive statistics are reported in Table 4. Three *t*-tests were used to compare FCAT reading scores and student grades in social studies and science between students who had GIS instruction and those who did not. An adjusted alpha level of .0167 was used to assess statistical significance for each of the three *t*-tests.

Means were compared between groups using independent samples *t*-tests. Based on the Levene test and using the adjusted alpha level of .0167, variability in FCAT reading scores within the GIS group was not significantly different from variability in FCAT reading scores within the non-GIS group, $F(1,1299) = 4.66$, $p = .031$. The difference in average FCAT scores between those who received GIS instruction and those

who did not was statistically significant but not of practical significance. Although the null hypothesis was rejected for FCAT reading, the effect size was small.

Table 4

Comparisons of Academic Achievement Between GIS and Non-GIS Students for 2009

Source	Group	*M*	*SD*	*N*	*t*	*df*	*p*	η^2
FCAT Reading	GIS	343.36	45.94	177	5.35	1299	0.000*	0.021
	Non GIS	320.19	54.64	1,124				
Science	GIS	3.98	0.97	181	2.34	257	0.020	0.020
	Non-GIS	3.79	1.07	1,100				
Social Studies	GIS	4.21	0.98	180	0.78	1243	0.438	0.000
	Non-GIS	4.14	1.01	1,065				

*p < .0167

Based on the Levene test and using the adjusted alpha level of .0167, variability in science grades within the GIS group was significantly different from variability in science grades within the non-GIS group, $F(1,1279) = 6.85$, $p = .009$. Consequently, a separate-variance *t*-test was used to compare means. As can be seen in Table 4 the difference in average science grades between GIS and non-GIS students was not statistically significant.

The results from the Levene test, using the adjusted alpha level of .0167, show that variability in social studies grades within the GIS group was not significantly different from variability in social studies grades within the non-GIS group, $F(1,1243) = .15$, $p = .704$. As can be seen in Table 4 the difference in average social studies grades between GIS and non-GIS students was not statistically significant.

The null hypothesis was not rejected for science or social studies achievement.

These results are consistent with the null hypothesis that GIS and non-GIS students show

no difference in science and social studies achievement.

Research question 5. Is the change in FCAT reading scores from 2008 to 2009 different

for those students who had GIS instruction and those who did not?

Null hypothesis 5. There is no significant difference in the change of FCAT reading

scores from 2008 to 2009 for students who had GIS instruction and those who did not.

Student data were obtained for FCAT reading scores from the 2008 and 2009

school years. Data analysis was performed to determine the difference in score results

from 2008 to 2009 for the 146 students who had scores available and received GIS

instruction and the difference in score results from 2008 to 2009 for remainder of the

school population, 1,138 students who did not have GIS instruction and had scores

available. To test the hypothesis, a 2 X 2 mixed model factorial ANOVA was used. The

between-subjects factor was group (GIS or no GIS). The within-subjects factor was

FCAT reading scores (2008 or 2009).

The test of between-subjects effects results of the comparison of FCAT scores for

GIS and non-GIS students was statistically significant ($F[1,1136] = 18.15$, $p < .001$). The

tests of within-subjects results of the comparison of 2008 FCAT (for GIS and non-GIS

combined) to 2009 FCAT (for GIS and non-GIS combined) were also statistically

significant ($F[1,1136] = 27.12$, $p < .001$). Table 5 provides the descriptive statistics for

FCAT reading scores by group and school year. Table 5 shows that the GIS group had

significantly higher FCAT scores than the non-GIS group and that the 2009 means are

significantly higher than 2008 means. The interaction effect was not statistically

significant $F(1,1136) = 2.50$, $p = .11$. The difference in FCAT reading scores from 2008 to 2009 for the GIS group was not significantly higher or lower than the difference in FCAT reading scores from 2008 to 2009 for the non-GIS group. The null hypothesis was not rejected. The results were consistent with the null hypothesis.

Table 5

Descriptive Statistics for FCAT Reading Scores by School Year and Group

Year	Group	M	SD	N
2008	GIS	332.96	44.28	146
	Non-GIS	316.09	59.70	992
2009	GIS	344.37	45.80	146
	Non-GIS	322.19	52.85	992

Research question 6a. Do FCAT reading scores differ between White students who had GIS instruction and those who did not, and between non-White students who had GIS instruction and those who did not?

Null hypothesis 6a. There is no significant difference in FCAT reading scores of White students who had GIS instruction and those who did not, and between non-White students who had GIS instruction and those who did not.

Student data were obtained for FCAT reading scores from 2009 and compared between groups (GIS, Non-GIS) using two independent samples *t*-tests, one for White students and one for non-White students. An adjusted alpha level of .025 was used to assess statistical significance for each of the two *t*-tests.

The results from the Levene test, using the adjusted alpha level of .025, show that variability in FCAT reading scores for White students within the GIS group was not

significantly different from variability in FCAT reading scores for White students within

the non-GIS group, $F(1,654) = .403, p = .526$. As can be seen in Table 6, for White

students, the difference in mean FCAT reading scores between GIS and non-GIS students

was statistically significant with a small effect size. The null hypothesis was rejected. The

results are consistent with the alternative hypothesis that FCAT reading scores for White

GIS students are significantly higher than for White students who did not receive GIS

instruction.

Table 6

Comparisons of FCAT Reading Between GIS and Non-GIS Students, White and

Non-White for 2009

	Group	*M*	*SD*	*N*	*t*	*df*	*p*	η^2
		White GIS and Non-GIS Students						
FCAT Reading	GIS	343.35	46.83	107	2.69	654	0.000*	0.010
	Non-GIS	320.19	59.14	549				
		Non-White GIS and Non-White, Non-GIS Students						
FCAT Reading	GIS	333.07	42.86	70	4.125	643	0.000*	0.025
	Non-GIS	305.12	48.03	575				

*p < .025

The results from the Levene test, using the adjusted alpha level of .025, show that

variability in FCAT reading scores for non-White students within the GIS group was not

significantly different from variability in FCAT reading scores for non-White students

within the non-GIS group, $F(1,643) = .3.99, p = .046$. For non-White students, Table 6

shows that FCAT reading scores were higher for GIS students than for non-GIS students.

This result was statistically significant with a small effect size. The null hypothesis was

rejected. The results are consistent with the alternative hypothesis that FCAT reading scores for non-White GIS students are significantly higher than for non-White students who did not receive GIS instruction.

Research question 6b. Is the difference in FCAT reading scores between White students who had GIS instruction and White students who did not have GIS instruction different from the difference in FCAT reading scores between non-White students who had GIS instruction and non-White students who did not have GIS instruction?

Null hypothesis 6b. The difference in FCAT reading scores between White students who had GIS instruction and White students who did not have GIS instruction is not significantly different from the difference in FCAT reading scores between non-White students who had GIS instruction and non-White students who did not have GIS instruction.

A 2 X 2 factorial ANOVA was used to test the null hypothesis. The dependent variable was FCAT reading from the 2008-09 school year. The independent variables were group (GIS instruction or not) and race (White or Non-White). Table 7 contains descriptive statistics for each group (White, Non-White, GIS, No-GIS) and subgroup (White GIS, Non-White GIS; White No-GIS, Non-White No-GIS).

The interaction between GIS and race was statistically significant, $F(1,1297) =$ 2.7, $p < .001$. Null hypothesis 6b was rejected. These results support the alternative hypothesis that the difference between White students who had GIS instruction and White students who did not have GIS instruction was significantly different from the difference between non-White students who had GIS instruction and non-White students who did not have GIS instruction.

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Table 7

Descriptive Statistics for FCAT Reading Scores by Group (GIS or no GIS) and Race (White and Non-White)

Group	Race	*M*	*SD*	*N*
GIS	Non-White	333.07	42.86	70
	White	350.08	46.83	107
	Total	343.36	45.94	177
No GIS	Non-White	305.12	54.67	575
	White	335.98	49.98	549
	Total	320.19	54.63	1,124
Total	Non-White	308.15	54.19	645
	White	338.28	49.72	656
	Total	323.34	54.10	1,301

Research question 7. Is the difference in academic achievement between those who received GIS instruction and those who did not receive GIS instruction moderated by gender, race, SES, or primary language?

Null hypothesis 7. The difference in academic achievement between those who receive GIS instruction and those who do not is not moderated by gender, race, SES, or primary language.

Twelve multiple regressions were used to test the null hypothesis, one for each combination of criterion variable and moderating variable. The criterion variables were the average final class grades in social studies, science and FCAT reading, from the

2008-09 school year. The independent variable was group (GIS instruction or not), and the moderating variables were the demographic variables (gender, race, socioeconomic status, or primary language). First, five centered variables were created for GIS and the four demographic variables by subtracting each variable's mean from each student's value on that variable. Then, four product terms were created by multiplying the centered GIS variable by each of the four demographic variables.

With FCAT reading achievement as the criterion variable and race as the moderating variable, results were not statistically significant (see Table 8). The null hypothesis was not rejected. The relationship between GIS and FCAT reading achievement was not moderated by race.

With FCAT reading achievement as the criterion variable and primary language as the moderating variable, results were statistically significant but not of practical significance (see Table 8). Although the null hypothesis was rejected, the moderating effect of primary language on the relationship between GIS and FCAT reading was too small.

With FCAT reading achievement as the criterion variable and gender as the moderating variable, results were not statistically significant (see Table 8). The null hypothesis was not rejected. The relationship between GIS and FCAT reading achievement was not moderated by gender.

With FCAT reading achievement as the criterion variable and socioeconomic status (SES) as the moderating variable, results were not statistically significant (see Table 8). The null hypothesis was not rejected. The relationship between GIS and FCAT reading achievement was not moderated by socioeconomic status (SES).

Table 8

Test of Moderating Effect of Race, Gender, SES, and Primary Language on the

Relationship Between Criterion Variables and GIS

Criterion	Source	Beta	t	df	p	η^2
FCAT Reading	GIS * Race	.044	1.64	1293	0.101	0.002
	GIS * Language	-.074	-2.79	1297	0.005*	0.006
	GIS * Gender	-.048	-1.75	1297	0.081	0.002
	GIS * SES	-.048	-1.88	1297	0.061	0.002
Social Studies	GIS * Race	.026	0.90	1245	0.368	0.001
	GIS * Language	-.017	-0.61	1249	0.540	0.000
	GIS * Gender	-.022	-0.77	1249	0.441	0.000
	GIS * SES	.010	0.36	1249	0.716	0.000
Science	GIS * Race	.082	2.93	1284	0.003*	0.006
	GIS * Language	-.016	-0.59	1288	0.559	0.000
	GIS * Gender	-.012	-0.43	1288	0.668	0.000
	GIS * SES	-.051	-1.86	1288	0.063	0.002

p < .0167

    With social studies achievement as the criterion variable, none of the results were statistically significant (see Table 8). The null hypothesis was not rejected. These results are consistent with the null hypothesis that the relationship between GIS and social studies achievement is not moderated by race, primary language, gender or SES.

With science achievement as the criterion variable and race as the moderating variable, results were statistically significant but not of practical significance (see Table 8). Although the null hypothesis was rejected, the moderating effect of race on the relationship between GIS and science achievement was too small to be meaningful.

With science achievement as the criterion variable and primary language, gender and SES as the moderating variables, results were not statistically significant (see Table 8). The null hypothesis was not rejected. The relationship between GIS and science achievement was not moderated by primary language.

To pinpoint which differences between means in FCAT reading scores for language were significant, a t-test was performed to compare non-native English speaking students who did and did not have GIS instruction. Based on the Levene test and using the adjusted alpha level of .025, variability in FCAT reading scores within the GIS group was not significantly different from variability in FCAT reading scores within the non-GIS group, $F(1,380) = .265, p = .607$. Table 9 shows that the mean FCAT reading score for non-native English speaking non-GIS students, 246.46, was significantly lower than the average FCAT reading score of non-native English speaking GIS students, 340.27.

Another t-test was performed to compare native English speaking students, both those who had GIS instruction and those who did not. Based on the Levene test and using the adjusted alpha level of .025, variability in FCAT reading scores within the GIS group was not significantly different from variability in FCAT reading scores within the non-GIS group, $F(1,917) = .774, p = .379$. Table 9 shows that the mean FCAT reading score

for native English speaking non-GIS students, 260.09, was significantly lower than the average FCAT reading score of native English speaking GIS students, 344.38.

Table 9

Effect of Groups on Moderation of FCAT Reading Scores by Primary Language

Source	Group	M	SD	N	t	df	p	η^2
		Non-Native English Speaking Students						
FCAT Reading	GIS	340.27	41.82	44	12.98	380	0.000*	0.307
	Non-GIS	246.46	45.49	338				
		Native English Speaking Students						
FCAT Reading	GIS	344.38	47.33	133	16.2	917	0.000*	0.222
	Non GIS	260.09	56.77	786				

p < .025

Additional analysis was performed to identify which differences between means in science grades for race were significant. A *t*-test was performed on non-White students, both those who had GIS instruction and those who did not. Based on the Levene test and using the adjusted alpha level of .025, variability in science grades within the GIS group was significantly different from variability in science grades within the non-GIS group, $F(1,660) = 65.67$, $p < .001$. Consequently, a separate-variance *t*-test was used to compare means. With science grades as the criterion variable and race as the moderating variable, results were statistically significant for non-White students. Table 10 shows that the mean science grades for non-White non-GIS students, 3.36, was significantly lower than the average science score of non-White GIS students, 4.06.

A *t*-test was also performed on White students, both those who had GIS instruction and those who did not. Based on the Levene test and using the adjusted alpha level of .025, variability in science grades within the GIS group was significantly

different from variability in science grades within the non-GIS group, $F(1,628) = 10.40$, p = .001. Consequently, a separate-variance t-test was used to compare means. Table 10 shows that the mean science grades for White non-GIS students, 3.81, was not significantly lower than the average science score of White GIS students, 3.94

Table 10

Effect of Groups on Moderation of Science Grades by Race

Source	Group	M	SD	N	t	df	p	η^2
			Non-White Students					
Science	GIS	4.06	0.88	70	5.89	111	0.000*	0.238
Grades	Non-GIS	3.36	1.34	592				
			White Students					
Science	GIS	3.94	1.03	111	1.13	182	0.26	0.006
Grades	Non-GIS	3.81	1.22	519				

$p < .025$

Research question 8. Is there a difference in academic achievement of students receiving different frequency of GIS instruction (twice a week or five times a week)?

Null hypothesis 8. There is no significant difference in academic achievement of students receiving different frequency of GIS instruction (twice a week or five times a week).

The dependent variables are average score in FCAT reading, and the final grades and social studies grades from the year in which they received GIS instruction. The independent variable is the time period (twice a week or five times a week) in which the students received GIS instruction. Three t-tests were used to test the null hypothesis (one with FCAT reading as the dependent variable, one with science grades as the dependent variable, and one with social studies grades as the dependent variable).

Means were calculated for each of the academic achievement variables by group (twice a week and five times a week). Descriptive statistics are reported in Table 11. Three *t*-tests were used to compare student FCAT reading scores and grades in science and social studies between students who had GIS instruction twice a week and five times a week. An adjusted alpha level of .0167 was used to assess statistical significance for each of the three *t*-tests.

Means were compared between groups using independent samples *t*-tests. Based on the Levene test and using the adjusted alpha level of .0167, variability in FCAT reading scores within the group receiving GIS instruction twice a week was not significantly different from variability in FCAT reading scores within the group receiving GIS instruction five times a week, $F(1,250) = 3.83$, $p = .051$. As can be seen in Table 11, the between-group difference in mean FCAT reading scores was not statistically significant. The null hypothesis was not rejected. These results are consistent with the null hypothesis that there is no difference in FCAT reading scores of students receiving different frequency of GIS instruction.

Table 11 also shows the results of the science and social studies grades for the two groups. Based on the Levene test and using the adjusted alpha level of .0167, variability in science grades within the group receiving GIS instruction twice a week was not significantly different from variability in science grades within the group receiving GIS instruction five times a week, $F(1,251) = 1.49$, $p = .223$. The difference in average science grades between those who received GIS instruction twice a week and those had GIS instruction five times a week was statistically significant but not of practical significance.

Table 11

Comparisons of Academic Achievement Between Students Who Had GIS Instruction

Twice a Week and Those Who Had Instruction Five Times a Week

Source	Group	M	SD	N	t	df	p	η^2
FCAT Reading	2 x week	340.01	55.56	75	-0.50	250	0.621	0.001
	5 x week	343.36	45.94	177				
Science	2 x week	4.34	0.97	74	2.47	251	0.014*	0.023
	5 x week	4.03	0.88	179				
Social Studies	2 x week	3.52	1.43	75	-3.83	104	0.000*	0.123
	5 x week	4.21	0.98	180				

*p < .0167

Based on the Levene test and using the adjusted alpha level of .0167, variability in social studies grades within the group receiving GIS instruction twice a week was significantly different from variability in social studies grades within the group receiving GIS instruction five times a week, $F(1,253) = 34.88$, $p < .001$. Consequently, a separate-variance t-test was used to compare means. The difference in average social studies grades between those who received GIS instruction twice a week and those had GIS instruction five times a week was statistically significant and of practical significance. The null hypothesis was rejected for science and social studies grades. The effect size was small for science grades, but was large enough to be of practical significance for social studies.

Teachers' Perceptions of GIS/GPS Staff Development and Integration of GIS into

Existing Curricula.

The following section includes the results for the final two research questions, which relate to teachers' perception of the GIS/GPS professional development workshops and the value of integrating GIS into their existing curricula. Symmetry tests developed by Cooper (1976) and Whitney (1978) were performed using a computer program developed by Morris (1979).

The number of teachers who actually responded to each item on the surveys is varied. In the tables, under the column labeled frequencies, L = teachers who responded low; H = the teachers who responded high; D = those teachers who responded difficult; E = teachers who responded easy; NU = teachers who responded not useful and VU = teachers who responded very useful.

Research question 9. How do teachers evaluate the GIS professional development training workshops?

Null hypothesis 9. The distribution of teachers' evaluations of the GIS professional development training is symmetric.

Responses of 62 teachers to a total of 9 items from both the 2007 GIS staff development feedback form (Appendix C) and the 2008 GIS staff development feedback form (Appendix D) were used to test the hypothesis. The following items were utilized to analyze the results. Please rate your understanding of the staff development presented:

Item 1A: *Prior to the staff development.*

Item 1B: *Following the staff development.*

Item 1C: *Overall quality of the staff development.*

Table 12

Analysis of Symmetry of Teacher Survey Responses for Research Question 9

Item	Frequencies					Cooper's Z	p	Whitney's T	p
			Teacher Survey ($N = 61$)						
	L				H				
1A	32	16	11	2	1	6.8	0.00000	9.9	0.00000
1B	0	1	12	35	14	5.6	0.00000	11.3	0.00000
1C	0	1	10	26	25	6.8	0.00000	12.4	0.00000
	D				E				
2A	2	9	26	21	4	1.5	0.13470	2.3	0.02250
2B	1	2	16	17	26	5.9	0.00000	8.5	0.00000
2C	2	3	15	18	24	5.3	0.00000	7.1	0.00000
2D	2	3	15	15	27	5.6	0.00000	7.3	0.00000
4A, 6A	1	4	26	21	8	2.9	0.00440	4.7	0.00010
	NU				VU				
4B, 6B	2	3	9	21	27	2.9	0.00000	4.7	0.00000

L=low; H=high; D=difficult; E=easy; NU=not useful and VU=very useful

How would you rate the GIS lesson plan utilized in the training session:

Item 2A: *Level of difficulty.*

Item 2B: *Topic material.*

Item 2C: *Length of time to complete the lesson.*

Item 2D: *Length of time for the training session.*

Please rate the following;

Item 4A from the 2007 survey and 6A from the 2008 survey: *Overall GIS program.*

Item 4B from the 2007 survey and 6B from the 2008 survey: *Lesson plans in Mapping Our World.*

Teacher responses were significantly more positive than would be expected in the population if the distribution of responses was symmetric for items 1B, 1C, 2B, 2C, 2D, 4A, 4B, 6A and 6B (see Table 12). Teacher responses were significantly more negative than would be expected in the population if the distribution of responses was symmetric for item 1A. Responses were not significantly more positive than would be expected in the population if the distribution of responses was symmetric for item 2A. The null hypothesis of symmetry was rejected. These results support the alternative hypothesis that teachers evaluate the GIS professional development training workshops positively.

Research question 10. Do teachers perceive incorporation of GIS into their K-12 curricula as beneficial to the students' learning experience?

Null hypothesis 10. The distribution of teachers' perceptions of incorporating GIS into their K-12 curricula as beneficial to the students' learning experience is symmetric.

Responses of 62 teachers to one item from the 2007 (Appendix C) GIS staff development feedback form and the identical question on the 2008 (Appendix D) GIS staff development feedback form were used to test the hypothesis. The following items were utilized to analyze the results.

Item 5A and item 7A: *How likely would you be to implement GIS in your classroom?*

Results presented in Table 13 show that teacher responses were significantly more positive than would be expected in the population if the distribution of responses was symmetric for item 5A and 7A. The null hypothesis of symmetry was rejected. These

results support the alternative hypothesis that teachers perceive incorporation of GIS into their K-12 curricula as beneficial to the students' learning experience.

Table 13

Analysis of Symmetry of Teacher Survey Responses for Research Question 10

Item	Frequencies					Cooper's Z	p	Whitney's T	p
	Teacher Survey ($N = 60$)								
	L				H				
5A, 7A	1	3	5	23	29	6.9	0.00000	10.6	0.00000

L=low and H=high

Chapter Summary

The findings in this study included three areas of research; students' perception of GIS and GPS instruction, the effect of GIS and GPS on students' academic achievement, including high-stakes testing and teachers' perception of GIS/GPS program and the professional development workshops.

Chapter 5 will explain the conclusions drawn from the findings and will discuss the correlation of these findings to the literature. In addition the implications of the study results will be explored as well as recommendations for future research.

CHAPTER 5 - CONCLUSIONS

School districts across the nation continue to grapple with issues of high-stakes testing and raising student achievement. With additional, more stringent federal and state mandates on the horizon, this situation has been elevated to an urgent concern in public education. One way to facilitate the acceleration of student academic achievement and strive to meet the demands of high-stakes testing is to engage students in the learning process. Meaningful education rests on student motivation for learning, the premise that learning occurs when students are active participants in the process. Using GIS in the classroom has the potential to promote student motivation for learning and holds promise for raising academic achievement. The concept of integrating GIS into curriculum is promoted by the constructivists' theory of learning; that we learn best by doing, by being active participants, and that we build or scaffold our learning on prior knowledge. Students are involved in the learning process by utilizing the computers and the GIS application and they work collaboratively, promoting teamwork. Students also build upon prior knowledge, and the knowledge gained may transfer to other subject topics. For those students who fall within the realm of the achievement gap and the digital divide, having the opportunity to experience the GIS in a classroom may also be the catalyst that elevates their learning processes and career prospects.

To successfully develop a GIS educational program, several components must be addressed. Gaining support from upper administration is crucial to encourage buy-in from

all stakeholders and to develop the steps necessary for implementation. In addition to developing a needs assessment and building a coalition, engaging teachers and gaining their buy-in is essential. The development of teacher training for GIS needs to be designed from the perspective of the teachers' area of expertise - education, not from a technical standpoint of learning the technology. To this end, design of the professional development for this research was based on hands-on training using GIS lessons that teachers could immediately transfer to their classrooms. Teachers must also be provided with adequate resources in the classroom such as sufficient computer systems and necessary materials, in addition to continued technical support.

If we are to raise the bar in academic achievement for K-12 students and provide a learning environment that both motivates students to learn and enhances the overall learning experience, public education must pursue new and innovative approaches to classroom learning. Our ability to remain a viable, well-educated nation ready to compete in the global society rests on our ability to meet the educational challenges facing this nation.

The purpose of this study was to explore outcomes of a GIS/GPS integration process: to (a) examine student responses to GIS and GPS inclusion in their curricula, (b) determine whether a relationship exists between inclusion of GIS into existing K-12 curricula and student achievement, (c) examine the effectiveness of GIS professional development for teachers, and (d) evaluate teacher perceptions of the value of integrating GIS into their existing curricula.

The researcher surveyed 256 middle school students who had participated in GIS instruction and collected grades from 1,425 students, both those who had GIS instruction

and those who did not. Data were also gathered from a total of 62 elementary, middle and high school teachers who attended the GIS professional development workshops.

The conclusions and discussion are presented in three areas of research; students' perceptions of GIS and GPS instruction; the relationship of GIS and GPS integration and students' academic achievement, including high-stakes test results, and teachers' perceptions of the GIS/GPS program and the professional development workshops.

Conclusions and Discussion

Students' Perceptions of the Influence of GIS and GPS on Learning and Their Evaluation

of the Program Instruction

GIS Instruction Enhances Student Learning

The results of the Likert-type survey questions for those students who had GIS indicate that the majority believe that the GIS and GPS enhanced their learning. That is, their perception was that the integration of this application into their curriculum was a positive learning experience. These positive findings point towards district implementation of this program based on Palm Beach County School District's fidelity scale.

Additionally, the teacher who implemented the GIS classes noted that many of the students, both those in the social studies class and those in the elective GIS class, indicated that they understood their science curriculum better after having been exposed to the GIS lesson plans, some of which had science-based content. This comment supports the notion of building on prior knowledge, transferring of knowledge, and the benefits of GIS as an interdisciplinary educational tool. Students' positive review of the program may be related to the fact that the lessons and exercises were hands-on activities

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with the computers, using data that was based on real-world information. The student's ability to construct knowledge was enhanced by the fact that each student had access to their own computer, the hands-on activity included the use of the GIS application, and the lessons promoted problem solving skills. Based on the teacher's observations and the student responses to the surveys, the students were encouraged to collaborate, were motivated to read about the topics and were interested in problem solving.

The questions on the GIS and GPS surveys posed to the students asked if they thought the GIS/GPS program could help improve their learning in topics such as social studies, science and math. The students were also asked if using the GIS gave them a better understanding of the social studies or science topic that was covered in the lessons. To measure whether GIS and GPS instruction had any impact on the students' perception of the influence of GIS instruction on their computer literacy skills, the students were asked if they felt that learning GIS improved their prior computer skills.

The findings support the literature which suggests that implementation of GIS into the classroom engages and motivates students in the learning process. Broda and Baxter (2002) refer to both GIS and GPS by stating, "Two technologies that have been in general use for many years, but are more recently appearing in the educational sector, provide the opportunity to reap the benefits of technology while engaging young adolescents in an interactive environment" (p. 49). Johansson (2003) states, "The recent emphasis on pedagogy focuses on a shift from a behaviorist to a constructivist approach in learning" (2003, p. 2). This shift may be a contributing factor to students' feeling engaged in the learning process while utilizing a GIS in the classroom. Pang (2006) comments on the benefits and appeal of constructivism for students when utilizing a GIS

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by stating, "Students that travel up and down the range of visualization methods to constructively explore, discover and hypothesize on various scientific theories and concepts will no longer be passive recipients of information, but active discoverers and constructors of knowledge" (2006, p. 20). Pang also suggests that by integrating GIS into the curriculum and "using authentic data for realistic outcomes, effective and engaged learning can be achieved" (p. 3). Her suggestion is supported by the results of the student survey in this research, which indicates students do believe the GIS instruction enhances their learning.

The integration of GIS incorporates a number of Gardner's multiple intelligences, which allow students who gravitate to different learning styles an opportunity to learn through the style that fits them best (as cited by Bloom & Palmer-Moloney, 2004). Because the GIS is a hands-on activity, uses data and graphics, and promotes collaborative work, students have an opportunity to be more engaged in the subject and the learning.

Students Respond Positively to GIS and GPS Instruction

Students positively evaluated both the GIS instructional methods and the environmental factors, such as whether they had the adequate tools to perform the tasks in the lessons. The positive responses to the instruction may be related to the active engagement required in GIS and GPS instruction that involves problem solving and builds a sense of competency and ownership in the learning. The literature suggests that GIS fosters problem-based learning and that in this process "teachers become instructors who will guide their students to the right sources and provide them with support and motivation in the process of self-directed learning" (Johansson, 2003, p. 2).

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GIS Instruction and FCAT Reading Scores

There is a positive relationship between GIS instruction and student performance on the FCAT reading test. The findings indicate that both White and non-White students who had GIS instruction performed significantly better on the high-stakes mandated FCAT reading test than students who did not have GIS instruction. Although these findings had a small effect, the results underscore the potential benefit GIS may have on academic achievement, especially for minority and English language learners. The actual length of time students were exposed to GIS was brief, only for one semester. Since the relationship does appear despite the brief time of exposure, the potential exists for a stronger relationship between GIS exposure and academic achievement, which might be realized after students have experienced several years of GIS in their curriculum. School districts across the nation are seeking ways to close the achievement gap; these results hold promise in achieving this goal.

Reading is the cornerstone to learning. If GIS integration positively impacts the elevation of reading scores, this learning can be transferred to other topics such as science, math, and so on. The students have the ability to construct new knowledge in other subjects by building upon the gains in reading which are related to the GIS/GPS instruction. This outcome may also be a residual effect of the students actually being engaged in the learning and motivated to comprehend and understand the lessons. It is important to remember, however, that the students in this study had been exposed to GIS instruction only for one semester. It seems logical that the extensive use of word

problems in the GIS lessons and continual use of the application over a longer period of time would continue to elevate these test scores.

While the 2009 FCAT reading score means are significantly higher than 2008 means and the GIS group had significantly higher FCAT reading scores than the non-GIS group the findings also revealed that the difference in FCAT reading scores from 2008 to 2009 for the GIS group was not significantly higher or lower than the difference in FCAT reading scores from 2008 to 2009 for the non-GIS group. This result may be attributable to the relatively brief expose to GIS instruction and the fact that FCAT reading is a very generalized test not specifically designed to measure the impact of technology integration.

The literature indicates that there is a need for evaluation on the effects of GIS instruction on academic gains. While studies report that there are pedagogical benefits of GIS in the K-12 school system, a number of authors note a gap in reporting academic achievement, and that performance on standardized tests remains to be empirically validated for those students who experience GIS instruction (Bloom & Palmer-Moloney 2004; Hagevik, 2003; Johansson 2003; Pang, 2006).

Frequency of GIS Instruction and Grades in Science and Social Studies

The difference in average social studies grades between those who received GIS instruction twice a week and those had GIS instruction five times a week for one semester show that students who had GIS instruction five times a week performed significantly better in social studies. The mean scores were higher in social studies for those students who had GIS instruction five times a week than for those students who had GIS instruction twice a week (see Table 11). The difference in average science grades

between those who received GIS instruction twice a week and those who had GIS instruction five times a week was statistically significant, but with a small effect size.

Results that are statistically significant but have a small effect size can occur when a sample size is relatively large. With a large sample, even very small differences between means can be statistically significant. When results are statistically significant with a small effect size, the results suggest that the means do indeed differ in the population, but by a very small degree. The small effect sizes may also be linked to brief amount of time that students were exposed to the GIS instruction.

Moderation of the Relationship Between GIS Interaction and Student Academic Achievement

Findings that were statistically significant but had a small effect size were also reported for several of the multiple regression analyses concerning whether the difference in academic achievement (FCAT reading scores and final grades in science and social studies) between those who received GIS instruction and those who did not receive GIS instruction was moderated by gender, race, SES, or primary language. With FCAT reading achievement as the criterion variable and primary language as the moderating variable, results were statistically significant but had a small effect size. With science achievement as the criterion variable and race as the moderating variable, the findings were statistically significant but the effect size was also small.

Another important finding is that the average FCAT reading score for non-native English speaking non-GIS students, 246.46, is significantly lower than the average FCAT reading score of students in each of the other three groups, whose average FCAT reading scores range from 344.38 for English speaking GIS students to 340.27 for non-native

English speaking GIS students (see Table 9). FCAT reading scores of non-native English speaking students improved for those who had GIS instruction, as well as English speaking students both those who had GIS and those who did not.

The findings also suggest that GIS integration may assist non-White students to master science concepts (see Table 10). The average science grades for non-White non-GIS students, 3.36, is significantly lower than the average science grades of students in each of the other three groups, whose average science grades range from 3.94 for white GIS students to 4.06 for non-white GIS students.

The Alliance for Excellent Education (2008) reports the U.S. ranks 15th of 30 Organization for Economic Cooperation and Development (OECD) countries in reading literacy, 21st out of 29 in science literacy, 25th out of 30 in math literacy, and 24th out of 29 in problem solving. While the research in this study did not evaluate math, the influence of GIS on high-stakes testing for FACT reading was significant. There was also evidence of statistical significance with a small effect size regarding FCAT reading as the criterion variable and primary language as the moderating variable. And when science final grades were evaluated and race was the moderating variable, results were statistically significant but also with a small effect size. Soublis-Smith (2008) acknowledges that those who are most adversely affected by NCLB and the high-stakes testing are minority and second language learners. With regards to English language learners Reed and Railsback (2003) suggest that project-based learning, cooperative learning, and the ability to access a student's prior knowledge as beneficial methods for mainstreaming these students.

The literature suggests that a strong asset of GIS as a learning tool in the K-12 environment may be the student-centered; problem-based learning, project-based learning inherent in the use of the application. (Bloom & Palmer-Moloney, 2004; Hagevik, 2003; Johansson 2003; Kierski, 2008; Pang, 2006; Yuda & Itoh, 2006). Johansson (2003) states that "Problem-based learning and inquiry-based learning are instructional methods which are based on constructivism and are challenging the customary methods used" (p. 2). The pedagogical benefits of GIS and potential academic gains may be influenced by the student's opportunity to construct knowledge.

The relationship between FCAT reading scores and GIS instruction was not moderated by race, gender, or SES. When analysis was performed with social studies achievement as the criterion variable, none of the findings were statistically significant. Similarly with science achievement as the criterion variable and primary language, gender and socioeconomic status (SES) as the moderating variables, the findings were not statistically significant.

Teachers' Evaluation of GIS Professional Development and Intent to Implement GIS in

Curricula

GIS Professional Development Evaluation

The findings were significantly more positive than would be expected for the questions that were used to analyze teachers' perceptions of the GIS professional development.

The results from the Likert-type survey questions for the 62 teachers who participated in the GIS professional development workshops indicates that the majority believe the professional development was informative and timely. A recurrent comment

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on the surveys indicated that teachers appreciated the ability to select a lesson and work at their own pace in the afternoon.

The majority of 62 teachers responded positively to the questions which pertained to delivery of the staff development and the actual GIS program. The first question asked teachers to rate their understanding of GIS prior to the staff development. As anticipated this response was negative as most teachers were unfamiliar with the application. The questions regarding their understanding after the staff development and their assessment for the overall staff development were significantly more positive than would be expected if the distribution of responses was symmetric.

Also the findings based on teacher responses to the actual hands-on GIS lesson plans used in the training, the level of difficulty, and their overall assessment of the GIS program and the lesson plans in the *Mapping Our World* book were all significantly more positive than would be expected if the distribution of responses was symmetric. When asked to rate the time allotted for completing the lessons, the result was neither positive nor negative, suggesting that the time provided to complete the lessons was just right. The responses regarding the overall time for the staff development workshops were significantly more positive than would be expected by if the distribution of responses was symmetric.

Intent to Integrate GIS into Curricula

The findings from the responses of teachers regarding how likely they would be to implement GIS in their classrooms were significantly more positive than would be expected. The results indicated that teachers could see the value of incorporating GIS into

their curriculum and perceived incorporation of GIS into their K-12 curricula as beneficial to the students' learning experience.

The research findings also reflect the literature that suggests most teachers who participate in a GIS professional development do see the value and benefits of teaching with GIS. Kerski (2001) notes in his study that "Teachers most often name enhanced student motivation, integration between subjects, and enhanced learning as benefits of implementing GIS" (p. 5). Teachers in this research study, after they experienced the GIS application and lessons in the professional development workshop indicated that they would be inclined to implement GIS in their classrooms.

Implications

GIS Integration into the Curriculum at Palm Beach County School District

Student Evaluations

A number of items within the GIS and GPS student survey are questions similarly utilized by Palm Beach County School District fidelity scale to determine if a program should be implemented district-wide and if so at what level of implementation. The school district's "fidelity scale provides an objective, structured way to give feedback about program development" (Palm Beach County School District, 2008).

The scale uses a series of survey question results which is evaluated by administrators to determine if a program should be recommended for implementation or if it is not supported. Rating of each question is based on a positive response of 50%. The fidelity scale for program implementation ranges from full implementation (>75%), to good (66% – 74%), to fair (65% - 56%), and to not supported (<56%). The range of implementation is based on the number of statements in the survey that exceed 50% in

positive responses. Based on results from the GIS and GPS student survey the program

falls in line with full implementation as all positive responses to the survey questions

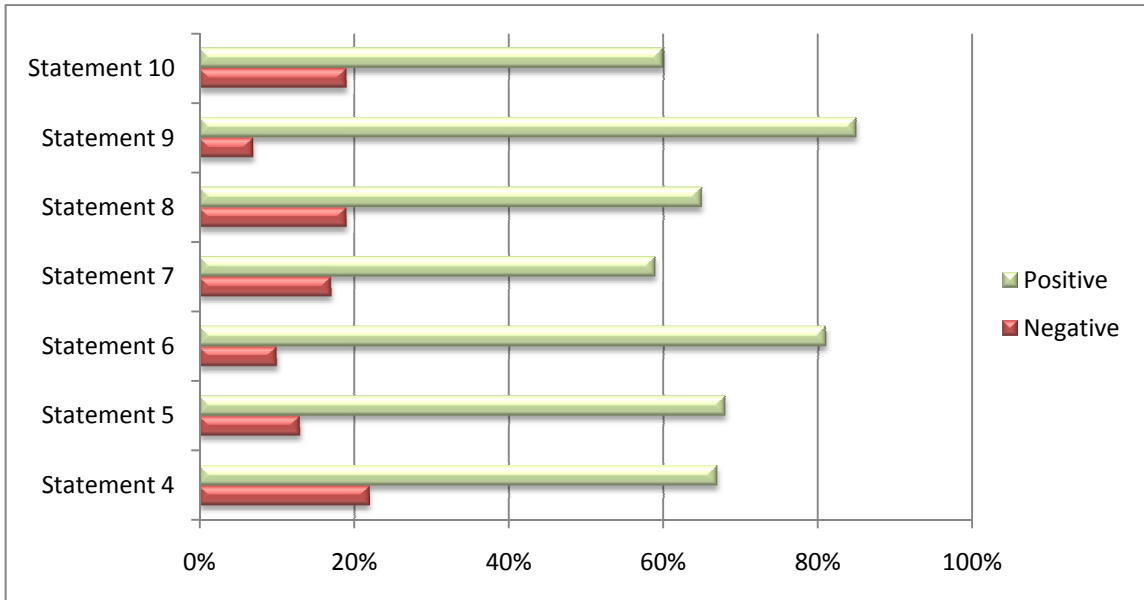exceed 50% for more than 75% of the questions (see Figures 4 & 5).
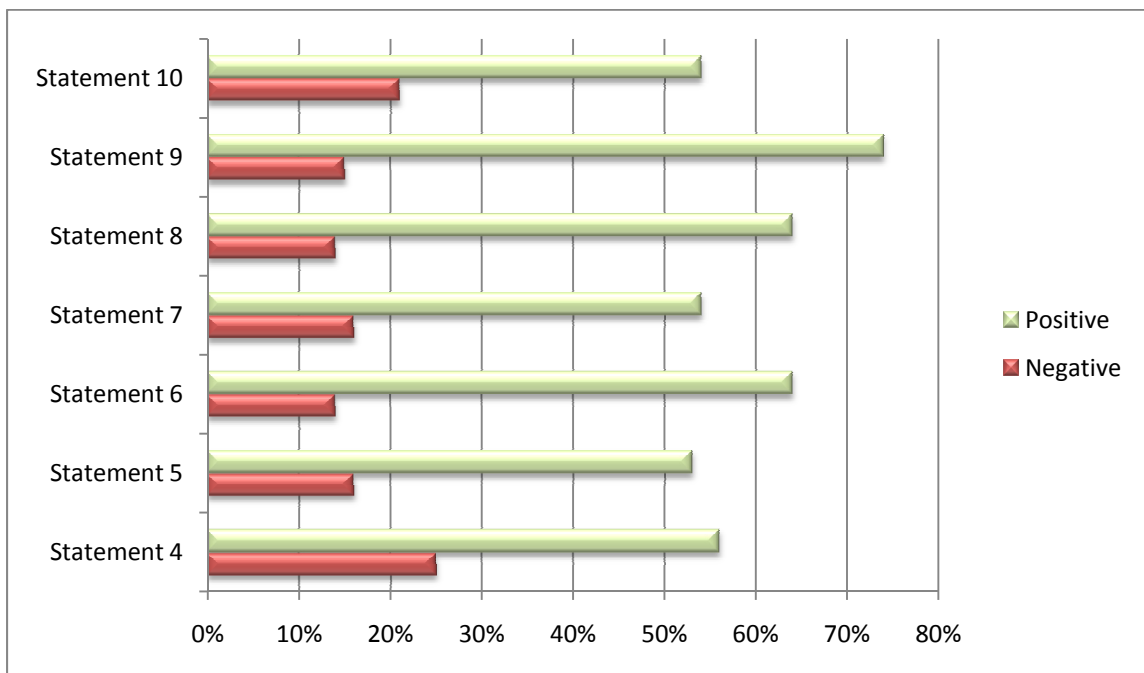

Figure 4. GIS student survey results.

Figure 5. GPS student survey results.

Academic Achievement

A correlation between GIS instruction and an increase in high-stakes testing does exist and may be amplified to a greater extent with extended exposure to GIS and GPS instruction. There is also an indication that the learning which occurs during GIS and GPS instruction is transferred to other areas as identified by the elevated FCAT reading scores for students who received GIS instruction compared to those who did not. It also appears the GIS and GPS instruction has a positive impact for learning gains in science and social studies. Based on these outcomes, further efforts to integrate GIS and GPS into the curriculum and measure those results are merited.

It is reasonable to question whether the Hawthorne effect was present in the results. The Hawthorne effect suggests that groups of people will adjust their performance based on the notion that they are being observed (Zaleznik, 1984). However, student responses to the surveys were anonymous and none of the students had any knowledge that their grades were being evaluated, or that they were being observed in any way; thus eliminating the potential for the presence of the Hawthorne effect.

Implications for Professional Development for GIS Teachers

The findings support the research of Shin (2008) and additional researchers who suggest that the implementation of best practices, including methodical steps to assess needs, develop, design and implement professional development training sessions will result in a positive experience for the participants. A variety of models for professional development and program planning for adults exist, including those mentioned by Caffarella (2002), Galbraith, Sisco, & Guglielmino (2001), Merriam & Simpson (2000) and Meltzer (2006); however, there is limited literature that specifically relates to

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professional development for GIS. From the perspective of GIS as a new technology for teachers, Meltzer (2006) discusses the importance of addressing teacher apprehension. The opportunity to diffuse teacher's reluctance to try new technology was addressed during the GIS professional development. The workshop was held in a computer training lab and each participant had his or her own PC and a GIS lesson plan book. They could take the same lessons that they worked on in the workshop and have a comfort level implementing the lessons into their own classroom. The professional development began with a brief presentation on what GIS is and how both the teachers and students could benefit from integrating this application into the classroom. The next module of the workshop involved everyone performing the tasks in lesson one, with the instructor leading on a projector. For the afternoon session teachers were asked to select a lesson that resonated with them and go through the steps on their own, asking for help when needed.

Concurring with Johansson (2003) who suggested that for practicing teachers to embrace the use of this new technology the professional development focus on a pedagogical perspective rather than a technical one, the GIS exercises that teachers performed in the workshop were the actual lesson plans that they would use with their students. The lessons in *Mapping Our World* reflect the subject content; learning the technology was a byproduct. The findings from the results of the teacher survey indicate that they evaluated the development, design and implementation of the GIS professional development workshops positively. While the findings from the teacher's survey indicated a positive response to the staff development, only a small percentage of teachers actually implemented the program into their classroom. The small percentage of

implementers revealed the major problems related to overcrowding in the schools; resulting in PC labs needing to be used as classrooms, and lack of sufficient hardware.

While the model used was well received, it appears that additional follow-up, release time, or some other incentive may be required to expand the integration of GIS into the curriculum.

Suggestions for Further Research

Student Surveys

Currently the student survey questions address their perception of the applications and the delivery of the instruction. Additional questions can be added to the surveys to gain insight on how to improve the program and delivery by asking for more detailed information regarding the functions of the GIS and GPS and the actual lessons used in the classroom.

Additional Academic Achievement Assessments

The actual length of time students were exposed to GIS was brief, one semester. Since the relationship does appear despite the brief time of exposure, the potential for greater significance in the results for academic achievement might be realized after students have experienced several years of GIS in their curriculum. Future research may also include a longitudinal study which follows students who have had GIS and GPS instruction over a series of years. Results of these studies may fortify the initial findings reported in this study. In addition interactions between learning styles, GIS instruction and academic achievement could be explored.

Continued research can include expansion for the pool of students and teachers across multiple schools within a school district and multiple school districts. This

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expansion will provide a greater cross referencing and add validity to the results. Additional studies concerning high-stakes test results may also be utilized to educate legislators on the academic benefits of GIS for K-12 public education institutions.

Teacher Training

Pre-service

Future research is recommended to explore the implementation and expansion of integrating GIS instruction into college education programs. Palm Beach County has begun to explore these possibilities by facilitating discussion with Florida Atlantic University. One of the teachers who attended the GIS professional development in 2008 is also a professor at the university, teaching science method classes. A meeting was held with the Coordinator of K-12 Teacher Training at the college of education at the university concerning the integration of GIS into instruction and this teacher has started incorporating GIS into the science method classes for teachers-to be.

In-service

Further research regarding GIS professional development for teachers may build upon results of previous studies in addition to the findings from this study. These findings can assist in refining the program design of GIS for adult learners and help to develop a structured, scalable approach to implementing the GIS educational model.

Educational Leadership

Additional research may include investigation into existing cultures and leadership styles at school districts. This research may assist in determining those districts which embrace the concepts of organizational learning, the basis for development and successful implementation of innovative ideas. The opportunity to

develop the GIS educational model was a result of Palm Beach County School Districts'

leadership. In an environment which empowers employees to pursue pioneering ideas and

work collaboratively, the ability to move new programs to fruition is greatly enhanced.

The literature suggests that for meaningful change to take place, leadership must

recognize the urgency and facilitate an environment that promotes a shared vision as well

as collaboration. The same approaches taken by successful businesses may be applied to

educational institutions. The urgency for school districts is found in the continual

challenges of high-stakes testing and the necessity to find new ways to raise students'

academic achievement. As Pisapia (2009) notes, "leaders need to shift from an over

reliance on the hierarchical skills of the 20th century to a greater respect for the

horizontal skills necessary in the 21st century" (p. 107). Moving organizations into the

new 21st century direction can be a dramatic cultural shift that will require an adjustment

in the leader's actions. Kotter (1996) states, "Often the most powerful way to

communicate new direction is through behavior" (p. 95). The style, mindset, and

approach that leaders take not only shape their individual organizations; they are shaping

our future. Kotter (1996) notes that developing a good vision "always involves a group of

people" (p. 79). Senge (2006) concurs, stating "A shared vision is the first step in

allowing people who mistrusted each other to begin to work together. It creates a

common identity. In fact, an organization's shared sense of purpose, vision and operating

values establish the most basic level of commonality" (p. 194).

Another aspect of empowering staff is team building "By giving a team clear

authority and then staying out of the way, management releases collective energy and

creativity" (Bolman & Deal, 2003, p. 105). The premise in building a team to address

challenges is that the sum is greater than the parts. Senge (2006) suggests, teams will "learn how to tap the potential for many minds to be more intelligent than one mind" (p. 219).

Bolman and Deal (2003) provide commentary on the shift in organizational approaches to developing projects and new initiatives. They note that "Much of the work in a large organization is now done in groups or teams" (p. 95). The rapid changes in society, based on the information age and technology have forced organizations to strive for enhanced organizational models that invariably include the creation of teams. Kotter (1996) comments on this organizational shift and the crucial role teams will have in operations by stating, "Today and more so in the immediate future, we will be seeing many additional attempts to transform organizations. Yet without a powerful guiding coalition, change stalls and carnage grows" (p. 66). The successful creation of this coalition, including participants from all areas of the school district both on the operational and academic sides, as well as community and industry partners, can provide the foundation for potential success regarding the implementation of GIS in K-12 curriculum. Continuing the research and evaluating district and school-based cultures will enhance the integration of these technologies into the classroom. By pursuing research concerning the leadership present at school districts, the findings may help to identify those districts or schools which would be most successful in implementation of a GIS program. Further research might also explore whether administrators who are exposed to the use of GIS and GPS in their leadership preparation program are more likely to support and champion the implementation of geospatial technologies into the classroom.

Recommended practices resulting from this study for integrating GIS into the K-12 curriculum have been incorporated into an overall model to assist school district administrators in developing their GIS plans and initiatives (see Figure 6). In addition to the overall model two sub-models are provided to assist in the actual implementation. The sub-models consist of development and delivery of the GIS professional development for teachers (see Figure 7), and implementation of GIS at the school (see Figure 8).
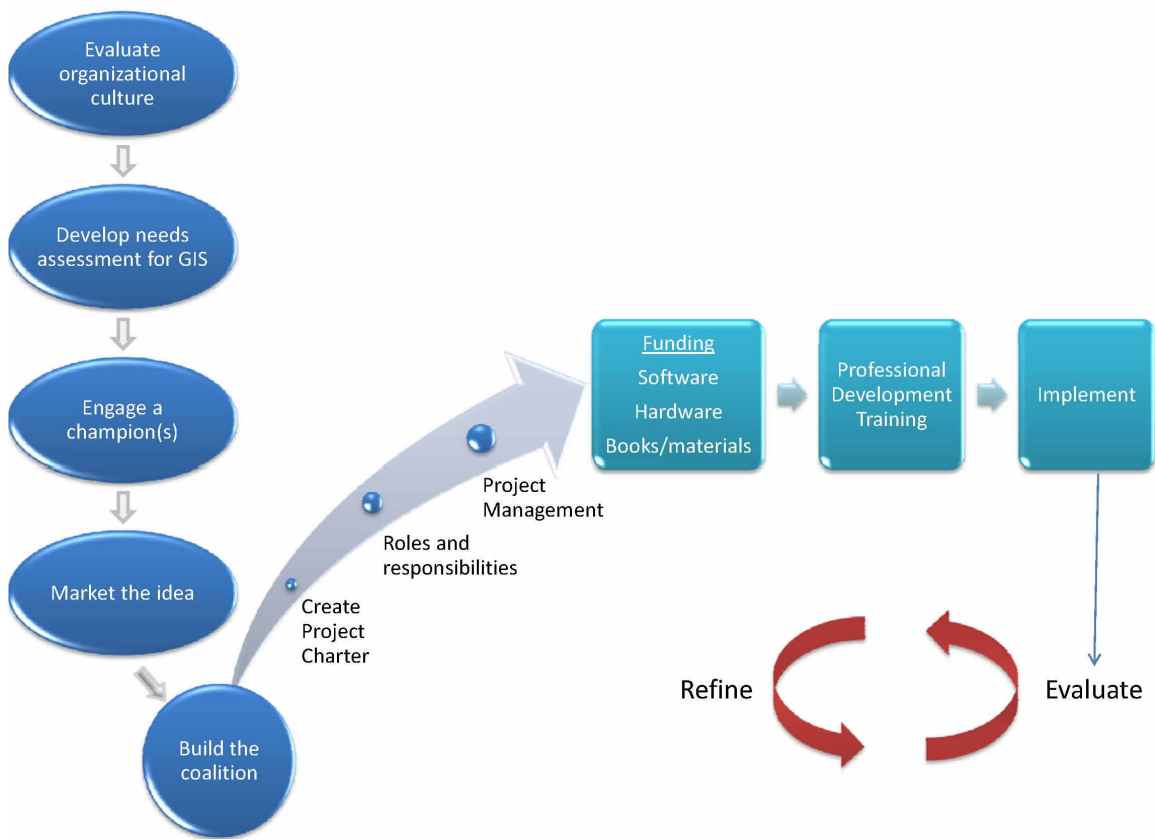
Figure 6. GIS educational model (GEM). Copyright © Donna L. Goldstein.
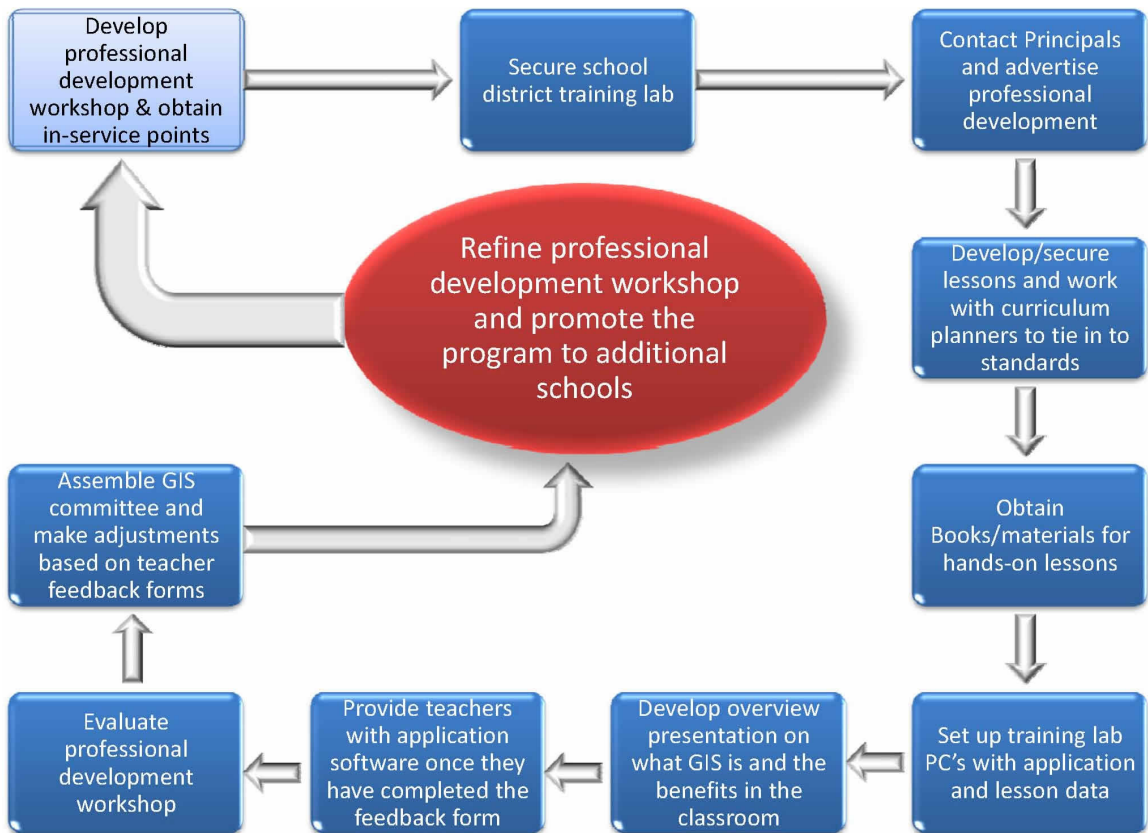
Figure 7. Professional development sub-model. Copyright © Donna L. Goldstein.
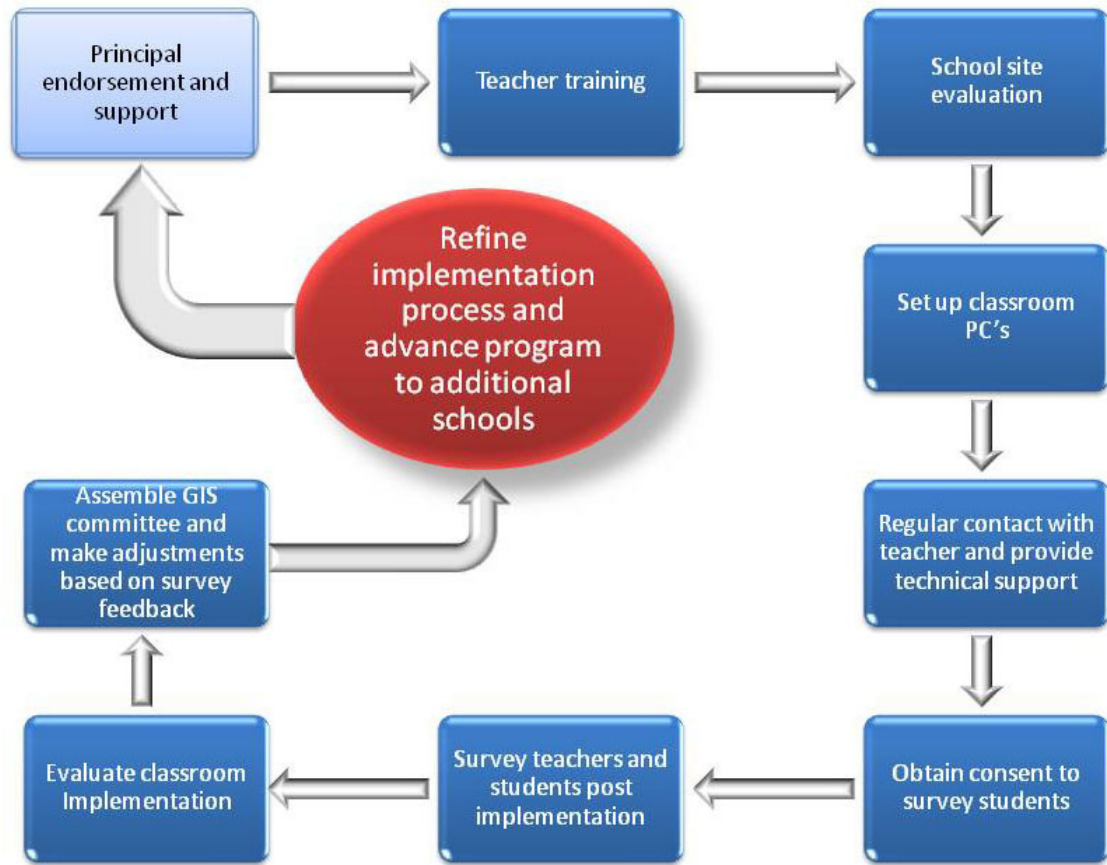
Figure 8. GIS implementation sub-model. Copyright © Donna L. Goldstein.

Chapter Summary

The integration of GIS and GPS instruction appears to hold promise for improving the learning environment and outcomes for K-12 learners. The findings of this study suggest that the majority of students perceive that GIS and GPS instruction does in fact enhance their learning, and they were quite satisfied with the methods of instruction. What is interesting is that the standardized FCAT reading test results, and science and social studies grades appears to corroborate the students' perceptions that GIS and GPS integration enhances their learning. While the results of this study substantiate the value

of implementation of GIS and GPS instruction in K-12 education, the extent of academic benefits to students requires continued research and longitudinal studies.

While implementing best practices of program planning into GIS professional development for adult learners yielded positive responses from participants, additional research may help to elevate the percentage of teachers who actually implement the GIS and GPS applications into their classroom curriculum.

Discussion on the political climate and culture of the school district also addressed the aspect of developing a coalition, involving all stakeholders in the vision and building teams. The same structure that can be seen in successful businesses applies to school districts as well. Essentially, the opportunity for new innovative ideas to take hold and come to fruition relies heavily on the educational leadership of the school district. It is these new innovative ideas, such as integration of GIS and GPS into the K-12 curriculum that can help elevate our students' learning, prepare them to become productive members of society, and arm them with the tools and knowledge necessary to compete in the 21st century global society. In most large government agencies change is slow to occur. There is an urgency, however, to address the national education reform crisis. As we slip behind other developed countries in educational rankings, we have an obligation to ensure all our children receive the best instruction we can provide: one that is inclusive, encourages and motivates them, and provides them with an environment that brings joy back to learning. At this juncture we have a choice regarding the legacy we leave our children - one that prepares them the future they will live in, or one that leaves some behind. Integrating GIS and GPS in curriculum may be one way to engage students in the learning process and raise the literacy and intellectual capacity of our youth.

APPENDIX A

Student Survey 2007-2008

1. I enjoy using the GIS software and look forward to the classes where I can use it.
   Strongly Agree   Agree Undecided   Disagree   Strongly Disagree

2. I would recommend the GIS class to others.
   Strongly Agree   Agree Undecided   Disagree   Strongly Disagree

3. I would like to use the GIS program in more classes.
   Strongly Agree   Agree Undecided   Disagree   Strongly Disagree

4. The skills that I am learning while using the GIS program helps to improve my
   computer skills.
   Strongly Agree   Agree Undecided   Disagree   Strongly Disagree

5. The GIS program can help improve my learning in other topics such as science
   and math.
   Strongly Agree   Agree Undecided   Disagree   Strongly Disagree

6. I am often told what we are going to learn at the beginning of each module in the
   GIS lesson.
   Yes   Sometimes   No

7. My teacher often makes a connection about what I'm learning now and what I
   have already learned in relation to GIS.
   Yes   Sometimes   No

8. During GIS class in the PC Lab I am able to follow the instructions from my own
   binder that has the GIS lesson plans to complete the assignment.
   Yes   Sometimes   No

9. In the GIS Lab classroom I have a computer to myself.
   Yes   Sometimes   No

10. Using the GIS gives me a better understanding of the social studies topic that is
    covered in the lessons.
    Yes   Sometimes   No

APPENDIX B

Student Survey 2008-2009

1. I enjoy using the GIS software and look forward to the classes where I can use it.
   Strongly Agree   Agree Undecided   Disagree   Strongly Disagree

2. I would recommend the GIS class to others.
   Strongly Agree   Agree Undecided   Disagree   Strongly Disagree

3. I would like to use the GIS program in science and social studies classes.
   Strongly Agree   Agree Undecided   Disagree   Strongly Disagree

4. Learning GIS has improved my prior computer skills.
   Strongly Agree   Agree Undecided   Disagree   Strongly Disagree

5. The GIS program can help improve my learning in topics such as social studies, science and math.
   Strongly Agree   Agree Undecided   Disagree   Strongly Disagree

6. I am often told what we are going to learn at the beginning of each module in the GIS lesson.
   Strongly Agree   Agree Undecided   Disagree   Strongly Disagree

7. My teacher often makes a connection about what I'm learning now and what I have already learned in relation to GIS.
   Strongly Agree   Agree Undecided   Disagree   Strongly Disagree

8. During GIS class in the PC Lab I am able to follow the instructions from my own binder of GIS lesson plans to complete the assignment.
   Strongly Agree   Agree Undecided   Disagree   Strongly Disagree

9. In the GIS Lab classroom I have a computer to myself.
   Strongly Agree   Agree Undecided   Disagree   Strongly Disagree

10. Using the GIS gives me a better understanding of the social studies or science topic that is covered in the lessons.
   Strongly Agree   Agree Undecided   Disagree   Strongly Disagree

Student Survey for GPS

1. I enjoy using the GPS software and look forward to the classes where I can use it.
   Strongly Agree   Agree Undecided   Disagree   Strongly Disagree

2. I would recommend the GPS class to others.

Strongly Agree   *Agree*   *Undecided*   *Disagree*   *Strongly Disagree*

3. I would like to use the GPS program in science and social studies classes.
    Strongly Agree   *Agree*   *Undecided*   *Disagree*   *Strongly Disagree*

4. Learning GPS has improved my prior computer skills.
    Strongly Agree   *Agree*   *Undecided*   *Disagree*   *Strongly Disagree*

5. The GPS program can help improve my learning in topics such as social studies, science and math.
    Strongly Agree   *Agree*   *Undecided*   *Disagree*   *Strongly Disagree*

6. I am often told what we are going to learn at the beginning of each the GPS lesson.
    Strongly Agree   *Agree*   *Undecided*   *Disagree*   *Strongly Disagree*

7. My teacher often makes a connection about what I'm learning now and what I have already learned in relation to GPS.
    Strongly Agree   *Agree*   *Undecided*   *Disagree*   *Strongly Disagree*

8. During GPS class I am able to follow the instructions from the assignment.
    Strongly Agree   *Agree*   *Undecided*   *Disagree*   *Strongly Disagree*

9. I have access to the GPS unit during the lesson.
    Strongly Agree   *Agree*   *Undecided*   *Disagree*   *Strongly Disagree*

10. Using the GPS I can relate better to the social studies or science topic that is covered in the lessons.
    Strongly Agree   *Agree*   *Undecided*   *Disagree*   *Strongly Disagree*

APPENDIX C

Teacher Feedback Form 2007

K-12 Curriculum, Adult and Community Education
Staff Development Feedback

Please assist us in our pursuit to continue to provide quality staff development, which meets the needs of you and your school, by completing this Staff Development Feedback form. Thank you in advance for your time and consideration.

Title of Staff Development: GIS: Global Information Systems
Presenter: Donna Goldstein, GIS Coordinator
Date: June 2007
Name (optional): _____

1. Please rate your understanding of the staff development presented.

    A. Prior to the staff development: 1   2   3   4   5
                                                       low…………….. ……….high

    B. Following the staff development: 1   2   3   4   5

                                                       low……………………high
    C. Overall quality of the staff development: 1   2   3   4   5

                                                       low……………………high

2. How would you rate the GIS lesson plan utilized in the training session?

    A. Level of difficulty: 1   2   3   4   5
                                                       difficult…………..……….easy

    B. Topic material: 1   2   3   4   5
                                                       not interesting……very interesting

    C. Length of time to complete the lesson: 1   2   3   4   5
        (If applicable please circle; long or short) too long/short……………just right

    D. Length of time for the training session: 1   2   3   4   5
        (If applicable please circle; long or short) too long/short……………just right

3. Do you find the program useful as a tool to complement your lesson planning?

    A. Prior to the staff development: 1   2   3   4   5
                                                       not useful……… very useful

B. Following the staff development: 1   2   3   4   5
not useful………very useful

4. Please rate the following.

A. Overall GIS program: 1   2   3   4   5
difficult……...…………easy

B. Lessons plans in Mapping Our World: 1   2   3   4   5
not useful……….very useful

5. How likely would you be to implement GIS?

A. In your classroom: 1   2   3   4   5
low……………….... ….high

B. On your home PC: 1   2   3   4   5
low…………….... ……….high

6. Would you be interested in participating in the following?

A. Additional GIS training/workshops: 1   2   3   4   5
low……………….. ……..high

B. A periodic GIS users group: 1   2   3   4   5
low……………….. ……..high

7. Would you be interested in additional GIS information?

A. GIS newsletter for educators: 1   2   3   4   5
low……………………….high

B. Additional lesson plans: 1   2   3   4   5
low…………………..….high

C. Industry wide newsletter and/or books: 1   2   3   4   5
low……………………….high

D. Other Teachers, agencies utilizing GIS: 1   2   3   4   5
low……………….. ……..high

8. If interested in questions 6. or 7. please provide your email
    address:_____

9. Do you have any unanswered questions? (if yes, please comment)
_____

10. Was the staff development delivered in a timely and effective manner? ____YES ____NO

Comments/Suggestions:_____

11. What did you find most beneficial?

_____

12. Recommendations for improvement:

_____

13. Other comments and/or suggestions for follow-up staff development:

_____

Teacher Feedback Form 2008
####### K-12 Curriculum, Adult and Community Education
####### Staff Development Feedback
Please assist us in our pursuit to continue to provide quality staff development, which meets the needs of you and your school, by completing this Staff Development Feedback form. Thank you in advance for your time and consideration.

Title of Staff Development: GIS: Geographic Information Systems
Presenter: Donna Goldstein, GIS Coordinator
Date: June/July 2008
Name: _____

1. Please rate your understanding of the staff development presented.

   A. Prior to the staff development: 1   2   3   4   5
                                            low…………………………….high

   B. Following the staff development: 1   2   3   4   5
                                            low…………………………….high

   C. Overall quality of the staff development: 1   2   3   4   5
                                            low…………………………….high

2. How would you rate the GIS lesson plan utilized in the training session?

   A. Level of difficulty: 1   2   3   4   5
                                            difficult……………………easy

   B. Topic material: 1   2   3   4   5
                                            not interesting……very interesting

   C. Length of time to complete the lesson: 1   2   3   4   5
      (If applicable please circle; long or short) too long/short……………just right

   D. Length of time for the training session: 1   2   3   4   5
      (If applicable please circle; long or short) too long/short……………just right

3. Please circle one of these professional development goals that this workshop
      addresses or write in your own goal:
      A. To develop strategies and best practices for implementing instruction
      B. To enhance knowledge and learn strategies for designing innovative lesson
      plans
      C. _____

4. Check all that apply. I will share this information with:
    A. Colleagues _____
    B. Department members_____
    C. List others:_____

5. State one strategy or best practice that you learned in this workshop that you will
    implement into a lesson that you will create and design for your students.

6. Please rate the following.

    A. Overall GIS program: 1   2   3   4   5
    difficult.…………..…………easy

    B. Lessons plans in Mapping Our World: 1   2   3   4   5
    not useful.……..…very useful

7. How likely would you be to implement GIS?

    A. In your classroom: 1   2   3   4   5
    low.…………………….high

    B. On your home PC: 1   2   3   4   5
    low.…………………….high

8. Would you be interested in participating in the following?

    A. Additional GIS training/workshops: 1   2   3   4   5
    low.…………………….high

    B. A periodic GIS users group: 1   2   3   4   5
    low.…………………….high

9. Would you be interested in additional GIS information?

    A. GIS newsletter for educators: 1   2   3   4   5
    low.…………………….high

    B. Additional lesson plans: 1   2   3   4   5
    low.…………………….high

    C. Industry wide newsletter and/or books: 1   2   3   4   5
    low.…………………….high

    D. Other Teachers, agencies utilizing GIS: 1   2   3   4   5
    low.…………………….high

10. If interested in questions 6. or 7. please provide your email
    address:_____

11. Do you have any unanswered questions? (if yes, please comment)
_____

12. Was the staff development delivered in a timely and effective manner? ____YES
    ____NO

Comments/Suggestions:_____

13. What did you find most beneficial?
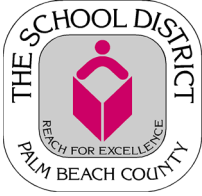_____

14. Recommendations for improvement:
_____

15. Other comments and/or suggestions for follow-up staff development:
_____

APPENDIX E

PROJECT CHARTER - GIS Educational Model (GEM)

Approval of the Project Charter indicates the signatory understands of the purpose and content described in this document. By signing this document, each individual agrees that the project should be initiated and necessary resources should be committed as described herein.

Approver Name	Title	Signature	Date
Ann Killets	CAO		

Student Achievement Goals and Focus Areas

THIS PROJECT SUPPORTS THE FOLLOWING DISTRICT KEY RESULTS:
#5. Upper level math and science courses - All schools will increase enrollment and performance of each racial/ethnic group in upper level mathematics and science courses, with a particular emphasis on underrepresented populations.
#8. Dropout and graduation rates - All schools will decrease dropout rates and increase graduation rates for students of each racial/ethnic group.
#9. Suspensions - All schools will reduce suspensions and eliminate disproportionate suspension rates among student groups.

THIS PROJECT SUPPORTS THE FOLLOWING FOCUS AREAS:
#1. Students Achievement
#4. Effective and Rigorous Instructional Program
#5. Quality Faculty//Work Force Aligned and Need
#6. Staff Development and Training

Section 1.   Project Overview

1.1.1   Project Statement

Describe the reason(s) for initiating the project.

Palm Beach County School District (PBCSD) currently has a district wide site license for the GIS software application. The license allows PBCSD to load the application on every PC the District owns and teachers and staff may load the software on their home PC's. The GIS has been utilized primarily by School District Operational Departments for some time however, with the industry and academic surge in the use of GIS, the School District has an exceptional opportunity to include this application in academic curriculum. To ensure students are provided with technical skills needed to compete in the global society and to help raise academic achievement it is recommended that curriculum instruction include GIS/GPS.

GIS in the Classroom

Use of this technology in the classroom curriculum is expected to help contribute to academic achievement for all students, including ESE, ESOL and Alternative Education. In addition, incorporation of this application and its fundamental approach of utilizing multiple intelligences will assist in closing the achievement gap, narrowing the digital divide and reducing the dropout rate. The learning outcomes will increase students' skills in the following areas; critical thinking, analytical approaches to problem solving, computer (technology) literacy, 21st century workforce skills, communication and presentation skills, citizenship, and community participation. Furthermore, GIS encompasses SCANS competencies which include students identifying resources, working with others, using information, and understanding complex and changing inter relationships. In addition GIS can be applied to a variety of topics in both the physical and social sciences including mathematics and art/design. As such, GIS provides a great foundation for interdisciplinary projects. Students utilizing GIS may retain a greater breadth and depth of knowledge while teachers will benefit by learning a valuable new skill that leverages the subject matter they teach.

In addition to students acquiring much needed technical skills, GIS can be incorporated into the following subject areas:
- Social Studies - explore demographic information for countries of the world; visualization of historical events; explore natural change over time.
- Science Education - explore natural phenomena such as earthquakes and volcano locations or explore habits of animals and impact of humans.
- Business and Marketing Education - business location analysis; create travel routes for a business that will be delivering goods in a town or city.
- Language Arts - explore locations of a books plot; map the travel logs/journals of a specific author.
- Mathematics - explore mathematical functions of demographic data (i.e.

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differences between the number of males and females of cities, proportions of Hispanic Americans to African Americans in major US cities).

- Health and Physical Education-explore locations and spread of diseases and illnesses.

GIS for Future Employment

Incorporating GIS into classroom curriculum gives students a competitive edge in what has become a global market place.

The U.S. Department of Labor identified GIS as "one of the three most important emerging and evolving fields", along with nanotechnology and biotechnology and the worldwide geospatial market grew to $30 billion in 2005.

- The U.S. military has spent more than $1 billion on commercial remote sensing and GIS in the past two years
- The American Congress on Surveying and Mapping has identified learning GIS and GPS as a solution to the imminent crisis in filling the void of skilled workers, noting that the average age of a surveyor today is currently 58.
- U.S. - 900,000 additional jobs in geospatial technology expected from 2002 to 2012
- NASA - 26% of their most highly trained geotech staff is due to retire in the next decade
- National Imagery and Mapping Agency is expected to need 7,000 people trained in GIS in the next three years.

1.2   Project Description

Describe the approach the project will use to address the District's needs.

The project will address the District goals listed below by infusing appropriate curriculum with geospatial technology (GIS/GPS). This technology will engage students academically and provide them with a competitive edge. Resources include training and GIS technical support from District headquarters. Deliverables include the GIS software, GIS lesson plans and data sets.

1.3   Project Goals and Objectives

Describe the goals and objectives of the project.

Implementing GIS into classroom curriculum can address the District's goals of increased literacy and graduation rates by focusing on the following School Board Goals (Adopted May 1999):

1. Increase literacy in reading, writing and mathematics, for all students, including students in Exceptional Student Education and English Speakers of Other Languages
2. Improve achievement at critically low performing schools and among students in Quartile One district wide
3. Implement a challenging curriculum, including methods for individualized and group instruction that supports the Board's mission and goals.
4. Provide continuous staff development that supports the Board's mission and goals.
5. Provide experiences that prepare students for productive citizenship.
GIS can also assist in reducing "nature deficit disorder" as outlined in the book *Last Child in the Woods*.

1.4 Project Scope

Describe the project scope. The scope defines project limits and identifies the products and/or services delivered by the project. The scope establishes the boundaries of the project.

Project Includes
Implement GIS into existing Science and Social Studies curriculum
Implement GIS into existing Criminal Justice Career Academy
Implement GIS into Alternative Education
Develop a GIS Career Academy based on Florida's Department of Education Geospatial Information Systems Technology program modeled after the STARS program and to be included in STEM Career Clustering SY2008-2009
Broad reaching potential: enhanced skills for job opportunities, higher educational path, possible inclusion in Adult and Community Education and Virtual school

Project Excludes
GIS Certification except when implemented in a GIS Career Academy

1.5 Critical Success Factors
Describe the factors or characteristics that are deemed critical to the success of a project, such that, in their absence the project will fail.
- Teacher interest
- Principal approval
- Adequate Professional Development & Training
- Adequate hardware (PC's, Laptops, GPS units) to accommodate the software and associated curriculum program

- Facility conducive to instruction (Media Center, existing Lab, Mobile GIS platform)

1.6 Assumptions

Describe any project assumptions related to technology, resources, scope, expectations, or schedules.

- Technology – PBCSD will maintain yearly GIS site license contract.
- Resources - Adequate facilities/necessary hardware will be available. Internal staff will be available for training during Phase I of implementation. Additional resources may be required to augment internal staff for teacher training during phases two and three.
- Scope – GIS implementation into curriculum will occur in 3 Phases. Initial phase will involve several schools incorporating GIS into their existing Social Studies/Science program and implementation at an Alternative school and Criminal Justice Career Academy. Phase two will involve program adjustments and expansion. Phase three will include development of a GIS Career Academy.
- Expectations – There will ample interest by teachers and support by Principals to move the project forward. Hardware issues and adequate classroom accommodations will be met to facilitate this program at identified schools.
- Schedules – will be adjusted as needed.

1.7 Constraints

Describe any project constraints being imposed in areas such as schedule, budget, resources, products to be reused, technology to be employed, products to be acquired, and interfaces to other products. Constraints are based on the current knowledge.

- Scheduling - Open Lab periods are limited and many Media Centers are unavailable
- Budget – Staff development dollars for teacher training. Project may need to include provisions for laptops and GPS units.
- Resources – Additional trainers may be required in the future.
- Products to be reused - May include refreshed laptops from Administration.

Section 2. Project Authority and Milestones

2.1 Funding Authority

Identify the fiscal year funding amounts and source of authorization. Identify the method of financing for the project.

- Existing GIS Site License – Renewed Annually by IT

- GPS units –TBD By Each School – 1 set of 20 units = $1,700
- Professional Staff Development Training – TBD By Curriculum's Staff Development @$50.00 per Book - Training delivered By in House Staff.

2.2   Project Oversight Authority

Describe management control over the project. Describe external oversight and relevant policies, if any.
- Quarterly Team meetings
- Monthly communication with participating teachers
- Conduct post semester evaluations; qualitative and quantitative

Milestone/Deliverable   Target Date

Milestone/Deliverable	Target Date
GIS Professional Development Training Workshop for Social Studies teachers	June 2007 (completed)
Load software on Media Center PC's (Boca Middle)	October 2007 (completed)
Implementation at Boca Middle Social Studies	November 2007 (completed)
Identify Alternative school(s)	November 2007
Identify Criminal Justice Career Academy(s)	November 2007 (completed)
Identify existing Choice program(s)	November 2007 (on-going)
Identify existing school(s) for inclusion in Social Studies	December 2007 (on-going)
Identify existing school(s) for inclusion in Science	December 2007 (on-going)
Training for Educational Technology staff, IT Customer service staff and Career Ed staff	December 2007 (completed)
Implementation at Park Vista Social Studies	When Media Center becomes available
Develop priority matrix	January 2008 (on-going)
Develop metrics of measurement for program evaluation	January 2008 (completed)
Determine potential GIS Career Academy	January 2008 (completed 11/2008)
Develop timeline based on identification of identified schools for participation	February 2008 (on-going)
Implementation at Jupiter High Environment Science Academy (PBCC is providing the course)	February 2008 (completed)
Determine Schools/Programs for further expansion	February 2008 (on-going)
GIS users group	TBD
Criminal Justice teachers meet with county Criminal Justice GIS analyst – develop lesson plans	May 2008 (completed)
Identify existing school(s) for inclusion in	December 2007

Social Studies	(on-going)
Identify existing school(s) for inclusion in Science	December 2007 (on-going)
Training for Educational Technology staff, IT Customer service staff and Career Ed staff	December 2007 (completed)
Implementation at Park Vista Social Studies	When Media Center becomes available
Develop priority matrix	January 2008 (on-going)
Create GIS lab classroom for Boca Middle School	June-July 2008 (completed)
GIS/GPS staff development – Science & Social Studies teachers, Gumbo Limbo, Loxahatchee Refuge & FAU at Pine Jog	July 2008 (completed)
Staff Development sessions – Social Studies Conference	August 2008 (completed)
GIS presentation to Alternative Education staff	October 2008 (completed)
Identified Santaluces for Career Academy – identify Academy Coordinator	November 2008 TBD
GIS Presentation to Social Studies Chairpersons	January 2009

2.3   Major Project Milestones

List the project's major milestones and deliverables and the target dates. This list should reflect products and/or services delivered to the end user as well as to project management.

Section 3.   Project Organization

3.1   Project Structure

Describe the organizational structure of the project team and stakeholders.
Sponsors: Mary Vreeland, Director: Choice Programs and School Choice & Kristin Garrison, Director: Planning Department
Project Manager: Donna Goldstein, GIS Coordinator
Team Members: Connie Scotchel-Gross, Manager Career Ed.
TBA, Manager/Choice Programs
Sally Rozanski, Manager, Secondary Education
Jeraline March, Specialist/Career Ed.
Jim Politis, Specialist/Career Ed.
Mark Howard, Specialist, Specialist/Education Technology
Ed. Harris, Network Technician
Karen Epstein, Alternative Education
            Optional Team Member: Fred Barch, Program Planner/Science,
            Pine Jog Elementary Principal
Project Management Office, Glenda Izzarone

3.2   Roles and Responsibilities

Summarize roles and responsibilities for the project team and stakeholders identified in the project structure above.

Responsibility	Role
Sally Rozanski/Laurie Cotton	GIS/GPS in Social Studies curriculum/ Science curriculum
Fred Barch/Wendy Spielman	GIS/GPS in Science curriculum
Karen Epstein/Jeff Orloff	GIS/GPS in Alternative Education
Jeraline March	GIS/GPS in Criminal Justice Career Academies
Jim Politis/Ed Harris	Determine available Labs and Media Centers – availability for schools to accommodate program
Connie Scotchel-Gross, Manager/Career Education TBA, Manager/Choice Programs	GIS/GPS in existing Choice programs
Mary Vreeland/Jim Politis	Identify potential school(s) for development of new GIS Career Academy
Kristin Garrison/ Donna Goldstein	Strategic Planning oversight
All team members	Determine schools/programs for further expansion
Ed Harris, Mark Howard, Donna Goldstein	Technical program development, technical specifications and hardware issues
Donna Goldstein	Coordination, training and implementation assistance
Donna Goldstein	Train staff from Educational Technology, Career Ed and IT Customer support

Milestone   Responsibility   Role

Milestone	Responsibility	Role
GIS Professional Development Training Workshop for Social Studies teachers	Donna Goldstein	Completed
Load software on Media Center PC's (Boca Middle)	Donna Goldstein ITSA	Completed
Implementation at Boca Middle Social Studies	Susan Oyer	• Up and running in classroom • After School GIS Club

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		• Show Mastery by students
Identify Alternative school(s)	Karen Epstein/Jeff Orloff Ed Harris	• Identify sites • Identify specific curriculum
Identify Criminal Justice Career Academy(s)	Jeraline March	• Atlantic High School • Forest Hill High • Glades Central High School • Lake Worth High School
Identify existing Choice program(s)/Career Academies	Connie Scotchel-Gross TBA, Manager/Choice Programs	Choice/Magnet/Career Ed.
Identify existing school(s) for inclusion in Social Studies	Laurie Cotton	Social Studies Curriculum Planner
Identify existing school(s) for inclusion in Science	Wendy Spielman	Science Curriculum Planner
Implementation at Park Vista Social Studies	Martha Brown	Delayed due to overcrowding
Develop priority matrix	Team members	
Develop tools for measurement of program evaluation	Donna Goldstein	• Students need to demonstrate mastery of program. • Pre and post survey • Comparison of test scores
Determine potential GIS Career Academy	Mary Vreeland	• Choice 5 Year Plan for FY09 • Jim Politis will consider the classes, etc., that could fall into the GIS Career Academy
Develop timeline based on identification of identified schools for participation	Donna Goldstein	
Implementation at Jupiter High Environment Science Academy (PBCC is providing the course)	Neal White	• 10 laptops donated by FPL – these laptops need operating software. (possible additional 10 in December 07) • PBCC will be providing GIS/GPS for his students this Spring • Need exit mastery for Environmental lesson plans
Determine Schools/Programs for further expansion	Team members	
Mobile laptops with cart	Jim Politis, Ed Harris, Mark Howard	Use laptops as check out for teachers use
Admin Training	Donna Goldstein	• Career Ed staff

		• Educational Technology staff • IT Customer Service staff
GIS/GPS staff development training	Donna Goldstein	• Develop 1- week training program
Staff development for social studies conference	Donna Goldstein	• 4 - 1 hour sessions
Presentation to Alternative Education staff	Donna Goldstein	• Develop presentation and provide materials to encourage integration of GIS
Identified Santaluces for GIS Career Academy - Identify Academy Coordinator	Jim Politis	• Development of in-house GIS Career Academy
GIS presentation to Social Studies Chairpersons	Donna Goldstein/Laurie Cotton	• Develop presentation and provide materials to encourage integration of GIS into the curriculum
Implementation of GIS into Criminal Justice Career Academies	Jeraline Marsh	• Expand GIS integration
GIS presentation to Academic Leadership Team	Donna Goldstein/Kris Garrison	• Educate leaders on the benefit of GIS in K-12 curriculum
Integrate GIS into existing Civil Engineering Project Lead the Way at Jupiter High	Jim Politis	• Expand GIS integration

3.3   Responsibility Matrix

Complete the responsibility matrix for each of the project roles. As a graphical depiction of a more detailed perspective of responsibilities, the matrix should reflect by functional role the assigned responsibility for key milestones and activities.

3.4   Project Facilities and Material Resources

Describe the project's requirements for facilities and resources, such as office space, special facilities, computer equipment, office equipment, and support tools. Identify responsibilities for provisioning the specific items needed to support the project development environment.

Resource Requirement	Responsibility
PC's and/or Laptops	Ed Harris, Mark Howard
GPS units	School, Mark Howard

Resource Requirement	Responsibility
Lesson materials (books)	Donna Goldstein, Laurie Cotton, Sally Rozanski, Wendy Spielman, Jeraline March
Space – Lab, Media Center or Mobile laptops with cart	Jim Politis, Ed Harris, Mark Howard
Training for Teachers and Staff	Donna Goldstein, Jim Politis, Jeraline Marsh

Section 4.   Points of Contact

Identify primary and secondary contacts for the project.

Role	Name/Title/Department	Phone	Email
PM	Donna Goldstein/GIS Coordinator/Planning	434-7468	goldstein@palmbeach.k12.fl.us
PMO	Glenda Izzarone/Manager, Compliance	434-8397	izzaron@palmbeach.k12.fl.us

Section 5.   Glossary

Define all terms and acronyms required to interpret the Project Charter properly.
GIS – Geographic Information System
GPS – Global Positioning System
ESE - Exceptional Student Education
ESOL - English Speakers of Other Languages
SCANS - Secretary's Commission on Achieving Necessary Skills
STARS - Scholarship Tuition for At-Risk Students
STEM – Science, Technology, Engineering, Mathematics

Section 6.   Revision History

Identify document changes.

| Version	Date	Name	Description
2	7/9/2007	Donna Goldstein	updates
3	2/16/2008	Donna Goldstein	updates
4	7/21/2008	Donna Goldstein	updates
5	11/3/2008	Donna Goldstein	updates

Section 7.   Appendices

Table F1.

Pilot Study GIS Student Survey 2007-08 – Student Motivation

	Strongly Agree		Agree		Undecided		Disagree		Strongly Disagree	
	%	n	%	n	%	n	%	n	%	n
Item 1	11	7	45	27	14	8	15	9	15	9
Item 2	20	12	25	15	30	18	8	5	17	10
Item 3	13	8	25	15	22	13	17	10	23	14
Item 4	19	11	43	26	15	9	15	9	8	5
Item 5	6	4	32	19	35	21	14	8	13	5
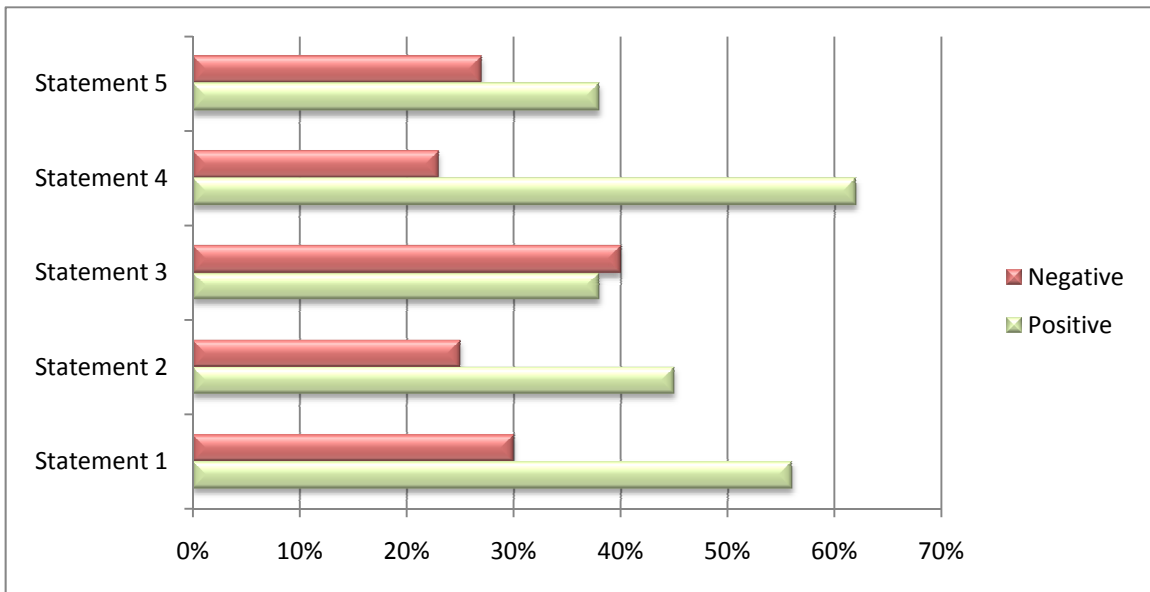
Figure F1. Pilot study GIS student survey 2007-08 – student motivation.

APPENDIX G

Table G1. *Pilot Study GIS Student Survey 2007-08 - Program Evaluation*

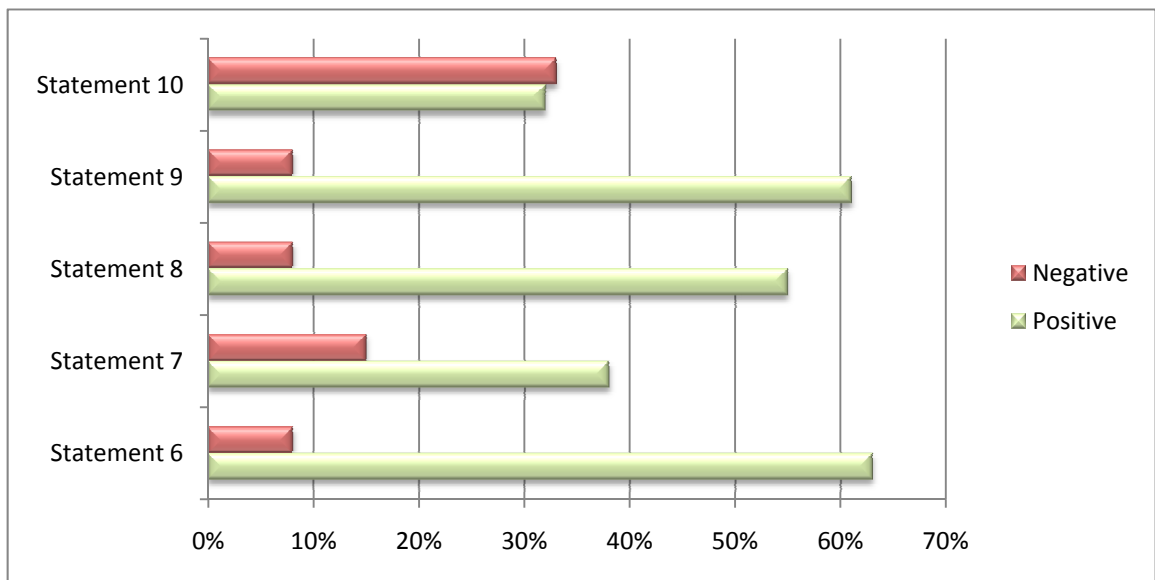|	Yes		Sometimes		No	
	%	*n*	*%*	*n*	*%*	*n*
Item 6	63	38	28	17	8	5
Item 7	38	23	47	28	15	9
Item 8	55	33	37	22	8	5
Item 9	61	37	30	18	8	5
Item 10	32	19	35	21	33	20

Figure G1. Pilot study GIS student survey 2007-08 - program evaluation.

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