2008

An Analysis Of Predictors Of Enrollment And Successful Achievement For Girls In High School Advanced Placement Physics

Darlene DePalma
University of Central Florida

AN ANALYSIS OF PREDICTORS OF ENROLLMENT AND SUCCESSFUL ACHIEVEMENT FOR GIRLS IN HIGH SCHOOL ADVANCED PLACEMENT PHYSICS

by

DARLENE M. DEPALMA
B.S. Florida Institute of Technology, 1992
M.S. Florida Institute of Technology, 2000

A dissertation submitted in partial fulfillment of the requirements
for the degree of Doctor of Education
in the Department of Educational Studies
in the College of Education
at the University of Central Florida
Orlando, Florida

Spring Term
2008

Major Professor: David N. Boote

ABSTRACT

A problem within science education in the United States persists. U.S students rank lower in science than most other students from participating countries on international tests of achievement (National Center for Education Statistics, 2003). In addition, U.S. students overall enrollment rate in high school Advanced Placement (AP) physics is still low compared to other academic domains, especially for females. This problem is the background for the purpose of this study.

This investigation examined cognitive and motivational variables thought to play a part in the under-representation of females in AP physics. Cognitive variables consisted of mathematics, reading, and science knowledge, as measured by scores on the 10th and 11th grade Florida Comprehensive Assessment Tests (FCAT). The motivational factors of attitude, stereotypical views toward science, self-efficacy, and epistemological beliefs were measured by a questionnaire developed with questions taken from previously proven reliable and valid instruments. A general survey regarding participation in extracurricular activities was also included. The sample included 12th grade students from two high schools located in Seminole County, Florida. Of the 106 participants, 20 girls and 27 boys were enrolled in AP physics, and 39 girls and 20 boys were enrolled in other elective science courses.

Differences between males and females enrolled in AP physics were examined, as well as differences between females enrolled in AP physics and females that chose not to participate in AP physics, in order to determine predictors that apply exclusively to female enrollment in high school AP physics and predictors of an anticipated science related college major. Data were first analyzed by Exploratory Factor Analysis, followed by Analysis of Variance (ANOVA), independent t-tests, univariate analysis, and logistic regression analysis.

One overall theme that emerged from this research was findings that refute the ideas that females have lower achievement scores, lower attitude, lower self-efficacy, and more stereotypical views regarding science than males. Secondly, the only significant differences found between males and females enrolled in AP physics were for stereotypical views toward science and one factor from the epistemological views questions, both of which favored females. Although the non AP boys significantly outscored non AP girls on science FCAT scores, the only other significant differences found between these groups of students were related to attitude, with the girls scoring higher than the boys on both counts.

There were significant differences found for numerous variables between AP and non AP females, however, most of the same differences were found between the two ability groups of male students as well. This leads to the conclusion that these factors certainly play an important role in AP physics enrollment for both genders. But the few significant differences found exclusively between the two female ability groups; reading ability, stereotypical views toward science, and the epistemological beliefs regarding branches of physics being related by common principles and aspects of physics need to be inferred instead of directly measured, may play a more important role in increasing enrollment numbers of females.

I dedicate this to the most important people in my life, my children Tiffany and Jason, and grandchildren Joey, Ariel, Jason II, and Mallorie. Thank you for your support and understanding, without which this would not have been possible. And to my late husband and parents, who were taken away from me much too soon, I wish you were still here to share this extraordinary experience and accomplishment in my life.

ACKNOWLEDGMENTS

I would like to extend my deepest gratitude to all of those who shared in this endeavor. Although the dissertation process is often a lonely experience, I was fortunate enough to receive praise and encouragement from many talented and inspiring people. It was because of all of you, I never once felt alone.

First and foremost, to my committee chair Dr. David Boote, my most sincere thanks for the countless hours spent trying to decipher my initial work and critiquing my progress. Thank you for your sense of humor, your research and writing suggestions, and your patience with my stubborn writing habits. Your invaluable advice helped me to not only create, but truly understand the meaning of my work. To my committee members, Dr. Karen Biraimah, Dr. Robert Everett, Dr. Cynthia Hutchinson, and Dr. Alison Morrison Shetlar; thank you so much for your continued patience, support, and kind understanding. And to Dr. Kay Allen, thank you for all of your help during the past few years. You've been so much more than a professor, you've been a confidant, mentor, and friend.

Thank you to the teachers and students of the graduating class of 2007 from Winter Springs High School and Lake Mary High School, who so graciously participated in this study. Without you, this project would not have been possible.

Thank you to my family, Tiffany, Jason, Heather, and Cesar, all of whom gave me space when it was needed, and were a constant source of support. During my times of doubt, you were always there to push me forward. And thank you to my grandchildren, Joey and Ariel, who I suspect to be the culprits in the few cases of disappearing papers. After overcoming a little extra stress, I was provided with an opportunity to rewrite those pages in a better and much more organized way.

And last, but certainly not least, thank you to my fantastic University of Central Florida cohort group who continuously encouraged and motivated one another. I would like to extend a very special thank you to Dr. Edie Gaythwaite, and Jackie Davis. The cruise and girls' nights out were great down-time motivators, but the constant support and available shoulders to lean on were invaluable. You are truly friends for life.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

AAAS	American Association for the Advancement of Science
AAUW	American Association of University Women
ANOVA	Analysis of Variance
AP	Advanced Placement
ASDQ	Academic Self Description Questionnaire
CAD	Contrasting Alternatives Design
CORI	Concept-Oriented Reading Instruction
FCAT	Florida Comprehensive Assessment Test
NAEP	National Assessment of Educational Progress
NCES	National Center for Education Statistics
NCTM	National Council of Teachers of Mathematics
NELS:88	National Education Longitudinal Study of 1988
NSF	National Science Foundation
SAT	Scholastic Aptitude Test
SPSS	Statistical Package for the Social Sciences
TIMSS	Third International Mathematics and Science Study
VASS	Views About Science Survey

CHAPTER ONE: INTRODUCTION

Numerous factors, both inside and outside of the school setting, have been identified during the past 30 years of educational research to play significant roles in females' non-participation in the physical sciences. However, cognitive factors such as academic ability, and motivational factors such as attitude, have generally been researched separately which did not allow researchers to determine benefits they may have had on one another. Therefore, it is not the intent of this study to dwell on individual factors that have already been well documented to play significant roles in female non-participation in science. Instead, it is more exploratory in nature, and examines how cognitive and motivational factors may be inter-related, as well as related to the quality of science learning. In addition, it is felt that instead of focusing on variables over which educators have little or no control, such as socioeconomic status of students, it may be more beneficial to identify key factors within the grasp of the school environment in order to understand why girls are not choosing upper level physical science courses, and focus on how such factors may be manipulated from within the educational environment to promote participation and successful achievement.

Recent research continues to support the same trend of low overall academic performance, low enrollment numbers in upper level science classes, and a continuing gender achievement gap that has consistently been reported to flourish in this country for more than 30 years (Callahan, Tomlinson, Reis, & Kaplan, 2000; Cavallo & Laubach, 2001). As today's society continues its growing dependency on technological and scientific advances, participation and successful achievement of students in the physical sciences is again becoming a major educational concern.

According to the National Science Foundation (NSF), females have remained strong in the biological sciences and have substantially narrowed the gender gap in mathematics achievement, however, they still remain extremely underrepresented in the physical sciences and science technologies in high school, post secondary education, and the labor force (NSF, 2002). Considering the abundance of research conducted on the topic of high school science achievement of girls, only minimal, sporadic, and inconsistent progress has been made. According to Lee (1987), speculation on why such differences exist in science education contains at least four heavily researched possibilities:

- Genetic differences between males and females (e.g., Benbow & Stanley, 1980)
- Differences in how science is viewed by males and females as important or relevant (e.g., Linn & Hyde, 1989)
- Sex-related socialization differences (e.g., Farenga & Joyce, 1998)
- Biased standardized tests, such as the Scholastic Aptitude Test (e.g., Spencer, Steele, & Quinn, 1999)

The majority of research stemming from the late 1970's and 1980's has successfully shown social, family, and cultural influences to play influential roles in the science achievement gap, however, the focus tends to be more toward gender differences rather than specific differences among females, or upon factors that reinforce non-participation and low achievement, rather than those that promote success in science. Unfortunately, after extensive studies, considerable expense, and numerous modifications in curriculum, statistics have not changed significantly, and the problem persists.

Although there have been promising reports of increased enrollment of females in advanced level science courses, physics continues to be the least popular high school science class for many females (Neuschatz & McFarling, 2003). The increased enrollment trend may simply be due to state or district requirements concerning the number of science credits necessary for high school graduation. Since 2001, the number of science courses required for graduation has continued to increase in many states, but it may still be too little too late. According to the U. S. Department of Labor (2007), six million jobs in technical fields will go unfilled in 2008 because American students to not have the required math and science skills.

Problem Statement

In an attempt to positively impact the number of female participants in upper level science, this research study seeks to identify cognitive and motivational variables that may benefit one another in their convergence to promote participation and successful achievement in physical science for females. A considerable amount of time, money, and effort has been expended on research concerning gender differences in science education over the past 30 years. Yet, statistics regarding the enrollment of females in advanced level physical science courses, as well as related college majors and careers, have not improved accordingly.

Purpose of the Study

The desired outcome of the current investigation was to identify cognitive and motivational variables that may be managed within the school environment by teachers and counselors in order to promote female participation in advanced level physical science courses, since existing research seems to have focused primarily on elements that that have hindered participation, or cannot be altered by educators. There were two main objectives to this study. First, an attempt was made to determine factors that may contribute, either solely or collectively, to successful completion of Advanced Placement (AP) physics by females in high school. Secondly, factors were identified to be possible predictors of AP physics enrollment for females, as well as predictors of science-related college majors for females.

Research Questions

The current study strives to answer the following four research questions:

1) Is there a difference in the cognitive factors of reading, mathematics, and science ability, or in the motivational factors of science related attitude, self-efficacy, stereotypical views, and epistemological beliefs between 12th grade AP physics females and non AP physics females, or between AP physics females and AP physics males?
2) Which factors defined in this study are most strongly associated with female enrollment in AP physics?
3) Is there a difference between AP physics females and non AP physics females, or

between AP physics females and AP physics males concerning an anticipated science-related college major, and if so, which factors defined in this study, either solely or collectively, most strongly predict that choice?

4) Is there a relationship between student involvement in school related activities and enrollment in upper level science?

Significance of the Study

This study identified factors that educators may be able to manipulate in order to increase participation and achievement of girls in advanced level physical science. Although the subjects in this study are 12th grade students, the results of the questionnaires may help in future studies by identifying individuals early enough to implement measures for maintaining positive attitudes, interest, and self-confidence. In addition, if variables can be identified as predictors of successful achievement, teachers and counselors can help direct more girls in a positive direction. By learning more about girls maintaining positive attitudes about mathematics and science, as well as about themselves, classrooms can become more accommodating to the needs of young girls and focus on variables that will help all students become comfortable and successful in the science classroom.

This study also has strong theoretical and research based implications as it contributes to the body of research literature regarding gender, academic self-efficacy and achievement in science. Furthermore, a clear understanding of females' issues enhanced by the results from this study can inform better educational practices and enable schools to address the needs of females with the potential to be successful in the physical science domains.

Research Design

This research study first explored differences among the four gender/ability groups of AP females, non AP females, AP males, and non AP males, in order to determine which of the 14 factors could be related solely to female participation. In addition, analyses were conducted to determine factors that may be predictors for female enrollment in AP physics, as well as predictors for an anticipated science related college major. AP students were those students who were enrolled in AP physics during the 2006-2007 school-year, and the non AP students were those students who had elected not to enroll in AP physics.

The data for this study were collected from two public high schools within Seminole County, Florida. The sample, obtained through purposive sampling procedures, consisted of 106 high school seniors: 27 males and 20 females were enrolled in AP physics, and 20 males and 39 females were enrolled in elective science courses. Data related to academics, such as Florida Comprehensive Assessment Test (FCAT) scores for reading, mathematics, and science were obtained from student transcripts provided by the schools. Data for the motivational factors of attitude, stereotypical views, self-efficacy, and epistemological beliefs were obtained from a single survey instrument. Although questions contained on the survey were chosen from pre-existing instruments, exploratory factor analysis was conducted to reaffirm validity and reliability.

The research design involved two phases of data analysis. First, mean scores of gender/ability groups for each variable were compared to find significant differences using Analysis of Variance (ANOVA) and independent t-test procedures. The second phase of the analysis was conducted through logistic regression to determine which factors were the most significant predictors of AP physics enrollment and anticipated science related college major for females.

Basic Assumptions

For this study, the assumptions that students answered the survey items honestly and to the best of their ability, and that the questionnaire items accurately measured the variables under consideration, were made.

Limitations

This study contains the following limitations that may affect the ability to draw conclusions or infer results beyond the scope of the study.

- Since the study considered only independent variables that may be manipulated within the school environment, other extraneous variables which have been found to affect achievement and participation in science have not been controlled.
- The sample of students used in this study had taken the science portion of the FCAT in both 10th and 11th grades. Therefore, test scores may not be generalizable to all students.
- Homogeneity of groups was based solely on science class level.
- Since the sample contained participants from only two high schools within the same school districts, results may not be generalizable to all 12th grade students.
- Because of historically low enrollment of females in Advanced Placement physics

classes, the available sample size was limited.

- While it was assumed that students would answer survey questions truthfully, the accuracy of responses may be limited by the students' recollection of past events.
- Strengths and weaknesses of a correlational design were inherited. The study did not use an experimental or longitudinal design, so it is inappropriate to make a clear statement concerning causality. Relations that are identified cannot be determined to establish causation, and the possibility of reverse causation must be considered.
- The initial portion of the survey designed to examine the role of peers in advanced science involvement was rejected by the school district. Therefore, the survey was restructured to include only participation in extra-curricular activities.

Definition of Terms

Terms used frequently throughout the study are defined as follows:

- *Adolescents*: Refers to students at the middle school level (Grades 6 - 8)
- *Advance Placement courses*: College Board courses offered in high school, from which college credit may be earned for successful completion.
- *Cognitive factors*: For this study, cognitive factors consist of mathematics, science, and reading ability as asses by scores obtained from the Florida Comprehensive Assessment Test.
- *Domain*: A particular discipline within science, such as physics or chemistry.

- *Educators*: Includes teachers, guidance counselors, administrators, tutors, and mentors with whom the students have contact.
- *Extra-curricular activities*: Activities used for this study include athletics, academic and non academic school sponsored clubs. They are defined to be physically or mentally stimulating, contain structural parameters, are voluntary, and award no academic credit for participation.
- *Florida Comprehensive Assessment Test (FCAT)*: A criterion and norm referenced test mandated in the State of Florida consisting of mathematics, reading, and writing portions to be administered to all public school students in grades 3 through 10, and a science portion to be administered to all students in grades 4, 8, and 11.
- *Motivational factors*: The motivations factors used in this study consist of student attitude toward science, science and mathematics self-efficacy, epistemological beliefs toward science learning, and stereotypical views toward science.
- *National Educational Longitudinal Study of 1988 (NELS:88)*: Data collected through the National Center of Education Statistics from a nationally representative sample of grade 8 students surveyed in 1988. The base year sample consisted of 1052 public, private, and parochial schools throughout the United States.

Summary

Despite ongoing concern on the subject of females pursuing advanced level science courses, majors, and careers, the physical sciences remain heavily male dominated, with physics demonstrating one of the most severe under-representations of women (NSF, 2002). Thirty years of research have given us valuable insight to the roles of numerous variables, however, the majority of previous research focuses on factors that inhibit rather than promote participation and success. This study contributes to the body of knowledge by providing additional insight into the role of cognitive and motivational factors working together in facilitating female participation in sciences that are male-dominated. Because boys and girls are often taught using the same curriculum within the same environment, it is vital to understand how particular factors influence gender related participation. By understanding how certain factors enhance female engagement in the physical sciences, educators can develop a curriculum that will promote higher enrollment of females in the physical sciences.

CHAPTER TWO: REVIEW OF LITERATURE

Considering the abundance of research conducted on the topic of high school science achievement of girls, only minimal, sporadic, and inconsistent progress has been made. The majority of research stemming from the late 1970's and 1980's has successfully shown social, family, and cultural influences to play significant roles in the science achievement gap. Even though a positive attitude toward science may begin at home for most students, research has demonstrated that school factors influence science related attitude more strongly than parental or home factors (e.g., Davis, 1999; Simpson & Oliver, 1990). In the past, cognitive and motivational factors were generally researched separately in educational issues, which did not allow researchers to determine benefits they may have on one another. Therefore, it has been widely accepted that cognitive abilities and prior knowledge were the primary prerequisites of learning (e.g., Snow, 1989). However, knowledge gained concerning cognitive, motivational, and social learning processes over the past 25 years may make it beneficial to investigate relations between motivational factors and learning criteria, and the consequences they may have on domain specific participation.

In addition, previous research concerning science achievement has focused primarily on variables over which educators have little control, and remain fairly stable in the lives of most students, such as socioeconomic status, ethnicity, school demographics, and parental influences. Therefore, it may prove more beneficial to focus on how certain cognitive and motivational factors associated with the school environment are inter-related as well as related to the quality of learning science. Investigation of the sole and joint effects of relevant factors on the achievement and persistence of females in upper level science may be helpful in solving the continuing gender gap puzzle.

Obviously, not all females are fated to become outstanding science students in pursuit of science college majors or careers, but then again, neither are all males. But if females with the interest and ability to persist in high science achievement can be recognized at an early age, the educational system can become better prepared to provide the support and guidance needed to keep them involved in science activities and higher level courses throughout high school and beyond. Therefore, the purpose of this study was not to focus on factors that keep girls away from science, but instead, attempt to determine qualities that may be unique to females involved in advanced level science.

Fundamental goals of science education include comprehension of concepts, reasoning ability, problem solving skills, and cognitive abilities such as reading skill, use of learning strategies, and background science knowledge, all of which may play an important role in promoting achievement as well as interest. In reviewing the literature, there were no studies found in which these influences were measured simultaneously for advanced level science achievement of high school females. However, research has determined significant relationships between individual factors, or various combinations of factors, and science achievement, which are included in the following review.

This review of literature is divided into four main sections. The first section explores the overall underachievement of U. S. students compared to students in other countries, and the detrimental effects this may have on the technological advancements and economy of this country. The second section is a review of the academic domains of reading, mathematics, and science, and how prior knowledge and ability in these three areas affect science persistence and achievement. The third section reviews literature on the motivational factors used in this study, specifically, science related attitude, self-efficacy, and epistemological beliefs, and the roles they play in science achievement. The final section critiques the literature that has focused on high school students' relationships with peers and involvement in extra-curricular activities, as well as their part in science participation of high school females.

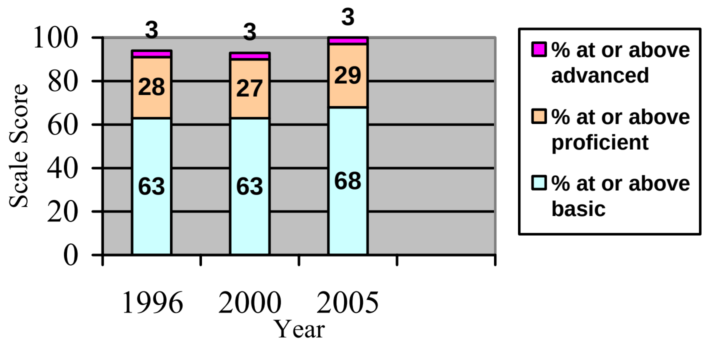
Are Students Learning Science?

With the world becoming increasingly more dependent on scientific and technological advances, the issue of science achievement of students is once again an important topic of discussion, not only in education circles, but in society as a whole. Economists estimate that at least 50% of the nation's economic growth over the past 50 years is a result of science technology advances, and emergences of industries in fields such as biotechnology, pharmaceuticals, and medical imaging are directly linked to scientific breakthroughs (Greenwood & Kovacs-North, 1999). Goal five of the National Education Goals set by President Bush in 1990 states that, by the year 2000, students in the United States will rank number one in the world in mathematics and science achievement (National Education Goals Report, 1995). Instead, students throughout the country continue to show a diminishing interest in science as they move through school (Jovanovic & King, 1998), and continue to be outperformed by many other countries on international science achievement tests (Linn, Lewis, Tsuchida, & Songer, 2000).

The National Assessment of Educational Progress (NAEP) has charted U.S. student performance in a variety of academic subject areas for over 30 years using three separate testing programs. The contents of the long term trend assessment has remained virtually unchanged since it was first administered to students in science in 1969 and in mathematics in 1973, thereby providing a good basis for analyzing achievement trends of students. The most recent student assessment was administered in 1999, the results of which showed an improvement in overall science achievement, although not consistently, for 9 and 13 year olds from 1970 through 1999. Assessment reports for 17 year olds showed lower performance in 1999 than the first assessment administered in 1969, and the average scores tended to favor males over females (National Science Board, 2004).

The second program of assessment used by the NAEP is the national test which is based on more contemporary standards of what students should know and be able to do in the academic domains. The most recent national assessment data was collected in 2005 for 4th, 8th, and 12th grade students with somewhat disappointing results, as shown in Figure 1.

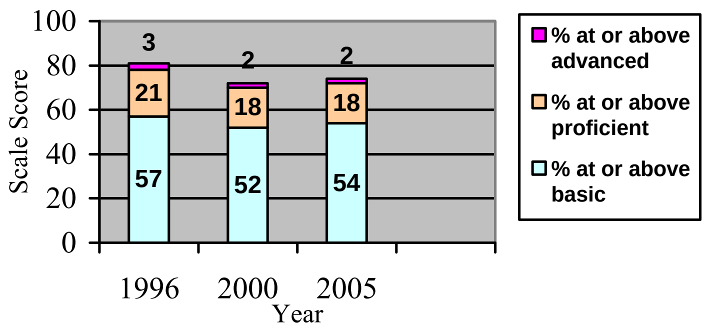
Results of the 4th grade assessment consist of a slight decrease for the percentage of students performing at or above the proficient level from 1996 to 2000 while those performing at or above the basic level and the advanced level remained consistent at 63% and 3%, respectively. The 2005 results show an increase in the percentage of students performing at or above the basic and proficient levels, while the advanced level remained unchanged. At the 8th grade level, the percentage of students performing at least at the basic level was 60% in 1996, 59% in 2000, and 59% in 2005, a considerable decrease from the 4th grade level results.



Source: U.S. Department of Education, National Assessment of Educational Progress (NAEP), 1996, 2000, 2005 Science Assessments

Figure 1: Fourth Grade Trend in Science Achievement Level

Figure 2 shows an even more dramatic decline in student science performance at the 12th grade level, where in 2005, only 54% of the students were achieving at or above the proficient level and a mere 2% were at or above the advanced level.



Source: U.S. Department of Education, National Assessment of Educational Progress (NAEP), 1996, 2000, 2005 Science Assessments

Figure 2: Twelfth Grade Trend in NAEP Science Achievement Level

When compared on an international level, U.S. students continue to perform poorly in science. Twelfth-grade students enrolled in AP physics comprise only 1% of the 12th grade population in this country, compared to 10% to 20% of students in other nations enrolled in advanced science courses. In addition, the 1995 Third International Mathematics and Science Study (TIMSS) revealed that AP physics students in the U.S. performed below the international average, and lower than 12 other nations (Callahan et al., 2000).

Do Gender Differences Still Exist in Science Learning?

Research on gender differences in academic achievement has been ongoing for decades, however, researchers have agreed on few of the findings. For example, it is widely acknowledged that, on average, females score higher than males on verbal ability tests (Hyde & Linn, 1988), and males score higher than females on tests of mathematics and spatial abilities (Hedges & Nowell, 1995; Hyde, Fennema, & Lamon, 1990). An additional agreed upon finding is that the physical sciences in high school, college, and the work force are dominated by males, with physics having the greatest under-representation of women (National Science Foundation, 2002)

Gender equity in science education gained national attention after the American Association of University Women's (AAUW) publication of *The AAUW Report: How Schools Shortchange Girls* in 1992, which focused primarily on science and its need of reform. Fifteen year later, a low participation rate of females in the physical and technological sciences is still a major educational concern. Research has overwhelmingly shown that there is indeed a gender difference in science learning, and women are still considered to be at a disadvantage (Ziegler, Finsterwald, & Grassinger, 2005). Numerous factors such as home environment (Aldrige & Goldman, 2002), parental influence (Desimone, 1999), student personality (Paunonen & Ashton, 2001), and motivation (Skaalvik & Rankin, 1995) have all been cited to play significant roles in the problem. Low numbers of female physics teachers and professors (Neuschatz & McFarling, 2003), biased textbooks and instructional methods (AAUW, 1999), and stereotypical views of physics being a male domain (Schiebinger, 1999), have also been considered to be part of the problem. Although research has identified many parts of the puzzle, it is still unclear why such factors have such a profound effect on science achievement and persistence at the high school level and beyond (AAUW, 1992; Simpson & Oliver, 1990).

According to the National Science Foundation (2002), females have remained strong in the biological sciences and have substantially narrowed the gender gap in mathematics achievement, but remain extremely underrepresented in the physical sciences and science technologies not only in high school, but also in post-secondary education and the labor force. In the past 30 years, females have made great strides in their post-secondary education, receiving 57% of all bachelor degrees, 59% of master's degrees, and 45% of doctoral degrees awarded in 2001, a dramatic improvement from the respective 43%, 40%, and 13% received in 1970 (National Center for Education Statistics, 2004). However, the percentage of women receiving doctorate degrees in physics in 2004 was 15.5%, an increase of only 3.2% from 1995 (NSF, 2006). Degrees in female majority fields such as the health profession and education have led to lower paying occupations than degrees in the more technically oriented, male majority fields such as engineering, physical sciences, and science technologies, in which females are still very much a minority (see Table 1).

Table 1

Percent of Bachelor's, Master's, and Doctoral Degrees Awarded to Females

	1970	1980	1990	2001
Biological/Life Sciences				
Bachelor	29.7	42.1	50.8	59.5
Master	31.5	37.1	50.8	57.6
Doctor	14.3	26.0	37.7	44.1
Computer/Information Sciences				
Bachelor	12.9	30.2	29.9	27.7
Master	9.3	20.9	28.1	33.9
Doctor	1.9	11.3	14.8	17.7
Engineering				
Bachelor	0.7	9.3	13.8	19.9
Master	1.1	7.0	13.8	21.2
Doctor	0.7	3.8	8.9	16.5
Physical Science/Science Technologies				
Bachelor	13.6	23.7	31.3	41.2
Master	14.2	18.6	26.4	36.5
Doctor	5.4	12.4	19.4	26.8

Source: U.S. Department of Education, 2004

As if the number of degrees awarded to women in critical scientific areas isn't bad enough, the overall number of college degrees awarded in these areas remains low. Europe and Asia together produce five times as many degreed scientists and engineers as the United States. As a result of a lack of investment by the U.S. in scientific research and development since 2001, an increasing number of businesses are moving their research and development operations in areas such as physics, mathematics, engineering, and medical technology to other countries (Research America, 2004).

Although the science and engineering workforce in the United States continues to grow, women hold a disproportionate number of positions in these areas. In 2000, more than 4 million people worked in science and engineering fields, the numbers of which have increased at an average annual rate of 3.6% since 1990. However, only 25% of those positions were held by women, with the growth in female representation between 1990 and 2000 to be only 3 percentage points (NSF, 2006).

Academic Ability in Science, Reading, and Mathematics

When ability in specific academic domains such as mathematics and science is measured by standardized tests, as is most often the case in research, boys tend to outperform girls, even though girls generally do as well, if not better, in course grades (Halpern et al., 2007). Research has determined that tests such as the mathematics section of the Scholastic Aptitude Test (SAT-M) under-predict females' performance in college math courses (Wainer & Steinberg, 1992), which suggests that ability alone is not what hinders girls in mathematics and science achievement and persistence. However, results of studies continue to report that pre-high school achievement in academics plays a role in females' choice of high school science course selection (e.g., Vanleuvan, 2004), as well as in their performance in those courses (e.g., Gallenstein, 2005). Therefore, such studies were reviewed in an attempt to determine what effects, if any, academic achievement in the domains of science, mathematics, and reading, have on advanced high school science performance.

The Role of Prior Science Knowledge

Children begin to acquire science and mathematical knowledge at an early age through normal play and family activities, which is necessary for continued interest and success in later years (Gallenstein, 2005; Mullis & Jenkins, 1988). However, due to the societal gender stereotyping which is often unknowingly reinforced by parents, boys tend to have more experiences with science related toys that encourage skills such as construction and manipulation than do girls (Aldridge & Goldman, 2002; Blakemore & Centers, 2005). This trend continues through adolescence, when the typical interests of boys include sports and computer games, which require attention to numerical information and builds the knowledge base, while many adolescent females are reportedly more concerned with peer relationships and personal appearance (Kimball, 1989).

The influence of parents, teachers, peers, and society all appear to have a large affect on how girls view their science ability and potential (Walberg, 1981). Beginning at infancy, girls' home environment is often very different from that of boys. Little girls play with dolls, stuffed animals, and domestic utensils, and tend to perform activities more related to fine motor skills such as drawing and sewing. In addition, they are often discouraged from exploring on their own and are sometimes protected more than boys by parents from taking many risks. Boys, however, tend to play more with sports related toys, vehicles, tools, and building blocks, and are encouraged to take things apart and put them back together again, explore, and discover (Blakemore & Centers, 2005). Such play provides them with early opportunities to develop basic math and science skills, giving them what many see as an advantage toward learning science even before starting school (Aldridge & Goldman, 2002;

Jones, Howe, & Rua, 2000).

The literature has remained fairly consistent over the past three decades in reporting that girls perform as well, if not better than boys in science up until adolescence, when gender differences in science attitude, interest, and achievement begin to occur (Connolly, Hatchette, & McMaster, 1999). This gap in achievement continues to increase each year as students progress through school, and by high school, females enroll in fewer science related electives, participate in fewer science based activities, have more negative attitudes toward science, and have lower science achievement scores (Kahle & Lakes, 1983; Oakes, 1990).

Science at the Elementary Level

The existence of gender differences regarding science achievement, interest, and motivation at the elementary school level is rare within the available literature. One study involving more than 2,500 5th grade students found somewhat of a science performance difference regarding test format. Students were grouped as low, medium, and high ability, and test items were either multiple choice or open ended questions. Although the high ability girls performed equally well on both test formats, they were outperformed by high ability boys on the open ended questions regarding physical science (Dimitrov, 1999).

The majority of research has suggested that girls and boys enjoy science equally at the elementary school level (AAUW, 1991; Speary Smith, 2001), and attitudes of young girls toward science are generally positive at this age (Ormerod & Duckworth, 1975). In addition, of the few studies that claim an existence of gender differences in science learning of elementary-aged children, most report that girls actually possess a greater interest than boys (Fouad & Smith, 1996; Mullis & Jenkins, 1988). Although Farenga and Joyce (1998) reported girls to have less motivation toward science as early as elementary school, a study of self-confidence and motivational goals at the 5th and 6th grade level showed few gender differences, supporting most of the prior research, however, boys did begin to report higher confidence levels in science ability (Meech & Jones, 1996). Additionally, elementary students have been found to possess significantly more positive attitudes toward science than students in 7th grade (Morrell & Lederman, 1998), and consider science more important and valuable than high school students (Neathery, 1997).

Some studies within the literature have claimed a gender difference beginning at the elementary school level concerning the preference of the sub-domains of science, and suggest that girls prefer biological and life sciences, whereas the interests of boys lie more in the direction of the physical sciences (e.g. Rand & Gibb, 1989). However, a study conducted by Johnson (1999) focused on 14 gifted girls in kindergarten to determine if a preference would be demonstrated through direct observations of the girls' interactions with various science materials. The three observation forms used initially in a pilot study, from which revisions were made to ensure high inter-rater reliabilities, focused on time spent on each activity, types of science processing skills used while interacting with the materials, and cognitive levels used during activities. Parents were also interviewed in order to determine the number of opportunities provided for the children outside of the school setting to pursue activities related to biology and physical science.

During the observations, all girls were provided with the same materials, and were video taped individually to decrease any peer influence. Results showed the girls spent approximately the same amount of time interacting with both types of materials, averaging 55% of the total time with biology related tasks (ranging from 29% to 79%) and 45% with physical science related tasks (ranging from 21% to 71%). None of the girls spent the entire time with just one type of activity, and 8 girls spent between 45% and 69% of their time with the physical science materials. Additionally, the girls used a similar number of science processing skills, 6.6 for biology and 6.0 for physical science, out of a possible 10, and the average number of cognitive skills used in biology was 4.09, and 4.14 for physical science, out of a possible 6. Therefore, the results suggest that young females do not demonstrate a preference for biological science over physical science, but may simply be exposed to more opportunities to interact with biological related activities outside of school. The parent interviews found that only two families encouraged participation in physical science related family outings, while all families mentioned activities related to biological science. Although several parents mentioned that their daughters were interested in how things work, and 9 of the 14 girls enjoyed playing with toys such as building blocks and Tinker Toys, only one parent, an architect, shared an interest in physical science while 11 shared a mutual interest in biological related material. Of the many science related activities provided at home in which the girls took part, including reading materials, television shows, toys, family outings, and topics of curiosity, it was found that the girls were exposed to almost three times as many biology related experiences as activities related to the physical sciences.

This may be an unintentional message reinforcing societal gender stereotypes that physical science is not appropriate for girls being sent to children by parents who are unaware, and therefore, unsupportive, of the interests of their children. Results may also support the suggestion that by adolescence, girls have lost much of their self-confidence and may be unwilling to even attempt physical science related activities due to the lack of earlier experiences. This could possibly explain why girls in junior high and high school who choose to participate in upper level science often prefer the life sciences over physical science (Jones, 1991).

Limitations of the study include a relatively small sample size from only two school districts within the same area, and possibly the fact that it pertained only to gifted girls, since "gifted" may be defined very differently within public and private schools as well as in different areas of the country. Additionally, the results were not compared to comparable studies regarding boys, therefore, it may be difficult to generalize the outcome to only girls when boys of the same age may show similar results. However, the importance of providing opportunities for children to develop positive attitudes toward science as early as possible is clear (Anderman & Maehr, 1994). Girls' interest toward physical science needs to be identified early in order to build a comfort level, and supported by allowing them to spend more time with related activities to build a knowledge base for potential future achievement (Johnson, 1999).

Adolescence, Science, and Middle School

If there is one area in which the past 30 years of science education research is in agreement, it would be that gender differences in science learning become most prominent during the middle school years, which makes it the most significant time for intervention measures to be implemented (AAUW, 1992; DeBacker & Nelson, 2000; Haussler & Hoffman, 2002). Much of the previous research has shown that by the time students reach high school, many motivation and educational aspirations have already been determined based partly on previous academic successes and failures (Singh, Granville, & Dika, 2002). Therefore, it may be especially important to focus on factors relating to science achievement of middle school students since this is the time when choices concerning enrollment in higher level high school courses takes place, which in turn, influences postsecondary and occupational opportunities (Vanleuvan, 2004).

There have been several large studies in which analyses of NAEP data show adolescent girls perceive science as more difficult and less enjoyable (Mullis & Jenkins, 1988). In addition, Kahle and Lakes (1983) found that 13 to 17 year old girls considered science careers to be too much work, and did not believe it was an area in which they would be successful. Although there is little difference between the genders regarding the overall importance of science, girls believe that boys have a much better understanding, and often rate its usefulness higher for boys than for themselves, which appears to have an affect on persistence (Linn & Hyde, 1989). Adolescent girls often attribute their science ability, which is usually underestimated, to either luck or effort, and blame their own inadequacies or lack of ability for their failures (AAUW, 1992; Graham, 2001). Conversely, boys credit their success in science to ability, which is often over estimated, and tend to place the blame of their failures on external factors such as subject difficulty or poor instruction (Oakes, 1990; Tobias, 1990). This has been theorized to give boys a sense of control over their achievement, which in turn, increases their self-confidence and persistence (Sadker, Sadker, & Klein, 1991).

Science in High School

It has been determined that when male and female high school students take the same amount and same kinds of science courses, females tend to perform better and receive higher grades (Kahle & Meece, 1994), even though males show significantly higher positive attitudes (Simpson & Oliver, 1990). Therefore, it is not that girls in high school don't have the ability to be successful in science, but rather that they may be faced with an array of unique obstacles to overcome, beginning at an early age, which affect motivation, attitude, and interest in upper level science.

Research supports the suggestion that by the time girls reach high school science classes, they possess considerably less prior science knowledge than their male counterparts (Dresel, Ziegler, Broome, & Heller, 1998). However, bringing more prior knowledge into the science classroom is not always seen as an advantage, especially in physics, since such knowledge is often incorrect or incomplete (Gallenstein, 2005). Misconceptions about science concepts are often difficult to correct by the time students reach high school, and may interfere with comprehension. Although studies have shown classroom instruction to decrease the rate of error, the types of errors that students make are usually not affected (Ziegler & Ziegler, as cited in Dresel et al., 1998).

Results of studies have produced conflicting results concerning the role prior knowledge plays in science achievement. It has been suggested by some to be a significant predictor of conceptual understanding as well as a critical component of successful science achievement (Tobias, 1994). Prior knowledge has been positively linked to text learning and comprehension by allowing students to integrate new material more easily (McNamara, Kintsch, Songer, & Kintsch, 1996), cognitive task performance (Snow, 1989), higher achievement (Mullis & Jenkins, 1988), and increased performance on standardized tests (Kimball, 1989). Additionally, lack of sufficient and relevant prior knowledge has been suggested to produce less self confidence, and less willingness to attempt science based activities (Rand & Gibb, 1989). Yet, other studies have found prior knowledge to play a much less significant role in achievement. Schiefele (1999) reports that it has only weak to moderate effects on text learning, but also proposes that the results obtained may be due to the low level of difficulty of the texts used for the research.

In a larger study, Dresel and colleagues (1998) investigated gender differences in previous physics knowledge of 547 female and 641 male students in Germany before the start of an 8th grade introductory physics course. Although all students had little prior knowledge regarding mechanics and the concept of mass, it was much more pronounced for females, who were also found to have considerably less prior knowledge in areas concerning theoretical concepts. Results reveal that the higher level of previous knowledge for boys does not explain their higher course grades, due to the incomplete and faulty information which actually acts to inhibit the comprehension of conceptual knowledge. It is also interesting to note that in addition to previous knowledge, the difference in grades could not be explained by ability either, since even the high ability girls received lower grades than the boys.

Therefore, the results tend to support the assumption that self-related variables, such as self efficacy in science, may better explain gender differences in grades, and the researchers believe that interventions concerning self-related cognition of girls would be more promising in narrowing the achievement gap.

Reading and Mathematics Connections to Science

Within the reviewed literature, the subdivisions of declarative, procedural, and conditional knowledge are defined as individual components of knowledge. Declarative knowledge represents the factual information, agreed upon by experts, transmitted from teacher to student (Kirk & MacPhail, 2002). Procedural knowledge relates to information on how to generate various actions during learning (Paris, Lipson, & Wixson, 1983), and conditional knowledge is knowing when, why, and how to expand the previous two types of knowledge in order to encompass different situations (Brooks & Brooks, 1993). Since the fundamental goals of science education include comprehension of concepts, reasoning ability, and problem solving skills, reading and mathematics proficiency at all three of the aforementioned knowledge levels play an important role in science achievement. Procedural knowledge in reading may include how to scan and summarize text, which are crucial components of reading an advanced level physics textbook. Additionally, the conditional knowledge of applying skills and concepts learned in mathematics to problem solving in physics is a necessity for successful achievement.

The following sections review and critique previous studies on reading and mathematics achievement, and discuss how significant findings may be related to achievement and persistence in advanced level science.

Reading

Proficient reading skill has always been a critical part of educational standards, but with the high stakes now attached to national and state standardized tests, reading has taken on yet more importance. One goal of the National Standards requires students to read and interpret media reports on science related issues, and many state assessments require students to show comprehension through synthesizing articles from a variety of sources (Flick & Lederman, 2002). However, reading proficiency is not often recognized nor encouraged in many science classrooms, and effective strategies for comprehension of textbook material are rarely taught (Pressley, 2002).

Science textbooks and proficient reading

There have been several inadequacies associated with science texts, which may account for teachers' reluctance in requiring reading comprehension in the classroom. According to American Association for the Advancement of Science (AAAS, 2002), most science texts do not properly follow standards-based principles for concept learning, and content, which is often weak and consists of material that is typically too advanced for the intended age group (Radcliffe, Caverly, Peterson, & Emmons, 2004). In addition, students often find science textbooks boring, and are not able to summarize the reading or solve problems based on the given explanations (Harp & Mayer, 1997). In an attempt to identify how well students could comprehend scientific material, a high school teacher asked students in introductory physics classes to read short passages from the text. After reading, only about 10% were able to answer questions about what they had read, and nearly one-third did not even bother to read, and instead, put their heads down in disinterest (Sprague & Cotturone, 2003).

Nevertheless, the textbook is the primary source for teaching content science, especially in the middle school grades (Radcliffe et al., 2004). However, the actual reading of the material is often limited to obtaining superficial facts and definitions rather than comprehension of concepts and principles (Laine, Bullock, & Ford, 1998). Results from a 1994 study by Driscoll, Moallem, Dick, and Kirby found that when middle school science teachers made reading the textbook optional, most students used it only to find definitions, which proved to be ineffective as evidenced by the low test scores on a unit test of facts and vocabulary.

Educators must realize that the format and purpose of a science textbook is very different from that of language arts, and requires different reading skills for comprehension. Being able to answer low level questions, verify the information read, and recall information does not ensure that the material is understood at a deeper level. The goal of reading science is conceptual understanding, which requires the use of metacognitive learning strategies and higher order thinking (Flick & Lederman, 2002). For example, students must know the purpose for which they are reading, relate the new information to previous knowledge, be able to predict, interpret, and summarize information, and monitor their comprehension (Radcliffe et al., 2004). Other integral parts of science achievement require students to investigate problems through inquiry, summarize and relate knowledge gained through reading in order to understand the purpose, identify key concepts, and decide upon appropriate information and applications (Flick & Lederman). By integrating such higher level learning processes, students have the new information from the text available to use in novel situations or problem solving tasks (McNamara et al., 1996). Findings from recent research conducted in middle school science classrooms where effective textbook reading strategies were taught report students benefited from the use of concept maps, learned science by reading, found reading more enjoyable, and read more often (Radcliffe et al.), which supports previous research linking reading to greater science knowledge, grade point average, improved recall and retention, and higher learning goals (Laine et al., 1998).

Concept-Oriented Reading Instruction (CORI) is a strategy that has been used in classrooms to link reading and science together, and is based on the assumption that proficient reading is a result of cognitive comprehension strategies, motivational processes, conceptual knowledge, and interaction among students (Wigfield, Guthrie, Tonks, & Perencevich, 2004). Science activities are used to attract student interest, books are available for students to help them connect the activities to reading, and important points are emphasized to help students connect the activities to higher level concepts. In addition, student collaboration is encouraged, and reading strategies such as questioning, searching for information, summarizing, and organizing are taught to help students link the new information to prior knowledge. Research results have shown that students who received CORI instruction for one year surpassed students who received only traditional reading instruction in science comprehension (Guthrie, Wigfield, & VonSecker, 2000). However, implementation of such learning techniques requires teachers to develop a confidence that their students will learn, as well as considerable time and effort, persistence, and patience since evidence of student learning takes time to develop (Radcliff et al., 2004).

The above information suggests that there is a relationship among the factors of reading ability, previous knowledge, metacognitive learning strategies, and interest as well as effects on science comprehension and achievement. Greater subject knowledge is usually obtained by those students who read more often, use effective reading and learning strategies, and show a greater interest in the subject in which they are reading (Laine et al., 1998).

Mathematics

Mathematics and science go hand in hand, and when exploring achievement variables in science, mathematics ability must be addressed since it has been considered to be the most significant academic area affecting achievement and success in upper level science courses and related careers (Vanleuvan, 2004; Wang & Goldschmidt, 2003). Decades of research has been consistent in reporting that gender differences regarding the value of mathematics, performance, and enrollment in advanced mathematics courses are well in place by adolescence, and remain fairly constant throughout high school and college (Hyde et al., 1990), thereby contributing to the low numbers of women in mathematics and science related careers. From an early 1980 study involving Scholastic Aptitude Test mathematics scores from over 10,000 students, Benbow and Stanley concluded that males have superior mathematical ability over females due to biological factors affecting spatial abilities. As a result of such theories, and consistent with science, mathematics has been stereotypically labeled as a male domain (Kimball, 1989; Steele, 1997).

Other variables that have been associated with females' reluctance in pursuing upper level mathematics throughout the literature include gender stereotyping (Nosek, Banaji, & Greenwald, 2002), learning style differences (Kimball, 1989), attitude (Vanayan, White, Yuen, & Teper, 1997), and self-efficacy (Wigfield & Eccles, 2002). As a result of decades of research on the subject, the gender gap has narrowed regarding enrollment in high school mathematics courses over the past 20 years (Rock & Pollack, 1995), however, other gender-related differences in mathematics still exist and reasons for these differences have not yet been adequately explained nor addressed within the educational system. The importance of determining when and how gender differences in mathematics achievement is undeniable, and findings may help to raise awareness within the educational community that these differences have not yet completely disappeared, and appropriate interventions to promote the success of females in mathematics and science are still necessary.

Elementary level mathematics

Research from the past four decades has shown inconsistent results concerning gender differences in mathematics achievement in young children. Some studies have suggested that there is no gender difference in students' mathematics value or performance in elementary grades (e.g. Sprigler & Alsap, 2003), some claim that young girls perform slightly better than boys (Carpenter, Lindquist, Mathews, & Silver, 1983), while others maintain that girls experience a decline in the perceived value of mathematics beginning in first grade which continues through high school (Fredricks & Eccles, 2002).

According to Ginsburg and Baron (1993), young children are naturally interested in science and mathematics, and spontaneously construct basic concepts on a daily basis through activities such as counting, comparing, and sorting as they actively explore their environment. Concepts such as time and distance are learned through daily classroom routines, and through the manipulation of blocks and puzzles, children are introduced to geometrical and spatial relationships (Charlesworth & Lind, 2003). According to the National Council of Teachers of Mathematics (NCTM, 2000), mathematics is a part of children's daily lives which builds and grows due to natural curiosity and enthusiasm. Therefore, gender differences in mathematical ability are rarely seen at the elementary school level. However, by the time girls reach adolescence, a significant change in attitude and achievement regarding the domain of mathematics, as with science, may begin to emerge.

Adolescents and mathematics

Benbow and Stanley's 1980 study consisting of data collected and analyzed over an eight year period showed a significant difference in mathematics reasoning ability between the sexes. Subsequent studies produced consistent results, ultimately suggesting the interesting notion that the gender difference in mathematics ability may be due to biological factors such as androgens and testosterone affecting the development of the brain, and therefore affecting spatial abilities (Benbow & Stanley, 1983). This theory is somewhat supported in a recent study by Sprigler and Alsup (2003) in which cognitive ability, scholastic aptitude, and achievement tasks measuring reasoning skills were found to have no significant effect on the sub-skill of analysis synthesis ability of 239 elementary students. As a result, the researchers suggest that, considering no apparent differences in young students, biological factors may play a role in the mathematic ability of developing adolescents, where differences begin to emerge around age 13 and increase substantially by the end of high school. However, since the students involved in this study were referred to a gifted program based on teacher and parent recommendations as well as high standardized test scores, the researchers had no control over the selection of the sample which may limit the generalizability of the results.

Numerous studies regarding differences in spatial skill abilities have also added to the theory that the mathematical gender gap may be due to biological differences of males and females (e.g. Halpern & Lamay, 2000; Lord & Rupert, 1995). Through a meta-analysis of 172 studies, Linn and Petersen (1985) found the largest gender difference to be in mental rotation which involves the ability to quickly and accurately rotate a 2 or 3 dimensional figure. Males tend to have more ability to use a holistic approach on this type of task, found to be more advantageous than the part by part strategy most oft used by females. Only a minimal difference was found between males and females in spatial visualization, which consists of a combination of visual and non-visual strategies requiring multi-step manipulations of information. Spatial visualization is defined to be more characteristic of general ability than spatial ability, and the mathematical task most closely associated with science achievement (Fennema & Sherman, 1977). These results, however, are inconsistent with a number of studies which have revealed males have a greater visual spatial ability than females (e.g. Battista, 1990). On the more real-world tasks, results of studies have been mixed, but where significant differences were found, they most often favored the performance of males (e.g. Harris, 1981). It is not clear whether the more abstract measures of spatial ability are related to real world tasks, although some studies have shown a relationship (e.g. Sholl, 1989).

High school and post-high school mathematics

Voyer (1996) claims that most measures used to determine mathematics achievement of high school students are not appropriate. Most of the research has used standardized test scores or experimenter-administered tests as predictors of academic performance (e.g. Matsumoto, 1995), which overwhelmingly report boys outperforming girls. However, few studies are conducted using classroom grades as measures of achievement, but when they are reported, gender differences tend to favor girls (e.g. Gadzella & Davenport, 1985).

Even though samples are large when national data such as SAT scores are used to measure mathematics achievement, such tests are self-selected by primarily college bound students and are not necessarily representative of all students nationwide (Hedges & Nowell, 1995). Data from the 1988 National Education Longitudinal Study (NELS:88) data base, which provides results from a nationwide test designed and conducted by the National Center for Education Statistics (NCES), are also used in many studies that consistently show gender differences in mathematics achievement to be more prevalent in higher ability students. It was found that the percentage of female students in mathematics courses decreases from 8th to 12th grade, and this difference in enrollment increased as the score range became more extreme (NCES, 2004). The most substantial difference was found for 12th grade mathematics students scoring above the 95th percentile, where males outnumbered females by 2 to 1. Studies conducted through meta-analysis (e.g. Matsumoto, 1995) also appear to report males outperforming females in mathematics achievement; however, the degree of difference tends to be smaller than those found in individual studies.

Studies that have used reasonably representative samples of the nationwide student population generally provide results inconsistent with those based on more selective sampling. In addition to large scale assessments (e.g. Armstrong, 1985), Han and Hoover (1994) studied data from test-norming samples, and Catsambis (1995) conducted a secondary analysis of data collected from national probability samples. Generally, gender differences on central tendency measures of mathematics ability for these types of studies are less pronounced or negligible, and the achievement of males shows to be more variable. According to Fan, Wagner, and Manstead (1995), it is this greater variability rather than the mean score difference that has contributed most to observed male dominance seen in selective sampling.

In other attempts to explain such male dominance on standardized tests while females continue to receive higher classroom grades in mathematics, researchers have focused on the content of tests used, differing learning styles of males and females, and selectivity of the samples. Kimball (1989) suggests that, consistent with science, more mathematics experience through activities outside of the classroom may provide boys with an advantage on standardized tests which often involve novel problems rather than the more familiar classroom-type problems. In addition, adolescent males' interests are drawn to activities that require attention to numerical information such as sports and video or computer games, whereas the typical interests of adolescent females are reported to be related more often to personal appearance and relationships (Jones et al., 2000). Girls may also be at a disadvantage when tests are timed, which some suggest may measure testing speed rather than academic ability (Sprigler& Alsup, 2003). Gallagher (1989) found that when time constraints are removed, girls are able to perform as well as boys on standardized tests.

Limitations of many mathematics related studies include the validity of self reported grades by students being affected by memory or social desirability, as well as small or highly selective sample sizes used. However, the implications of the results are important, and parallel the results of Linn (1990), who reasons course grades are more reflective than standardized test scores concerning the effort required for careers in mathematics and science None the less, standardized test scores continue to be used as a basis for college admission or scholarships even though they may underestimate the potential of females' mathematical ability.

Trusty's 2002 study analyzed data spanning a 6 year period from NELS:88 for students who enrolled in college after high school, and found that the effects of upper level mathematics courses in high school to be most significant for women. Taking high school calculus more than doubled the odds of females choosing a mathematics or science major, independent of socioeconomic variables, academic performance, and attitude. These results are consistent with Ware and Lee's 1988 study which found the number of mathematics courses taken in high school to have the strongest effect on college major choice for women. The results also propose that lower mathematics achievement in earlier grades leads to less stringent courses in high school, possibly blocking females from science based fields. In turn, enrollment in high school calculus, as well as the pursuit of science based careers, has been found to be most influenced by students' educational aspirations (Reynolds & Conaway, 2003).

In lieu of such findings suggesting low participation of females in science related careers attributed solely to mathematics ability, Schaeffers, Epperson, and Nauta (1997) researched how multiple constructs work together to influence persistence in the field of engineering. Results showed that in addition to a strong association with ability, positive self efficacy and interest in both mathematics and science added significantly to the prediction of persistence. These results confirm Ethington's 1988 study, which used data from the College Board Admissions Testing Program's national sample of 10,000 college bound high school seniors, and found self-rating to have a stronger influence on intended major and SAT mathematics performance than the number of years of math courses taken in high school. Additionally, higher self-ratings were found to enhance the chances of females majoring in engineering or physical science, suggesting that the shaping positive attitudes toward mathematics and science and encouraging females to enroll in mathematics and science courses during middle school to be essential.

Motivational Factors

Motivational factors such as attitude, interest, and self-efficacy are considered complex social factors which are difficult to measure with a high degree of reliability and validity (Singh et al., 2002). Yet, these complex social factors are what many researchers maintain play a significant role in the continued gender difference concerning science participation and persistence (Kahle & Meece, 1994). It's felt by many that by the time students reach high school, attitude, motivation, and educational aspirations have already been determined based on previous experiences and are difficult to change (Singh et al.). As a result, approximately only one-quarter of high school females enroll in a high school physics course (Phillips, Barrow, & Chandrasekhar, 2002). Consequently, in an attempt to attract and maintain talented students in the science field throughout high school and beyond, it is important to determine which variables play significant roles in female participation in science, and why, when, and how these variables begin to have such an impact.

Science-Related Attitude

Attitude toward science is generally defined as an enduring positive or negative feeling about science (Koballa & Crawley, 1985). Research has documented that attitude toward science may be fostered by several factors both inside and outside of the school setting, including instructional methods, classroom environment, role models, peer and parental relationships, and societal factors, all of which may play a significant role in promoting success for females (Kahle & Meece, 1994).

At the elementary school level, very few, if any gender differences have been reported regarding attitude toward science (Sperry Smith, 2001). The attitudes toward science that are established at this early age by girls are generally positive, and interest in science is often found to be greater for girls than for boys (Mullis & Jenkins, 1988). However, science related attitude and interest toward science appear to decline for girls, and by adolescence, may be well formulated and difficult to change (Ziegler et al., 2005). It was found that when male and female high school students take the same amount and same kinds of science courses, males show significantly higher attitudes, even though females tend to perform better and receive higher grades (AAUW, 1992; Kahle & Meece, 1994).

Students who enjoy science and have positive perceptions and attitudes tend to be more interested and engaged in science courses through active involvement and commitment, which has been positively related to achievement (Reynolds & Walberg, 1992; Skaalvik & Rankin, 1995) and future course selection (Helmke, 1989). But girls' confidence in ability, interest, and participation in science, as well as overall self-esteem have been found to rapidly decline during adolescence, resulting in less participation in science classes (Haussler & Hoffman, 2002; Jones et al., 2000), higher rates of dropping out of upper level science courses (Farenga & Joyce, 1998), and less motivation to pursue science related careers (DeBacker & Nelson, 2000).

Singh and colleagues (2002) examined the science performance of a nationally representative sample of 8th grade students based on school motivation, attitude toward science, academic time, and science learning. Questions reflecting motivation, academic engagement, and science interest were selected from the NELS:88 database, and science achievement was measured through course and standardized achievement test grades. Those students who were determined to have a more positive attitude toward science and were more highly motivated were more likely to spend more time on science homework, which in turn, increased achievement, supporting the findings of several previous studies (Reynolds & Walberg, 1992).

Perceptions of Science as a Male Domain

One of the major concerns through decades of research has been the reputation acquired by the physical sciences as being a male domain, a view still held today by many students and a large portion of society (DeBacker & Nelson, 2000). In a study that emphasizes the capability and impact of stereotypical societal views, Sadker and Sadker (1994) asked over 1100 students to describe what their lives would be like if they awoke the next day as the opposite gender. While 42% of the girls responded with positive comments such as being treated with more respect, feeling more secure, and making more money, only 5% of the boys reported something positive about being female. Typical responses included being punished less, not getting hurt in fights, not paying for dates, and being able to cry or flirt their way out of trouble.

Attitudes of parents and teachers, especially in how they view children as learners of science, are important factors in how children view their own science ability (Singh et al., 2002). Girls have been frequently discouraged from exploring their interest in science fields by parents, teachers, or counselors who may unintentionally steer them toward a more female-oriented occupation (AAUW, 1992). Gender stereotyping of academic domains such as science and mathematics has been determined to be one of the major factors of gender related differences in these areas, and has been found to have a negative impact on attitude, motivation, and interest of girls as they progress through school (DeBacker & Nelson, 2000). Such stereotypical views are still held by girls and boys of all ages, as evidenced through studies using the Draw-A-Scientist test, which reveal that girls are much less likely to hold positive images of themselves as future scientists, whom they typically depict as a white male wearing a lab coat and glasses (Finson, 2002). Despite holding less stereotypical views about gender appropriate careers than elementary aged students, there is still a significant gender difference in preferences toward a science career among secondary students (Miller & Budd, 1999).

In a classroom where discussion, problem solving, and lab activities are essential for learning science, such components are often dominated by boys while the girls remain more passive (Guzzetti & Williams, 1996). Research over the past 20 years has documented that science teachers from elementary school through college commonly ask boys more abstract and complex questions which require higher order thinking, and give boys more detailed feedback than they do girls (Graham, 2001). Additionally, teachers tend to choose science based activities that appeal more to the interests of boys, use teaching methods more conductive to male learning styles, foster competition more than cooperativeness, and praise boys for the quality of their work while commending girls for neatness (AAUW, 1992).

Perceiving science as a male domain has been negatively correlated with achievement, persistence, motivation, and attitude for high school girls (DeBacker & Nelson, 2000), but the same correlation was not found for boys. This claim supports other research that has consistently found boys stereotyping science as a male subject area much more often than girls (Greenfield, 1997).

Self-Efficacy

Self efficacy is a term originating from Bandura's (1977) social learning theory, and is defined as a person's beliefs about the ability to perform a behavior successfully, which affects the initiation of the behavior, amount of effort put forth, and degree of persistence in the face of obstacles. It has been defined more recently as a feeling of adequacy (Harlan & Rivkin, 2004), and is a term that occurs frequently in literature pertaining to achievement, especially during adolescence. According to Bandura's (1986) social cognitive theory, self efficacy functions as a mediator of the effects of prior achievement, knowledge, and skills on subsequent achievement, and is often a better predictor of success than ability. In studies concerning students in middle school through college, mathematics self-efficacy has often been found to be a significant predictor of mathematics performance, and act as a mediator between gender and mathematics achievement (e.g., Graham, 2001; Pajares & Graham, 1999). Wigfield, Eccles, and Pintrich (1986) found that by middle school, boys have much higher perceived mathematics ability than girls, which correlates with mathematics achievement at that level, thus supporting Badura's theory.

The literature supports the suggestion of self-efficacy in science as a predominant predictor of persistence, enrollment in advanced classes, and aspirations toward a science based career (e.g., Ethington, 1988; Wigfield & Eccles, 2002). However, this is another area in which gender differences favoring males is frequently reported (e.g., Marsh & Yeung, 1998). According to Terwilliger and Titus (1995), significant differences between girls and boys in overall self-efficacy begin to appear between the ages of 14 and 15, and during this time of developing self-identity and making important life choices, many adolescent girls report being unhappy with themselves, and becoming more timid and self-conflicted (AAUW, 1991). This overall decrease in self confidence and self esteem coincides with a more negative attitude and lowered self-efficacy toward specific academic domains (DeBacker & Nelson, 2000) where differences begin to reach confirmation levels in 7th grade for the physical sciences (Marsh, Barnes, Cairns, & Tidman, 1984) as well as lowered aspirations to pursue a science based career (DeBacker & Nelson). According to AAUW (1992), when girls perceive themselves as incapable of science proficiency, their aspirations begin to deteriorate, they are more apt to give up when facing difficulty, and become insecure about their ability to succeed on tasks they consider difficult or requiring high ability. This may then be an important factor concerning the lower probability of girls enrolling in advanced level courses to enhance the likelihood of entering science related occupational fields (Eccles, 1994).

Ziegler and colleagues (2005) studied the affects of self-efficacy of 8th grade students during their first physics class in Germany, and found that midway through the course, girls reported lower self perceived ability compared to boys. There was no gender difference isolated with respect to prior knowledge, interest had no influence on self-perceived ability, and with no convincing proof offered throughout the years of research that girls have less science ability than boys, the authors suggest that persistence in science cannot be predicted solely by academic performance, and perceived ability plays an important role in the motivational factors necessary for success. One limitation noted for this study is the fact that German college preparatory schools are comprised of students in the top 30% of the national student population, and the mildly gifted students represent the top 6% of the 8th grade students. Therefore, results of the study may not be generalized to the entire 8th grade population of students within the United States.

Students tend to choose activities and set goals based on what they believe they are able to accomplish. Science self-efficacy has been found to influence achievement, and failure to enroll in courses because of low self-efficacy can block many able students from pursuing science related careers (Zeldin & Pajares, 2000). However, there have been far fewer studies regarding science self-efficacy as a predictor of science achievement, possibly because it is much more difficult to design unambiguous measures of criteria in the area of science than in the domain of mathematics. Most often, science self-efficacy research is connected to science teaching (e.g., Cannon & Sharmann, 1996) or career choice (e.g., Gwilliam & Betz, 2001). Some investigations have found significant correlations between science self-efficacy and science achievement when standardized tests are used as a measure of achievement (e.g., Britner & Pajares, 2001). However, research studies must be interpreted with caution when student self-reports of previous science grades are used as achievement measures (e.g. Jinks & Morgan, 1996), since such achievement criteria may not be as reliable as grades obtained from student transcripts.

There are other problems associated with studies on science related self-efficacy as well, and comparison of previous research is difficult. Science self-efficacy is defined as confidence to succeed in science related tasks, but the tasks are not defined the same in all studies. Performance criteria have included application of scientific principles, classroom activities and grades (e.g. Jinks & Morgan, 1996); or items used to measure science self-efficacy were combined with items measuring other constructs such as ability compared to other students (e.g., Meece & Jones, 1996). Therefore, the construct of science related self-efficacy must be clearly defined and matched accordingly with outcomes. In investigations in which the instrument measuring self-efficacy was appropriately matched with subsequent achievement measures as suggested by Bandura (1997), science self-efficacy was positively correlated with science performance (e.g., Kupermintz & Roeser, 2001).

Epistemological Beliefs

Epistemological beliefs refer to students' ideas about the nature and acquisition of knowledge (Hammer, 1994), and researchers have devoted much attention to exploring how such beliefs may relate to various student characteristics and learning outcomes (e.g., Qian & Alvermann, 1995). Most of the reviewed literature agrees that epistemological beliefs toward learning contain four independent dimensions: structure of knowledge, stability of knowledge, speed of learning, and ability to learn; and students are capable of holding varied levels of sophistication for each of them (Dweck & Legget, 1988; Hofer & Pintrich, 1997). The four dimensions of epistemological beliefs are defined as follows (Schommer-Aikins, Mau, Brookhart, & Hutter, 2000):

- *Structure of knowledge* – addresses students beliefs about the complexity of knowledge
- *Stability of knowledge* – beliefs as to whether knowledge is absolutely certain, or tentative and conditional
- *Speed of learning* – addresses the rate at which learning occurs
- *Ability to learn* – addresses whether the ability to learn is an innate or learned characteristic

In the sophisticated view, knowledge is considered an interrelated series of ideas that are tentative, knowledge continues to build gradually over time, and learning can be improved with effort. Conversely, the naïve student view is that knowledge is a collection of isolated facts that are absolutely certain, learning should occur quickly, and the ability to learn is fixed from birth and inflexible (Hammer, 1994; Schommer-Aikins et al., 2000). Since there have been questions raised in the literature concerning the validity of speed of learning and ability to learn as being epistemological issues (e.g., Hofer & Pintrich, 1997), those two dimensions were omitted from the questionnaire used in the current study.

Few studies were found throughout the literature that examined how epistemological beliefs of students relate to other motivational factors such as attitude, although it has been documented that students are more apt to display lower self-efficacy in the face of academic challenges when holding the naïve view of their ability being determined by only genetics (Dweck & Leggett, 1988). In addition, research that has focused on gender differences in this area has been inconclusive. While some studies found no differences between males and females (e.g., Buehl, Alexander, & Murphy, 2002; Hofer, 2000), others found females to have more sophisticated beliefs in the dimensions of stability of knowledge (e.g., Bendixen, Schraw, & Dunkle, 1998), speed of learning, and ability to learn (e.g., Neber & Schommer-Aikins, 2002). Therefore, further investigation on relationships between epistemological beliefs, gender differences, and motivational variables may provide new information regarding the learning processes and allow educators to structure curriculum in a way to optimize student motivation, especially in science.

Two areas of focus within the current literature found to be relevant to the current study include whether epistemological beliefs of students are domain specific, and how epistemological beliefs are related to other variables that are incorporated in this research. Most of the literature maintains that since academic domains differ in structure (Spiro & Jehng, 1990), epistemological beliefs are also domain specific. For undergraduate students, beliefs about learning were recently found to be significantly different between the areas of science and psychology (e.g., Hofer, 1999), and between the areas of mathematics and history (Buehl et al., 2002) on all four dimensions. Additionally, Paulsen and Well (1998) found significant knowledge belief differences between college students majoring in social sciences and education and those majoring in the natural sciences and engineering. However, it has not been made clear whether knowledge beliefs are shaped by the course of study, or if college major is selected based on beliefs.

Within the domain of science, the constructivist view that scientific knowledge, which is open to debate and interpretation, and evolves through argument and experimentation, is often held as ideal (Carey, Evans, Honda, Jay, & Unger 1989). Since such constructivist views of scientific knowledge have been linked to formulation of inferences and considerations of limitations (e.g., Tsai, 1998), beliefs in how new knowledge is constructed may be able to change previous inaccurate perceptions often held by students, especially in physics (Gallenstein, 2005). Tsai (1999) found that even after controlling for prior science achievement, students with more sophisticated views on learning generated more ideas of greater complexity from text reading, and held fewer misconceptions than students with more naïve knowledge beliefs. Concerning the relationship between epistemological beliefs and other relevant variables, connections have been found with learning characteristics (e.g., Qian & Alvermann, 1995), the learning environment (e.g., Hofer, 1999; Tsai, 1999), and learning outcomes (e.g., Kardash & Howell, 2000).

Significant correlations have been documented between all four dimensions of epistemological beliefs (structure, stability, speed and ability), and reading comprehension of students, as well as the use of reading strategies. At the elementary level, studies have found that youngsters who hold overall constructive beliefs about knowledge and learning outperform others on learning science from the textbook (Chan & Sachs, 2001), which may influence how students, regardless of age, comprehend written text (Kardash & Scholes, 1995). Students with more sophisticated beliefs tend to use higher level reading strategies, such as organization and elaboration rather than surface level strategies such as memorization, to process information from the text more deeply (Schraw, Bendixen, & Dunkle, 2002). For example, when knowledge is viewed as more tentative than certain, students tend to make better connections between ideas and are more able to draw inferences based on what is read. Similarly, when knowledge is viewed as a gradual process, students are more apt to resolve ambiguity encountered within the text (Kardash & Howell, 2000).

The final area in which epistemological beliefs may play an important role is within the environment of the science classroom. In a study that focused on the science learning of 8th grade females, information was presented to one group in the traditional lecture and textbook method while a second group received topics presented from various perspectives, used a variety of resources other than the text, and incorporated inquiry based explorations. After eight months, students in the traditional group held significantly fewer constructive views of knowledge than those in the inquiry-based class (Tsai, 1999), however, it must be noted that the new instructional techniques implemented were specifically designed to impact belief systems by addressing epistemological issues.

Tsai (1998) has well documented, however, that many students with more constructive views of knowledge consider most science classrooms to be inadequate, and prefer a learning environment that gives them the opportunity to solve real problems, interact with one another, and take control of their learning activities. Although the more structured, traditional learning environment may benefit students with more naïve beliefs about knowledge and learning, students with sophisticated beliefs may become frustrated, bored, and lose interest and motivation in science (Tsai, 2000).

Extra-Curricular Activities and Peer Relationships

In the review of literature concerning the influences of motivational factors on science achievement and persistence, peer relationships appear to be consistently and significantly related to self-efficacy, attitude, involvement in science based activities, science course selection, and science based career aspirations. Studies from the early 1980's suggest that young girls have a more positive image of themselves involved in science when their friends shared their views (Kahle & Lakes, 1983), and the recent findings of Tindall and Hamil (2004) concerning individual attitudes of girls toward science becoming significantly more similar to those of their peer groups as they progress through grades 6 through 10, support the earlier hypothesis. However, subsequent research reports that compared to boys, adolescent girls claim to have fewer friends interested in science (Kelly, 1988), and fewer science related conversations or activities with friends outside of the school environment

(Jovanovic & King, 1998).

Recent studies that have focused on the promotion of social relationships and subsequent positive influences on science related attitudes through science enrichment programs (e.g. Stake & Nickens, 2005) support Kahle and Lakes' (1983) findings. However, these studies were limited to students who are motivated and possess enough interest in science to spend extra time during the summer in science based activities. Therefore, in order to determine the effects of peer influence on the attitudes and self-efficacies of the majority of other students, the effects of student participation in extracurricular activities has become an increasingly important area of study.

The promotion of school achievement, self satisfaction, and pro-social behavior, all of which are important components for youth preparing to enter an increasingly demanding and technical labor market, have been found to be affected by peer relationships formed through social and extracurricular activities. Early sociological studies of the 1970's linked extracurricular activities to occupation and income (Osgood, Anderson, & Shaffer, 2004), and today it is argued that structured activities provide students an opportunity to develop skills beneficial in academic and social settings, as well as promote subsequent educational and occupational attainment (Eccles, Barber, Stone, & Hunt, 2003). Recent studies regarding structured activities and their effects on middle and high school students have suggested several positive outcomes related to academic achievement through factors such as self-esteem, self-confidence, and positive school related experiences (e.g., Cooper, Valentine, Nye, and Lindsay, 1999; Marsh & Kleitman, 2002).

Participation in structured extracurricular activities and social interest have previously been identified as two of the most important factors in self-satisfaction assessment for adolescents (Chinman & Linney, 1998). Structured extracurricular activities, including athletics and academic or vocational clubs, are defined to be those which are physically or mentally stimulating, contain structural parameters, are voluntary, and award no academic credit (Larson & Verma, 1999). Social interest involves students' sense of belonging, being liked by others, and concern of the welfare of others, and has been linked to an increased sense of competence and satisfaction with friendships, family, and school experiences (Kaplan & Maehr, 1999). High self-satisfaction, in turn, has consistently been associated with increased self-esteem and self-concept (Gilman, Huebner, & Laughlin, 2000), and positive school experiences including heightened educational aspirations, increased enrollment in advanced classes, higher grades and grade point averages, more time spent on homework, and increased standardized test scores (Cooper et al., 1999). In addition, Weissberg, Barton, and Shriver, (1997) found that students who participated in activities that reinforced pro-social behavior displayed significantly greater improvements in problem solving skills, and Mahoney (2000) suggests membership in pro-social peer groups provides students with stronger, more positive connections to school, increased academic achievement, and long-term educational outcomes.

Gilman (2001) examined the effects of perceived self-satisfaction on school experiences of 321 high school students in grades 9 through 12 and found that students who participated in more extracurricular activities reported significantly higher satisfaction with school, and those who regarded themselves with higher social interest reported significantly higher overall satisfaction, and satisfaction with friends and family. These results appear to support previous research suggesting that even during a time when adolescents' sense of identity may be changing due to the increased influence of peers (Larson & Verma, 1999), relationships remain important within the lives of students with high social interest (Gilman et al., 2000). However, the question of which factor promotes the other remains unanswered. Do the positive influences of family and friends promote pro-social behavior within the student, or do the social priorities of the student influence the positive relationships found among family and friends?

Participation in team sports has been related to many positive academic outcomes including increased educational aspirations and higher levels of post secondary education (Marsh & Kleitman, 2002). Remaining consistent with such results, Eccles and colleagues (2003) found that students involved in athletics during 10th grade liked school more at 10th and 12th grade levels, had higher than expected grade point averages in 12th grade, were more likely to attend college full time by age 21 and graduate by age 25. It must be noted however, that participation in extracurricular activities does not always produce positive effects for students (Eccles & Gootman, 2002), especially when students are involved in less structured activities among riskier peer groups (Dishion, McCord, & Poulin, 1999). In the majority of the reviewed literature, the reasons for the suggested associations, the role of student characteristics in activity selection, and the role of activity characteristics in student attrition remain unclear. Possibly, the nature of the activity will help in self-identity as well as peer group identity of students (Fine, 1987), which then may determine the positive or negative effects on pro-social and academic achievement

Summary

To summarize the preceding reviewed literature, middle school appears to be the critical time for intervention in order to promote success in science for girls. Reading proficiency is necessary for understanding material within science texts, and ability in mathematical problem solving is a skill necessary for advanced science achievement. Motivational factors such as self-efficacy, interest, and views toward science are especially important for females, since these are the characteristics which appear to be connected to enrollment in advanced level science courses in high school and aspirations toward a science based career. However, these are also the factors many research studies have found to recede during adolescence, resulting in less confidence in science ability. When girls view science, especially physical science, as a subject more important for boys requiring logical, analytical, and rational thinking, they may consider it to be beyond their reach of comprehension and choose to avoid them. However, if girls are provided with the tools to help them view knowledge and learning science in a more sophisticated epistemological manner, consider science as advantageous to their personal lives and as a subject in which they can excel, they may become more motivated toward advanced level high school classes, science-related college majors, and ultimately, science related careers.

CHAPTER THREE: METHODOLOGY

Although research focusing on gender differences in science education has been on-going for decades, the lack of participation of girls in the upper level physical sciences remains a nationwide concern. As society continues its increasing dependency on scientific and technological advances, many well qualified women may be missing out on important, prestigious, and well-paying career opportunities. Considering the amount of time, money, and effort expended on gender difference research in science education, statistics regarding the enrollment of females in high school and post secondary advanced level physical science courses have not improved accordingly (NSF, 2006). An attempt to determine factors that may promote participation and success of girls in high school advanced level science is the focus of the research questions within this dissertation:

1) Is there a difference in the cognitive factors of reading, mathematics, and science ability, or in the motivational factors of science related attitude, self-efficacy, stereotypical views, and epistemological beliefs between 12th grade AP physics females and non AP physics females, or between AP physics females and AP physics males?
2) Which factors defined in this study are most strongly associated with female enrollment in AP physics?
3) Is there a difference between AP physics females and non AP physics females, or between AP physics females and AP physics males concerning an anticipated science related college major, and if so, which factors defined in this study, either

solely or collectively, most strongly predict that choice?

4) Is there a relationship between student involvement in school related activities and enrollment in upper level science?

Research Design

Social Cognitive Theory provides one theoretical basis for the research design of this study by outlining relationships among past performance, academic level, and academic peer support with academic self-efficacy and achievement (Lent, Brown, & Hackett, 1994). The theory asserts that in addition to personal background factors, school environment factors such as academic peer support exert influence on self-efficacy and achievement variables, and self-efficacy mediates the relationships between the above mentioned variables and achievement (Byars & Hackett, 1998).

A causal-comparative research design was determined to be appropriate for this study in order to address questions involving differences in existing groups of students enrolled in specific science classes. Although causation is not established through identified relations through the implementation of causal-comparative methodology (Frankel & Wallen, 2000), it is considered an appropriate design when ability to select, control, and manipulate factors is limited (Reynolds & Conaway, 2003). It is also applicable as an exploratory tool in identifying information concerning the nature of the topic and gives a sense of direction for future research. But, despite the advantages, a causal comparative design has several limitations. It limits the control of internal validity threats, conclusions are often based on a very limited sample, and if a relationship is found, the possibility of reverse causation must be considered a possibility (Reynolds & Conaway).

Participants

The population of interest for this study was 12th grade high school students during the 2006-2007 school year in Seminole County Public Schools. In order to obtain the necessary specific data, the sample was chosen through purposive sampling procedures. Participants include 106 12th grade male and female students from two Seminole County high schools enrolled in various science classes during the fall semester of 2006 who volunteered to partake in the study. All appropriate research consent documents were obtained from Seminole County District Schools, principals, teachers, parents, students, and the University of Central Florida (see Appendices A-F).

During the 2006-2007 school year, Florida's Seminole County Public Schools had a total enrollment of over 66,000 students with ethnic backgrounds consisting of 59.9% white, 17.5% Hispanic, 13.4% black, and 3.6% Asian. The high schools within the county had a graduation rate of 81.3%, ranked 6th highest in the state for Florida Comprehensive Assessment Test (FCAT) reading scores, and 5th highest for FCAT mathematics scores (District Report Card, 2006). In addition, all Seminole County high schools (except Hagarty High School and Crooms Academy, since they did not yet have seniors at the time of this study) have been ranked in the national top 5% of high schools by Newsweek magazine (Seminole County Public Schools, 2007) for the past three consecutive years.

Since student participation in this study was voluntary, several students who were initially eligible either chose not to participate, did not return signed parent consent forms, or did not complete the survey. Additionally, six students who completed the questionnaire did not have FCAT science scores recorded on the transcripts provided by the schools, and were consequently omitted from the study. Therefore, the final number of participants in the study consisted of 106 students. Groups consisted of 20 females and 27 males in AP physics, and 39 females and 20 males in a non AP physics class.

There was concern about the adequacy of the sample size for this study since minimizing a Type I error typically requires a large sample, and specific guidelines were not found in reviewing the literature. A meaningful effect size, to which the sample size is inversely related, is difficult to judge since it is researcher-subjective and providing an estimate of the relationship is often the purpose of the study. One source of guidance used was identification of meta-analytical studies involving similar factors. Olejnik (1984) provides results of 11 major meta-analytic studies based on Cohen's (1992) definitions for small, medium, and large effect size, in order to provide some indication of typical effect size in social science research, of which variables relevant to this study are provided in Table 2.

Table 2

Effect Size Results from Meta-Analytical Studies

	Study	Effect Size
Motivation and Achievement	Uguroslu & Walburg, 1979	.70
Gender and Achievement	Dusek & Joseph, 1983	.20
Quantitative Cognitive Gender Differences	Rosenthal & Rubin, 1982	.35
Visual/Spatial Gender Differences	Rosenthal & Rubin, 1982	.50

With a total sample of 106 students, and independent group sizes ranging from 20 to

39, it would be reasonable to assume from the above guidelines that all analyses of the present study provide meaningful results at a .05 level of significance and a medium to large effect size. However, some literature pertaining to sample size and significance of statistics claims that since sample size is often fixed for a variety of reasons, and other possible provisions to improve the design of the study, such as narrowing the scope, should be considered (Lenth, 2001). According to Lenth, researchers should avoid measures claiming small, medium, and large effect size since they are simply asking for large, medium, or small sample sizes, and should instead follow the common rule of thumb of using as many subjects as can be obtained. Although sample size may not be equally important in all studies, the probability of a Type I error should be minimized while attempting to obtain a meaningful effect. In social science research where effect sizes tend to be small, a reasonable alternative for maintaining statistical power may be to accept an increased chance of a Type I error initially, and replicating the study in order to separate the errors from true effects (Olejnik, 1984).

Variables and Instrumentation

This section provides information on the variables and instruments used in this study. Details about scale items, response options, and reliability and validity are provided if this information was available in the reviewed literature. This section also details scoring procedures and modifications made to the scales of the original instruments.

A student questionnaire, due to its ability to explore, measure, and classify connections among such variables as opinions or behaviors, was used to collect student data.

Another advantage of the questionnaire is that it is presented to students in a familiar format and has the ability to collect information in an efficient process, minimizing the impact of the study on the participants (Norusis, 1990). Results of such research may be summarized in a variety of ways such as graphs and tables, and may determine specific patterns of continuity or causality among variables identified through detailed statistical analysis.

Students' gender and enrollment status in AP physics are constants in this study. Gender was self-reported by students on questionnaires, coded 0=male and 1=female for data analyses. Enrollment in AP Physics, either currently or prior to this study, was determined by student transcripts provided by the schools, and coded as 0=non enrollment in AP physics, and 1=enrollment in AP physics. Student names were not entered into the analyses to ensure confidentiality of participants.

Cognitive Factors

This study involves identification of possible differences in reading, mathematics, and science ability and in the motivational factors of attitude, epistemological beliefs, stereotypical views, and self-efficacy between student groups. Ability levels in the three subject domains for the purpose of this study are measured by the Florida Comprehensive Assessment Test scores obtained through student transcripts provided by the schools. The FCAT was selected as an indicator of ability for several reasons. It is part of Florida's overall plan to increase student achievement by implementing higher standards for students, and is therefore a requirement of all public school students. Statewide assessment in selected grades was authorized in the early 1970's, and in 1976 Florida Legislature approved assessments in grades 3, 5, 8, and 11, including the nation's first high school graduation test. In 1999, the test was expanded to Florida's Statewide Assessment Program to include all grades 3 through 10 (Florida Department of Education, 2004). In addition, such standardized tests have been used as measures of academic ability in the domains of reading and mathematics in several previous research studies (e.g., Nauta, Epperson, & Kahn, 1998), therefore, it is felt that FCAT scores in those subject areas for this study will be an accurate measurement of achievement.

FCAT Administration and Scoring

Another advantage of using FCAT scores for indices of achievement is that it is a criterion referenced and norm referenced test, designed to measure selected benchmarks in mathematics, reading, and science from the Sunshine State Standards, as well as individual student performance against national norms. One method used to report student scores is a scale score of 1 to 5, with 1 indicating the student has little success with the challenging content of the Sunshine State Standards, and 5 indicating proficiency. Passing the mathematics and reading sections of the FCAT with a score of 3 or higher is required for high school graduation, however, students who do not pass these two sections in 10th grade have several opportunities to retake the tests in 11th and 12th grades. Reading content assessed at the 10th grade level includes using words and phrases in correct context, identifying main ideas, plots, and purposes, recognizing comparisons and cause and effect, and synthesizing information from multiple sources from which to draw conclusions.

Mathematical content includes number sense, concepts, operations, measurement, geometry, algebraic thinking, data analysis, and probability.

Since the reading and mathematics portions of the FCAT are administered to students in 10th grade, the 12th grade participants of this study took these tests in February 2005. State results from the 2005 test reveal 32% of students scored a 3 or above in reading, and 63% scored a 3 or above in mathematics. In Seminole County, the average passing rate was 44% in reading, and 76% in mathematics (Florida Department of Education, 2006).

The science portion of the FCAT is a new addition to the state test, and was initially administered to 10th grade students in March 2005. However, the results of this test were not recorded on student transcripts, nor were they considered in school accountability grades for that year. The following year, it was decided by Florida Department of Education that the science portion would be administered to 11th graders. Therefore, in March 2006, the same group of students took a second science test. This grade was recorded on student transcripts and is the science ability score used in this study. Although passing the science portion of the FCAT is not required for graduation, it is becoming increasingly more important, and student performance is considered by the state of Florida for school accountability reports for the 2006-2007 school year. The content assessed by this portion includes physical, chemical, earth and space, life, and environmental science concepts, as well as scientific thinking. In 2006, 35% of 11th grade students statewide earned a 3 or above on the science portion. In Seminole County, 47% of the students earned a passing grade (Florida Department of Education, 2006).

Validity and Reliability

The FCAT, consistently reported to be a highly reliable and valid student assessment by the Florida Department of Education, reports internal consistency reliabilities for the Sunshine State Standards and the Norm Referenced Test portions using Cronbach's Alpha. For the FCAT administered between 2001 and 2003, alpha coefficients for reading are reported between .87 and .92, and for mathematics, between .87 and .93 (Florida Department of Education, 2004). At the time of this study, statistical data had not yet been reported by the state of Florida on reliability or validity for the science portion of the test.

Because FCAT assesses the content of the Sunshine State Standards, and is presumed to be developed using credible and trustworthy methods, the Florida Department of Education maintains that the content validity is substantiated. Criterion related validity of the test is supported by correlation of scores on the criterion-referenced portion and scores on the norm-referenced portion, which are both administered to students at approximately the same time. Correlations between the reading portions of the test are between .78 and .84, and those for the mathematics portion are between .76 and .85 (Florida Department of Education, 2004).

Limitations

Since this research study does not identify ethnicities of participants, a stereotype threat may be present in results containing FCAT scores. Differences in performance between minority and non-minority students on such standardized tests has been found to be partially explained by anxiety and evaluation apprehension produced by knowledge of negative stereotypes related to group membership (Steele & Aronson, 1995). In addition, Steele (1997) found that simply indicating one's race prior to taking a standardized test is sufficient to activate a stereotype threat.

In addition, the fact that students participating in this study took the science portion of the FCAT during 10th grade, and then retook the test during 11th grade may have had an effect on scores. Although this would not affect the generalization of results to students in 12th grade during the 2006-2007 school year, results may not be generalizable to subsequent 12th grade students.

Motivational Factors

In order to investigate and understand motivational factors such as attitude, views toward science, and self-efficacy, or any possible affects these factors may have on enrollment in advanced level courses, an instrument grounded in theory and appropriately tested with groups similar to the target population of this study was considered necessary. Since no preexisting instrument was found, there was a need to design one which would be capable of accurately measuring these variables. In addition, since the participants of this study were enrolled in various science courses during their senior year in high school, a survey specific to only one domain such as physics would not be as effective as an instrument with questions that could be generalized to all high school science. Therefore, the student survey developed for this study uses content from specific versions of pre-established instruments that contain subsets of topics relevant to this study with established validity and reliability, with care taken in obtaining proper consent from authors. Only relevant questions were chosen, thereby keeping the number of items for students to answer to a minimum, and multiple sections were constructed in order to keep the answer choice format as close as possible to the original instrument formats.

Although questions contained on the student survey were adapted from pre-existing instruments, reaffirming satisfactory validity and reliability was conducted through exploratory factor analysis using the Statistical Package for the Social Sciences (SPSS) Graduate Pack, Version 12.0 for Windows. The factor analysis is a procedure that reduces larger sets of variables to a smaller set of factors capable of accounting for a sufficient portion of total variability in the items.

Attitude and Epistemological Beliefs

Science related attitude and epistemological beliefs were measured by questions obtained from the Views About Science Survey (VASS), form P204 (Halloun, 1997). The instrument was originally developed by Halloun in collaboration with the modeling research team at Arizona State University in 1993, and by 1996 the instrument had been administered to over 10,000 high school and college students throughout the United States. Initially, the VASS was an open ended questionnaire used to identify patterns in student views toward science and assess the relationship between student views and science achievement. However, the essay format was neither cost efficient nor practical when administered to large numbers of students, and contradictory results were often obtained with items intended to measure the same construct. In an effort to revise the survey, the author rejected the multiple choice format, claiming that it usually does not allow more than a single choice (Halloun & Hestenes, 1998). Therefore, in order to produce a valid and reliable instrument format, Halloun devised the Contrasting Alternatives Design (CAD) which allowed a balance of responses between two contrasting alternatives. Questions consist of pairs of contrasting views about science, one of which is considered the expert view, and the second the folk view. The expert view is defined as that being most common among scientists and science educators, while the folk view is one often held by the lay community and science students of all levels (Halloun & Hestenes). Initially, response options consisted of eight choices; however, the answer scale was eventually changed to five choices, allowing researchers to treat items more as interval rather than ordinal (Halloun, 2001).

During the development of the VASS, the use of formal scientific terminology that students may not be familiar with was avoided, and questions addressed issues in a familiar context. Questions narrow issues to a single factor within a given dimension, and restrict issues to the scope of the target populations. In addition, the questionnaire often asks the same question in more than one context within the same discipline to account for student sensitivity to content. The final instrument is based on two broad dimensions: 1) the scientific dimension which encompasses the epistemology and methodology of science, and 2) the cognitive dimension which entails aspects of science education.

Included within the scientific dimension are the three domains of structure, methodology, and viability. Structure refers to science as a coherent body of knowledge about patterns in nature, which was found to have the highest correlation with achievement

(Halloun, 2001). Methodology questions refer to methods of science as being systematic and generic rather than situation specific, and viability refers to scientific knowledge as being approximate and refutable rather than exact or final. Within the cognitive dimension, questions refer to the three domains of learnability, critical thinking, and personal relevance. Learnability is defined as science being learnable by anyone willing to make the effort and not just by a few talented people. Critical thinking entails questions related to meaningful understanding of science such as concentrating on principles rather than memorizing facts, examining situations in many different ways, and looking for discrepancies in one's own knowledge rather than just accumulating new information. The third domain of personal relevance relates to science being relevant to everyone, and is not just an exclusive concern to scientists. The two domains of personal relevance and learnability relate to student attitude, and had the highest correlations with achievement (Halloun).

The student survey for this study contains VASS questions taken from the personal relevance and readiness to learn sections to measure student attitude toward science, and from the epistemology sub-section within the scientific dimension to measure epistemology beliefs of students toward science. The original instrument contained eight answer choices; however, the 19 questions chosen for the current study have five answer choices which is consistent with the revised instrument. The personal relevance domain consists of two sections denoted as R1 and R2, which contain a total of five questions to measure student attitude toward the relevance of science in everyday life as follows:

- R1: Science is relevant to everyone's life, it is not of exclusive concern to scientists

- R2: Studying science should be an enjoyable and self-satisfying experience rather than a frustrating one undertaken to satisfy curriculum requirement and other people's expectations.

Section R1 contains two questions and section R2 contains three questions. In an exploratory factor analysis, the five questions loaded as expected onto two factors explaining 68.6% of the total variance. The correlations established that had a value greater than .30 are summarized in Table 3.

Table 3

Factor Analysis for Attitude Toward Personal Relevance of Science

	Survey Question	Factor Loadings 1	2
R1a	In everyday life, science is (helpful/of no use)	.855	.653
R1b	Science should enable me to (relate to/be independent of) how I think about the natural world	.656	
R2a	Studying science is (enjoyable/frustrating)	.400	.309
R2b	Science courses should help me (do well on exams/develop my reasoning skills)	.589	.460
R2c	I study science (for my own interests/because it's expected)		.640

The readiness to learn domain of the original instrument consists of four sections labeled D1, D2, D3, and D4 and contain a total of seven questions designed to measure student attitude toward learning science as follows:

- D1: Science is learnable by anyone willing to make the effort, not just by a few talented people.
- D2: Achievement depends more on personal effort and perseverance than on the influence of teacher, peers, or textbook.
- D3: Understanding science favors students who come to class with a prepared mind rather than those who study only after the teacher covers materials in class.
- D4: Understanding favors those who seek scientific information from alternative sources and discuss it with peers rather than those who stick to the textbook.

Section D1 contains one question, and the remaining three sections contain two questions each. Table 4 contains the individual questions as well as the factor loadings greater than .30 obtained in an exploratory factor analysis for data from this study.

The seven items used in this study extracted three factors, explaining 64.6% of the total variance. After a review of the questions, it was determined that questions D2b and D1 both refer to the amount of student effort required for understanding, and could reasonably be grouped together as one factor, labeled D1. Similarly, questions D2a, D4a, and D4b all pertain to persistence and the use of alternative sources during times of difficulty in science understanding, which are grouped as D2 on the student survey used in this study. The loadings of the two questions on the third factor appear sound.

Table 4

Factor Analysis for VASS Attitude toward Readiness to Learn

	Survey Question	Factor Loadings 1	2	3
D1	Learning science requires (effort/ talent)	.966		
D2a	When experiencing difficulty, I (give up/ try to figure it out)		.458	
D2b	Understanding depends on (effort/ teacher explanation)	.327		
D3a	I review the chapter (before/after) it is covered in class			.992
D3b	I attempt to solve homework problems (before/after) they are worked out in class			.640
D4a	Discussing science with classmates (confuses me/helps develop my reasoning skills)		.456	
D4b	Using sources other than texts to learn science (confuses me/ enriches my knowledge)		.618	

The third portion of the VASS used for the student questionnaire pertains to epistemological beliefs of students toward science. The seven questions on the original instrument are divided among the following three sections:

- E1: Science is a coherent body of knowledge rather than a collection of isolated facts
- E2: Branches of physics are related by common principles

- E3: Some aspects of physics may need to be inferred instead of being measured directly

Section E1 contains three questions, and the remaining two sections contain two questions apiece. The factor analysis of data from this study extracted three factors, and the questions loaded on each factor consistent with the categories from the original instrument, explaining 68.1% of the variance (see Table 5).

Table 5

Exploratory Factor Analysis Results of Epistemology VASS Questions

	Survey Question	Factor Loadings		
		1	2	3
E1a	Branches of physics are (related by common principles/ are independent of one another)		.514	
E1b	Scientists check first time occurrences for (similarities to other events/ways to distinguish them)		.667	
E1c	Scientists check new information to (relate it to other knowledge/ascertain it merits independently)		.683	
E2a	(All possible aspects that may be attributed/only relevant aspects investigated) for a particular event			.471
E2b	To determine if two different objects behave the same way, similarities (in all aspects/subject to similar conditions) are checked			.754
E3a	Electrons and protons exist because they have been (seen/ attributed to observations)	.889		
E3b	Earth and moon attract because (it has been measured/ moon's revolution can be explained in such terms)	.535		

The three factors, labeled E1, E2, and E3, are designed to measure student beliefs about the complexity of science knowledge (E1) and the stability of science knowledge (E2 and E3). Since student beliefs about knowledge being an inherent trait, and about the speed of student learning, have not always been agreed upon in the current literature to be a true measure of epistemological beliefs (e.g., Hofer & Pintrich, 1997), questions measuring those constructs are included in the attitude portion (readiness to learn factors) of the student survey.

Reliability and validity of the VASS are not usually reported using conventional coefficients within the literature, but have been assessed indirectly instead. Items contained in the VASS are distributed throughout six dimensions that are grouped into subscales of scientific and cognitive domains, which measure different constructs. In addition, the number of items is not constant within the subscales, and the loading of items within subscales is not uniform (Halloun, 2001). However, the author claims that the instrument has been constantly assessed in all areas as various forms have been developed. Questions are based on what literature reviews, peer reviews, and analyses of previous forms have shown to be meaningful information concerning student views that significantly affect achievement in science. Item validity has been assessed in three ways: several university professors and high school teachers verified the validity of the items to assess intended measures, the same group agreed on answers considered to be the expert view, corroborating face validity, and exit interviews conducted with participating students ensured students understood the questions and the nature of the anticipated answers (Halloun). Internal consistency has also been assessed indirectly in terms of difficulty of the six dimensions. Student average scores remained fairly consistent on all dimensions, lending support to the reliability of the instrument.

One instance was found where correlation coefficients from one administration of the VASS were reported. The dimensions of structure, validity, and methodology within the scientific subscale had coefficients of .40, .61, and .78, respectively, and learnability, personal relevance, and reflective thinking, within the cognitive subscale had coefficients of .43, .56, and .91, respectively. When correlating the broad scientific and cognitive domains with the entire instrument, correlation coefficients had values of .64 and .92, respectively (Halloun, 2001).

Analyses were performed from the results of the current study in order to obtain reliability statistics for the groups of items loaded on each factor, as noted previously. The reliability coefficients obtained for the questions included in the R1 and R2 groups, which measure the personal relevance aspect of attitude toward science, were .70 and .64, respectively. The three factors used to measure readiness of learning, also an attitude measurement, produced reliability coefficients of .48 for questions included in D1, .49 for those in D2, and .76 for questions in D3. For the epistemological beliefs, section E1 questions produced an alpha of .65, alpha for questions in E2 was .48, and .67 for those in E3. All of the reliability coefficients obtained from data in this study are fairly consistent with those reported by Halloun (2001), therefore, the questions chosen from the VASS instrument are considered adequate to assess students' attitudes and epistemological beliefs toward science.

Self-Efficacy

Self-efficacy for this study is defined as students' confidence in their ability to achieve in both mathematics and science, and was measured with questions adapted from Marsh's (1992) Academic Self Description Questionnaire II (ASDQII). The original instrument is composed of 136 questions regarding students' general self-confidence toward school, as well as in 15 specific subject areas. Directions ask students to indicate the degree to which statements apply to them on a Likert-type scale ranging from 1 (definitely false) to 8 (definitely true).

The design of the ASDQII is based on previous research with the Self Description Questionnaire instruments. In preliminary analyses, coefficient alpha estimates for the 16 scales varied from .885 to .949, and factor analysis confirmed that the ASDQ scales correspond unambiguously to unique factors (Marsh, 1990). For the current study, eight questions concerning science self-efficacy and seven questions concerning mathematics self-efficacy were used from the ASDQII instrument. The answer scale remains consistent with the original instrument.

Relationships between ASDQII scales and achievement grades of students were examined using a Multitrait-Multimethod Matrix, which found achievement scores to be more highly correlated with the matching self-efficacy scale than with any other academic self-efficacy scale. This lends support to the theory that academic self-efficacy is content specific (Marsh, 1992). Specifically, the correlation coefficient between mathematics achievement and mathematics self-efficacy was .622, and .702 between science achievement and science self-efficacy. Out of the eight academic areas considered in the analysis, science and mathematics had the highest correlations (Marsh).

Analyses of the data obtained from the current study support the high validity and reliability of the ASDQII reported in the literature (Marsh, 1990; 1992). Correlation coefficients between the seven items measuring mathematics self-efficacy ranged from .40 to .75 with an alpha of .89. For the eight items measuring science self-efficacy, correlation coefficients ranged from .42 to .77, and a reliability coefficient of .91 was obtained.

Stereotypical Views Toward Women in Science

The final instrument from which questions were taken for the student survey is the Science Careers and Family Responsibility Scale. The purpose of this seven question survey is to determine students' attitudes toward science related careers for women, and views toward balancing such careers with raising a family. Answer choices on the original instrument are on a 5-point scale ranging from Strongly Agree (SA) to Strongly Disagree (SD), which remain consistent on the student survey used for the present study. An open-ended item was added to this portion of the survey to obtain information concerning students' anticipated college major.

The Science Careers and Family Responsibility Scale was developed for use at the 1997-1999 Newton Summer Science Academy, a 10 day program for female high school students, funded by the National Science Foundation. Statistics on validity and reliability of the instruments used during the program are not available in the literature, and contacting the author of the instrument directly provided no results. However, an instrument developed by

Lips (1992), which was found to be extremely similar to the one used at the Newton Academy, reported a reliability coefficient of .75, and Cronbach's alpha = .81. In addition, Lips claims support for the validity was indicated by a positive relationship between females' scales scores and their selection of science-related academic and vocational goals.

A factor analysis on data from this study conducted using the principal component method of extraction produced one factor explaining 41% of the total variance, and on which all seven items loaded with values ranging from .47 to .76 (see Table 6). As shown, a correlation matrix of the seven items produced 13 out of 21 values greater than .30, and a reliability coefficient of .74 was obtained.

Table 6

Correlations for Science Careers and Family Responsibility Scale

Question	Factor Loading	Correlation Coefficients Q1	Q2	Q3	Q4	Q5	Q6
It is very difficult for women to combine a career as a scientist with a family life	.474	—					
If a woman scientist takes time away from her career to have children, she will never catch up	.755	.421	—				
A woman who is dedicated to a science career can't devote much time or energy to her family	.618	.196	.390	—			
Women and men can find the time they need for a career in math and science even if they are involved in an intimate relationship	.690	.196	.392	.367	—		
A woman considering a career as a scientist / mathematician should not plan to have children	.649	.211	.339	.338	.360	—	
For women, there is nothing incompatible about planning a family and a scientific career	.564	.114	.319	.195	.324	.238	—
Most women scientists find that with a little ingenuity and support they can happily combine their career with having a family	.693	.162	.438	.270	.374	.388	.378

Extra-Curricular Activities

An additional purpose of this study was intended to determine the effects of peer relationships on females' science related attitudes and self-efficacies through the use of questions adapted from the Interactions with Peers Scale. However, the instrument was not approved by the school district, claiming questions were too intrusive and therefore, inappropriate. Since a relevant, pre-existing instrument that met school district guidelines was not found, the student questionnaire was restructured in an attempt to measure student involvement in extra-curricular activities. The new portion of the survey simply asked students to check activities in which they had been involved during their time in high school, and does not include questions specific to peer relationships. This change produces questionable validity and reliability of the instrument, and limits the generalization of results. But, since it has been found that student involvement in extra-curricular activities and related peer interactions play an important role in student academic choices (Chinman & Linney, 1998), results may provide some useful information nevertheless.

As a result of high correlations found among the individual items listed on the survey, extra-curricular activities were reduced to the two categories of school activities and school related sports. School related activities, coded EC1, include involvement in academic and non-academic clubs and other activities such as drama, band, and chorus. School related sports, coded as EC2, include participation in team or individual sports, cheerleading, and dance/drill teams. Analyses were conducted on participation based on student responses.

Data Collection

After final research approval was obtained from Seminole County Public Schools, science teachers from four high schools within the county were contacted to determine participation. A total of eight teachers from two high schools agreed to partake in the study. After distribution and collection of parental consent and student assent forms, the total number of student participants was determined. Consent and assent forms made it clear to students, parents, teachers, and principals that participation in the study was voluntary, there would be no rewards for those students choosing to participate, nor would there be detrimental effects concerning grades or relationships with instructors if they chose not to participate. In addition, it was stated that the study was designed solely for research purposes, and all responses would remain confidential to the extent provided by law.

Student questionnaires were distributed to participating students, which were completed within one class period in November, 2006. Student transcripts were provided by the administration offices of the respective high schools. After all data was collected, students were coded by numbers identifying them as male or female, and AP or non-AP. AP males and females are those students who were currently enrolled in, or had previously been enrolled in AP Physics., and non AP males and females refer to those students who had not taken an AP Physics during high school.

Analysis

After all data was collected, it was inputted into the SPSS for analyses. Students were coded according to gender as either male (0) or female (1), ability as either enrolled in AP physics (1) or not enrolled in AP physics (0), and gender/ability groups as AP male (1), non AP male (2), AP female (3), and non AP female (4). FCAT scores were used to measure student ability in reading, mathematics, and science. Significance for all analyses was measured at $p<.05$.

Data analyses involved descriptive statistics, correlation analyses, ANOVA, independent samples t-tests, univariate analysis, and logistic regression. Descriptive statistics provide an opportunity to examine patterns in student ability scores and motivational factors. Correlation analyses provide information about the bivariate relationships between and among the variables under consideration. ANOVA analyses compare mean scores of students by gender and ability, and independent samples t-tests are used to determine between which groups significant differences are found. Univariate analyses are used to examine possible relationships when dependent and independent variables are categorical, and logistic regression analyses provide information about the relationship between relevant factors and educational outcomes (i.e., enrollment in AP physics and future educational aspirations).

Research Question One

The first question posed in this study asks, “Is there a difference in the cognitive factors of reading, mathematics, and science ability, or in the motivational factors of science related attitude, self-efficacy, stereotypical views, and epistemological beliefs between 12th grade AP physics females and non AP physics females, or between AP physics females and AP physics males?”

Analyses to address possible differences between student groups include descriptive statistics, correlational analyses, ANOVA analyses, and independent samples t-tests. Pearson correlations were calculated for all variables to identify highly correlated variables, and to note any relationships that may cause exaggerated relations in the ANOVA analyses. One-way ANOVA analyses were used to compare the means of the independent variables on the dependent variables to determine if group means were statistically significantly different from each other. Powell (2002) asserts that while a one-way ANOVA may determine if a set of group means are equal, it usually provides little relevant information concerning differences. Therefore, independent samples t-tests were used to examine the mean scores of student groups. Probability P-P plots (cumulative proportions of variable versus test distribution) were run to verify normal distributions of data, and Levene's statistic was used to determine homogeneity of variance. If the significance level of Levene's F-statistic was found to be $<.05$, equal variances were not assumed when reporting results.

Research Question Two

Research question two asks, "Which factors defined in this study are most strongly associated with female enrollment in AP physics?" AP enrollment, the dependent variable, is coded as no (0) and yes (1), and the grouping variable, gender, is coded male (0) and female (1). Logistic regression analysis was used for this portion of the study to estimate the effect of factors on the odds of a student enrolling in AP physics. The one requirement that logistic regression does have is that observations be independent, which was met.

Initially, a stepwise logistic regression was run for exploratory purposes. Independent variables were added into the analysis as either individual factors or as blocks (for example, all three FCAT scores entered as one ability block) in order to examine effects and significance levels. Stepwise procedures within SPSS use the likelihood ratio test to determine which variables to include in the model, which is considered reliable when samples are small (Agresti, 1996). A second logistic regression analysis was then conducted using variables selected on the basis of significance levels provided in the initial test, and re-entered into a regression analysis using the "enter" procedure. Factors (or blocks) were entered into the model one at a time until the initial intercept model could no longer be improved.

Logistic regression analyses produce a likelihood ratio (-2LL) which reflects the significance of the unexplained variance of the dependent variable. As the model improves, -2LL decreases. Since the likelihood ratio has approximately a chi-square distribution, it is used to assess the significance of the regression, and is analogous to the use of the sum of squared errors in linear regression. When a second variable (or block) is added, a large chi-square and small p indicate the significance of that variable after adjusting for the variance of previously added variables. The chi-square statistic is equal to (-2LL of variable 1) minus (-2LL of variable 2). A well fitting model that is significant at .05 or better is one that is significantly different from the model containing only the constant. Therefore, variables were retained if justified through a significance level of <.05.

There is no direct analog in logistic regression to the R^2 used in linear regression representing the percentage of variance explained within a model. However, in logistic regression, variance of a dichotomous categorical dependent variable depends on its frequency distribution, Therefore, Nagelkerke's R^2, which varies from 0 to 1 and tends to run lower than R^2 in linear regression, can be used as an approximation to linear regression's R^2. It is not an actual percent of variance explained, but rather as an attempt to measure the strength of association.

Research Question Three

The third research question asks, "Is there a difference between AP physics females and non AP physics females, or between AP physics females and AP physics males concerning an anticipated science related college major, and if so, which factors defined in this study, either solely or collectively, most strongly predict that choice?"

The initial part of research question three was designed to evaluate any apparent differences between student groups concerning intentions to attend college and anticipated college major. Included on the student survey was an open-ended question asking students to check whether or not they intend to attend college, and if so, what college major they plan to pursue. When choices were inputted into the statistical program, they were coded as 0 (not attending college), 1 (college major is undecided), 2 (non science related major), and 3 (science related major). None of the 106 students within this sample indicated that they were not planning to attend college. Since the data is nominal, the non-parametric Mann Whitney U test for two independent samples was conducted for each set of student groups. Such tests have the advantages of not requiring assumptions for normality or homogeneity of variance, and since they compare medians rather than means, the potential influences of outliers within the data are negated. College major is the testing variable, and grouping variables are gender and ability.

The second part of research question three regards the prediction of a science related college major for student groups from the cognitive and motivational factors involved within the study. Logistic regression analysis was used for this portion of the analysis over discriminate analysis since it is more flexible in assumptions and types of data that can be analyzed, and predictor variables do not have to be normally distributed, linearly related, or of equal variance within each group (Tabachnick & Fidell, 1996). Additionally, logistic regression is well suited to models where the dependent variable is dichotomous. For this part of research question three, the dependent variable is "science related major", coded as either yes (1) or no (0). The response of undecided was not included in the analysis. Predictor variables were entered individually using a forward stepwise regression to determine if they meaningfully added to the initial model.

Research Question Four

The final research question asks, “Is there a relationship between student involvement in school related activities and enrollment in upper level science?” Students identified activities in which they have participated during high school. Activities were categorized as school related activities (EC1) and school related sports (EC2), and student information was inputted into SPSS as either yes (1) or no (0) for participation or non-participation in each category.

Since dependent and independent variables are categorical for this set of analyses, univariate analysis via chi-square test was conducted to examine possible relationships between the status of taking AP physics in high school and involvement in extra curricular activities. Chi-square is used to detect relationships between two categorical variables, and assume that the expected value for each cell to be five or higher. If this assumption is not met in SPSS, Fisher's exact test is conducted by default and the corresponding significance is reported.

Strengths and Weaknesses of Current Analyses

As previously noted, logistic regression analysis is well suited for the data upon which the study was based, since the two dependent variables (science related college major and enrollment in AP physics) are associated with a binary, categorical outcome. However, there are several ways in which this analysis limits the interpretability of findings in Chapter 4. Logistic regression techniques are, in general, better suited for larger sample sizes than what was used in this study (Pedhazur, 1997). In addition, since the dependent variable was categorical, there is no variance of the initial model. Therefore, descriptive statistics that rely on initial variability, such as effect sizes, cannot be reported and there is no way to discuss the extent to which the addition of variables reduces variability of the model.

Although Nagelkerke's R^2 is reported, there is disagreement in the literature concerning the effectiveness of such pseudo values (Pedhazur, 1997). A technique often used to determine effectiveness of logistic analysis models is the classification table which compares actual and expected group membership, recommended for predictive models (Long, 1997). Although this method may be useful for additional longitudinal studies based on information gained from this study, the purpose of the current study is to identify factors associated with identification rather than to predict identification. Therefore, a classification table is not useful for this analysis.

Although regression analyses used were appropriate given the structure of this study, there were limitations of the ability to assess the completeness of the models. Therefore, the discussion of results in subsequent chapters concerning research questions three and four focus on the nature of associations among individual variables rather than the effectiveness of the model as a whole.

Summary

The analysis techniques utilized for identification of significant variables were advantageous for the current study. ANOVA analyses and independent samples t-tests resulted in the identification of significant factors characteristic to particular student groups, and regression analyses were able to support the findings. As a result, findings from this study, which may be limited in their generalizability capabilities, can be used as a basis for further investigations utilizing larger, more diversified samples of students. Additionally, longitudinal studies beginning at the elementary or middle school level could be useful in identifying potentially successful advanced level high school science students.

CHAPTER FOUR: RESULTS

The purpose of this research study was to determine the extent to which certain cognitive and motivational factors related to female enrollment in high school Advanced Placement physics courses. The results of statistical analyses comparing females in AP physics to females not in AP physics, and to males in AP physics comprise the main part of this section. Although this study did not intend to specifically focus on gender differences, analyses comparing males and females were conducted, as well as analyses comparing males in AP physics and those not in AP physics to determine if results found for females were consistent with results found for males. Therefore, when statistical tests were performed, students were grouped in the following categories: 1) AP females, 2) Non AP females, 3) AP males, and 4) Non AP males. Of the 106 students participating in this study, 55.7% were female, and 44.3% were male, as indicated in Table 7.

Table 7
Characteristics of Study Participants

	Frequency	Percent
Gender		
Male	47	44.3
Female	59	55.7
Enrolled in AP Physics		
Male	27	25.5
Female	20	18.9
Enrolled in Other Science		
Male	20	18.9
Female	39	36.8

Research Question One

Research question one asks, "Is there a difference in the cognitive factors of reading, mathematics, and science ability, or in the motivational factors of science related attitude, self-efficacy, stereotypical science views, and epistemological beliefs between 12th grade females enrolled in AP physics and 12th grade females not enrolled in AP physics, or between females and males enrolled in AP physics?"

Research question one seeks to find specific factors that may be characteristic of females in AP physics. In order to answer this question, mean scores of student gender/ability groups were first calculated for all factors involved, and ANOVA analyses and independent samples t-tests were conducted to determine where statistically significant differences could be found.

Cognitive Factors

Using students' prior FCAT scores as measures of ability, statistically significant differences were found between mean scores of AP females and non AP females in reading ($t=4.40$, $p<.001$), mathematics ($t=2.86$, $p=.006$) and science ($t=4.91$, $p<.001$), however, there were no significant differences in any of the three domains between males and females enrolled in AP physics. As shown in Table 8, females in AP physics had the highest mean scores of all groups in reading ($M=4.45$) and science ($M=3.90$), and were only slightly below the mean score of AP males in mathematics. Non AP females had the lowest mean scores of all groups in reading ($M=3.49$) and science ($M=2.92$). Non AP males had the lowest mean score in mathematics (M=4.20) of all groups, although non AP females' mean score in mathematics (M=4.21) was only slightly above that of non AP males.

Table 8
Mean FCAT Scores by Gender and Ability Groups*

	Reading		Mathematics		Science	
	M	sd	M	sd	M	sd
Males	4.00	1.1	4.51	.66	3.55	.78
AP	4.22	1.1	4.74	.45	3.70	.78
Non AP	3.70	1.1	4.20	.77	3.35	.75
Females	3.81	1.0	4.37	.67	3.25	.80
AP	4.45	.61	4.70	.47	3.90	.79
Non AP	3.49	1.1	4.21	.70	2.92	.58

*Scores range from 1 (lowest) to 5 (highest)

The greatest statistically significant difference found between groups was in science mean scores ($F_{3,102}$=10.98, p<.001), accounting for almost 25% of the total variance in science scores (see Table 9). Significant differences between groups were also found for mean mathematics scores ($F_{3,102}$=6.19, p=.001) and mean reading scores ($F_{3,102}$=5.25, p=.002), accounting for 15.4% and 13.4% of the respective variances. As shown in Table 10, Levene's statistic was not significant for any group means in mathematics scores, therefore, under the assumption of equal variances, independent t-tests results revealed that higher mathematics ability is characteristic of both males and females in AP physics. However, because of the statistically significant differences in mean scores between AP females and non AP females in science (p<.001) and reading (p<.001), these two domains may play a more important role in upper level science course selection for females than for males.

Table 9

ANOVA for FCAT Scores

		Sum of Squares	df	Mean Square	F	Sig.	η^2
RFCAT	Between Groups	16.29	3	5.43	5.25	.002	.134
	Within Groups	105.56	102	1.04			
	Total	121.86	105				
MFCAT	Between Groups	7.09	3	2.37	6.19	.001	.154
	Within Groups	38.94	102	.38			
	Total	46.04	105				
SFCAT	Between Groups	16.39	3	5.46	10.98	.000	.244
	Within Groups	50.75	102	.50			
	Total	67.14	105				

Table 10

FCAT T-Tests by Gender/Ability Group

	Student Group	Levene's F (p)	t (df)	Sig (2-tailed)
RFCAT	AP/Non AP Females	10.24 (.002)[a]	4.40 (56.39)	.000***
	AP Males/Females	8.29 (.006)[a]	.92 (42.21)	.365
	AP/Non AP Males	.06 (.814)	1.60 (45)	.116
	Non AP Males/Females	.04 (.848)	.71 (57)	.481
MFCAT	AP/Non AP Females	1.13 (.293)	2.86 (57)	.006**
	AP Males/Females	.36 (.554)	.30 (45)	.764
	AP/Non AP Males	2.61 (.113)	3.04 (45)	.004**
	Non AP Males/Females	.06 (.815)	.03 (57)	.979
SFCAT	AP/Non AP Females	4.31 (.042)[a]	4.91 (29.86)	.000***
	AP Males/Females	.02 (890)	.85 (45)	.399
	AP/Non AP Males	.05 (.817)	1.57 (45)	.123
	Non AP Males/Females	4.37 (.041)[a]	2.24 (31.12)	.032*

[a] Equal variances not assumed

*Significant at p<.05, **Significant at p<.01, ***Significant at p<.001

Motivational Factors

The motivational factors included in these analyses consist of attitude (R1, R2, D1, D2, D3), stereotypical views toward women in science, epistemological beliefs (E1, E2, E3), mathematics self-efficacy, and science self-efficacy. ANOVA and t-tests were conducted to determine characteristics that may help identify females who participate and achieve in advanced level physics. The AP female group had the highest mean score of the four student gender/ability on all 11 factors, and significant differences were found between AP females and non AP females in all five areas. Although AP females outscored AP males in all areas, significant differences between the two groups were found for only one factor within the epistemological beliefs domain and for stereotypical views toward women in science.

Attitude

Between AP and non AP females, statistically significant mean score differences were found for both relevance factors, R1 (science is relevant to everyone's life: $t=4.17$, $p<.001$) and R2 (studying science should be an enjoyable and self satisfying experience: $t=3.02$, $p=.004$), and for one readiness to learn factor, D2 (understanding favors those who seek information from alternative sources: $t=2.53$, $p=.014$). As seen in Table 11, AP females had the highest mean scores on all attitude measures. Although AP females had higher mean scores than AP males on all five attitude measures, none of the differences in scores between the two groups were significant.

Table 11

Mean Attitude Scores*

	R1		R2		D1		D2		D3	
	M	sd	M	sd	M	sd	M	sd	M	sd
Males	3.91	1.04	3.79	.75	3.21	.83	3.77	.83	2.92	1.19
AP	4.35	.69	4.04	.59	3.26	.88	4.11	.53	3.35	1.18
Non AP	3.33	1.15	3.47	.82	3.15	.78	3.30	.93	2.35	.95
Females	3.94	.95	3.76	.75	3.50	.76	3.94	.66	3.22	1.24
AP	4.48	.47	4.15	.59	3.78	.90	4.23	.54	3.50	1.12
Non AP	3.67	1.02	3.56	.76	3.36	.65	3.80	.67	3.08	1.29

*Scores range from 1 (lowest) to 5 (highest)

As shown in Table 12, ANOVA analyses found significant differences between groups on both relevance factors, accounting for 20.4% of the variability in R1 and 14.2% of the variability in R2. Significant between group differences were also found on two of the three readiness to learn factors, accounting for 19% of the variance in scores for D2 (understanding science favors those who seek information from alternative sources, $p<.001$) and 10.3% of the variance in scores for D3 (learning science favors those with a prepared mind, $p=.011$). Subsequent t-tests, summarized in Table 13, found significant differences between the mean scores of AP and non AP females in factors R1 ($t=4.17$, $p<.001$), R2 ($t=3.02$, $p=.004$), and D2 ($t=2.53$, $p=.014$). However, these same differences also appeared between AP and non AP males (R1: $t=3.55$, $p=.001$; R2: $t=2.77$, $p=.008$; D2: $t=2.11$, $p=.044$).

No significant differences were found between AP males and females, or between non AP males and females. These results possibly indicate that regardless of gender, AP physics students hold higher science related attitudes than lower level science students.

Table 12

ANOVA for Attitude Scores

		Sum of Squares	df	Mean Square	F	Sig.	η^2
R1	Between Groups	20.77	3	6.92	8.72	.000	.204
	Within Groups	80.95	102	.79			
	Total	101.72	105				
R2	Between Groups	8.29	3	2.77	5.61	.001	.142
	Within Groups	50.28	102	.49			
	Total	58.58	105				
D1	Between Groups	4.58	3	1.53	2.48	.066	.068
	Within Groups	62.95	102	.62			
	Total	67.53	105				
D2	Between Groups	10.94	3	3.65	7.99	.000	.190
	Within Groups	46.58	102	.46			
	Total	57.52	105				
D3	Between Groups	16.17	3	5.39	3.91	.011	.103
	Within Groups	140.73	102	1.38			
	Total	156.90	105				

Table 13

Attitude T-Tests by Gender/Ability Group

	Student Group	Levene's F (p)	t (df)	Sig (2-tailed)
R1	AP/Non AP Females	7.51 (.008)[a]	4.17 (56.66)	.000***
	AP Males/Females	2.94 (.093)	.69 (45)	.496
	AP/Non AP Males	10.36 (.002)[a]	3.55 (28)	.001***
	Non AP Males/Females	1.56 (.216)	1.17 (57)	.247
R2	AP/Non AP Females	.81 (.373)	3.02 (57)	.004**
	AP Males/Females	.03 (.865)	.65 (45)	.521
	AP/Non AP Males	3.13 (.083)	2.77 (45)	.008**
	Non AP Males/Females	.67 (.418)	.46 (57)	.651
D1	AP/Non AP Females	4.53 (.038)[a]	1.84 (29.52)	.075
	AP Males/Females	.001 (.979)	1.97 (45)	.055
	AP/Non AP Males	1.29 (.262)	.44 (45)	.661
	Non AP Males/Females	.52 (.474)	1.09 (57)	.279
D2	AP/Non AP Females	.68 (.412)	2.53 (57)	.014*
	AP Males/Females	.07 (.787)	.77 (45)	.444
	AP/Non AP Males	7.81 (.008)[a]	3.49 (28.02)	.002**
	Non AP Males/Females	4.17 (.046)[a]	2.11 (29.30)	.044*
D3	AP/Non AP Females	2.02 (.160)	1.24 (57)	.219
	AP Males/Females	.10 (.756)	.43 (45)	.667
	AP/Non AP Males	.62 (435)	3.12 (45)	.003**
	Non AP Males/Females	4.30 (.043)[a]	2.45 (49.81)	.018*

[a] Equal variance not assumed
*Significant at p<.05, **Significant at p<.01, ***Significant at p<.001

Stereotypical Views

Mean score differences in stereotypical views toward women in science were statistically significant between AP and non AP females (t=3.27, p=.002), and between AP males and AP females (t=4.05, p<.001). Table 14 shows that AP females had the highest mean score (M=4.35) on a scale of 1 to 5, of all groups. Non AP females had a higher mean score (M=3.87) than either of the male groups, and non AP males had the lowest mean score (M=3.76) of all groups. ANOVA results presented in Table 15 reveal a significant difference between groups ($F_{3,102}$ =5.60, p=.001) that accounts for 14.2% of the variance in scores.

Table 14

Mean Stereotypical Views Scores

	SteVw	
	M	sd
Males	3.78	.52
AP	3.80	.49
Non AP	3.76	.56
Females	4.03	.57
AP	4.35	.42
Non AP	3.87	.58

Table 15

ANOVA for Stereotypical Views Scores

	Sum of Squares	df	Mean Square	F	Sig.	η2
Between Groups	4.66	3	1.55	5.60	.001	.142
Within Groups	28.29	102	.28			
Total	32.95	105				

Results of independent samples t-tests show a significant difference between AP females and both comparison groups. Considering significant differences were not found between the mean scores of AP and non AP males or between the mean scores non AP males and females (see Table 16), commonly held stereotypical views of women in science by girls may hinder their interest in advanced level science enrollment.

Table 16

Stereotypical Views T-Test by Gender/Ability Group

	Student Group	Levene's F (p)	t (df)	Sig (2-tailed)
StVw	AP/Non AP Females	1.15 (.288)	3.27 (57)	.002*
	AP Males/Females	.50 (.483)	4.05 (45)	.000**
	AP/Non AP Males	.48 (.494)	.22 (45)	.826
	Non AP Males/Females	.02 (.891)	.68 (57)	.501

*Significant at p<.01, **Significant at p<.001

Epistemological Beliefs

In the current study, three factors were utilized to measure students' epistemological beliefs toward science. Factor E1 represents science as a coherent body of knowledge, E2 refers to branches of physics being related by common principles, and E3 refers to the fact that some aspects of physics need to be inferred instead of directly measured. Between AP and non AP females, statistically significant differences were found in mean scores for two of the three epistemological beliefs factors, (E2: t=2.67, p=.01; E3: t=2.21, p=.031), both of which represent the stability of knowledge structure. A significant difference was also found between AP females and males on factor E2 (t=2.25, p=.03). However, only slightly more than 7% of the variance in scores ($F_{3,102}$ =2.68, p=.051) is explained for E2 (a given pattern is defined by a limited number of primary aspects common to a variety of physical realities) and 4.5% of the variance in scores ($F_{3,102}$ =1.60, p=.194) is explained for E3 (primary aspects of physical realities may need to be inferred from certain observations). As shown in Table 17, AP females had the highest mean score of all groups on all three factors, and non AP females had the lowest means on all three factors.

Table 17

Mean Epistemological Beliefs Scores [*]

	E1		E2		E3	
	M	sd	M	sd	M	sd
Males	3.74	.75	3.09	.90	3.64	1.05
AP	3.74	.76	3.07	1.03	3.67	1.13
Non AP	3.75	.76	3.10	.74	3.60	.95
Females	3.79	.68	3.28	.91	3.59	1.04
AP	3.92	.90	3.70	.83	4.00	.97
Non AP	3.73	.54	3.06	.88	3.38	1.03

*Scores range from 1 (lowest) to 5 (highest)

Table 18 shows that the significant differences found between AP and non AP females on factors E2 and E3 were not present between AP and non AP males, nor were there any differences found between non AP males and females. Although the amount of variance in scores explained by group differences is minimal for all three factors, higher level epistemological beliefs toward science may be characteristic of females in advanced level science. Additionally, there were no significant differences found between the mean scores of any two groups regarding factor E1, which represents the complexity of knowledge structure. Specifically, E1 measures whether students believe science is a loose collection of facts, or a coherent body of knowledge that continues to build upon itself. The mean score on item E1 was the highest of the three epistemological belief sections for all of the student groups except AP females.

Table 18

Epistemological Beliefs T-Tests by Gender/Ability Group

	Student Group	Levene's F (p)	t (df)	Sig (2-tailed)
E1	AP/Non AP Females	5.60 (.021)[a]	.87 (26.28)	.393
	AP Males/Females	.95 (.335)	.72 (45)	.475
	AP/Non AP Males	.82 (.371)	.03 (45)	.975
	Non AP Males/Females	6.7 (.012)[a]	.12 (29.24)	.905
E2	AP/Non AP Females	.001 (.980)	2.67 (57)	.010**
	AP Males/Females	.29 (.591)	2.24 (45)	.030*
	AP/Non AP Males	1.90 (.175)	.10 (45)	.924
	Non AP Males/Females	1.14 (.290)	.16 (57)	.877
E3	AP/Non AP Females	.05 (.826)	2.21 (57)	.031*
	AP Males/Females	.85 (.362)	1.06 (45)	.294
	AP/Non AP Males	1.42 (.240)	2.1 (45)	.832
	Non AP Males/Females	.28 (.599)	.78 (57)	.439

a Equal variance not assumed
*Significant at $p<.05$, **Significant at $p<.01$

Science and Mathematics Self-Efficacies

Between AP and non AP females, identical statistically significant differences were found in mean scores for science self-efficacy (t=3.04, p=.004) and mathematics self-efficacy (t=3.03, p=.004). There were no significant differences between scores of AP females and AP males, nor between non AP females and non AP males on either measure. Table 19 reveals that AP females had the highest mean score (on a scale of 1 to 8) of all groups for science self-efficacy (M=7.08) and mathematics self-efficacy (M=7.19). In addition, non AP females outscored non AP males, who had the lowest mean scores in both science (M=6.15) and mathematics (M=5.83) self-efficacy.

Table 19
Mean Self Efficacy Scores for Science and Mathematics

	SSE		MSE	
	M	sd	M	sd
Males	6.59	1.07	6.42	1.18
AP	6.92	.84	6.85	1.10
Non AP	6.15	1.20	5.83	1.03
Females	6.53	1.06	6.63	1.08
AP	7.08	.79	7.19	.82
Non AP	6.25	1.08	6.35	1.10

Significant differences were also found between mean scores of AP and non AP males for science self-efficacy (t=2.58, p=.013) and mathematics self-efficacy (t=3.23, p=.002). As seen in the ANOVA results presented in Table 20, differences in mean scores account for 17.1% of the variance in mathematics self-efficacy scores ($F_{3,102}$ =6.99, p<.001) and 13.5% of the variance in science self-efficacy scores ($F_{3,102}$ =5.32, p=.002).

Table 20

ANOVA for Science and Mathematics Self-Efficacies

		Sum of Squares	df	Mean Square	F	Sig.	η^2
SSE	Between Groups	16.02	3	5.34	5.32	.002	.135
	Within Groups	102.41	102	1.00			
	Total	118.43	105				
MSE	Between Groups	22.68	3	7.56	6.99	.000	.171
	Within Groups	110.33	102	1.08			
	Total	133.01	105				

Since differences were not seen between the genders within either ability group, but were found between AP and non AP students of each gender (as shown in Table 21), results suggest that science and mathematics self-efficacies may both play prominent roles in AP physics enrollment for both males and females.

Table 21

Science and Mathematics Self Efficacy T-Test by Gender/Ability Group

	Student Group	Levene's F (p)	t (df)	Sig (2-tailed)
SSE	AP/Non AP Females	3.67 (.061)	3.04 (57)	.004**
	AP Males/Females	1.37 (.248)	.65 (45)	.517
	AP/Non AP Males	1.62 (.210)	2.58 (45)	.013*
	Non AP Males/Females	.11 (.737)	.32 (57)	.750
MSE				
	AP/Non AP Females	2.76(.102)	3.03 (57)	.004**
	AP Males/Females	1.11 (.298)	1.16 (45)	.251
	AP/Non AP Males	.001(.981)	3.23 (45)	.002**
	Non AP Males/Females	.15 (.697)	1.76 (57)	.085

*Significant at $p<.05$, **Significant at $p<.01$

Research Question Two

Research questions two asks "Which factors defined in this study are most strongly associated with female enrollment in AP physics?" After examining the effects of various factors on the separate student gender/ability groups, research question two seeks to determine if any of these factors play a significant role in identifying females who elect to enroll in AP physics, which was the primary purpose of this study. Logistic regression analyzes the likelihood of belonging to a certain group, was utilized for this portion of the study. The dependent variable used in the analyses was enrollment in AP physics. The independent variables include reading, mathematics, and science FCAT scores; attitude factors R1, R2, D1, D2, D3; epistemological beliefs factors E1, E2, E3; science and mathematics self efficacy; and stereotypical views. The individual attitude and epistemological belief factors are defined as follows:

- R1: Science is relevant to everyone's life
- R2: Studying science should be enjoyable and self-satisfying
- D1: Learning science depends on effort and is learnable by anyone
- D2: Understanding science favors those who seek information from alternative sources
- D3: Learning science favors those with a prepared mind
- E1: Science is a coherent body of knowledge rather than a collection of isolated facts
- E2: Branches of physics are related by common principles

- E3: Some aspects of physics may need to be inferred instead of being measured directly

Stepwise logistic regression analyses were initially conducted separately for males and females which produced intercept models and tables of significance for all independent variables. Each variable was then entered individually by the researcher to determine its effect on the likelihood ratio (the unexplained variance of the dependent variable). If the inclusion of the variable reduced the likelihood ratio, it was retained in the model. The procedure of adding independent variables was continued until the model could no longer be improved.

For females, reading FCAT score was found to be the most significant predictor which reduced the likelihood ratio of 75.562 of the intercept model to 50.501 (see Table 22). With FCAT reading score held constant, three of the remaining independent variables were found to produce significant models when added as second predictor variables. Stereotypical views of women in science reduced the likelihood ratio to 18.049 (p=.009, Nagelkerke's R^2=.862). Science FCAT score reduced the likelihood ratio of the reading ability model to 41.407 (p=.028), and the epistemological belief factor E1 (Branches of physics are related by common principles) reduced the likelihood ratio of the reading ability model to 26.781 (p=.005). None of these three two-factor models could be improved by the addition of a third predictor variable. However, the best model was formed when science FCAT score and E1 were entered together as one block to the reading ability model. The interaction resulted in a reduction of the likelihood ratio to 13.296, a significance value of .022, and Nagelkerke's R^2

value of .903.

Table 22

Logistic Regression Models for Female and Male Enrollment in AP Physics

	Intercept Model	Model 1	Model 2	Model 3	Model 4
Females					
-2LL	75.562				
Factor 1		RFCAT	RFCAT	RFCAT	RFCAT
-2LL		50.501	50.501	50.501	50.501
Chi Square		25.061	25.061	25.061	25.061
Factor 2		SFCAT	E1	E1*SFCAT	SteVw
-2LL		41.407	26.781	13.296	18.049
Chi Square		9.094	23.721	37.206	32.452
Model Chi Square		34.155	48.782	62.267	57.513
Nagelkerke's R^2		.609	.779	.903	.862
Males					
-2LL	64.109				
Factor 1		D2	SteVw		
-2LL		41.866	37.287		
Chi Square		22.244	26.823		
Factor 2		R1	R2		
-2LL		17.961	17.948		
Chi Square		23.905	19.339		
Factor 3		SFCAT	D1		
-2LL		8.760	2.773		
Chi Square		9.201	15.175		
Model Chi Square		55.350	61.337		
Nagelkerke's R^2		.930	.979		

Using the same procedure as described above, analyses produced only two significant models for males, each consisting of three factors, which significantly predicted enrollment in AP physics. The first model (p=.027) contained two attitude factors D2 (achievement depends on personal effort and perseverance) and R1 (science is relevant to everyone's life), which reduced the intercept likelihood ratio from the initial intercept model value of 64.109 to 41.866 and 17.961, respectively. The third factor in this model was science FCAT score, reducing the likelihood ratio to 8.760 and producing a Nagelkerke's R^2 value of .930. The second model (p=.034, Nagelkerke's R^2=.979) consisted of stereotypical views as the most significant predictor (-2LL=37.827), followed by the attitude factors R2 (Studying science should be an enjoyable and self-satisfying experience, -2LL=17.948) and D1 (Science is learnable by anyone willing to make the effort, -2LL=2.773).

Research Question Three

Research question three asks "Is there a difference between AP and non AP physics females, or between AP physics females and AP physics males concerning an anticipated science related college major, and if so, which cognitive or motivational factors defined in this study, either solely or collectively, most strongly predict that choice?"

For the initial part of research question three, a significant difference was found only between the groups of AP and non AP females (p=.028) concerning an anticipated science related college major. Table 23 lists responses of undecided college major, non-science related major, and science related major as percentages within each student group. An additional student choice on the survey included "Not planning to attend college", however, it was not chosen by any of the 106 students in the sample and is omitted from the results.

Table 23

Anticipated College Major, as Percentages

Intended Major	AP Females	Non AP Females	AP Males	Non AP Males
Undecided	10	7.7	25.9	20
Non Science Related	5	41	11.1	40
Science Related	85	51.3	63	40

Since the dependent and independent variables are both categorical, the non-parametric Mann Whitney U test was conducted, and related z-scores were examined in order to determine if differences existed between groups. Table 24 shows the only statistically significant difference in an anticipated science related college major to be between the groups of AP and non AP females.

Table 24

Group Differences in Anticipated College Major

	Males/ Females AP	Males/ Females Non AP	AP/ Non AP Males	AP/ Non AP Females
Mann-Whitney U	210	326	216	273
Z Statistic	-1.65	-1.13	-1.29	-2.19
Significance	.099	.259	.196	.028*

Note: Negative z values indicate rank sums are lower than expected values
*Significant at $p<.05$

The second part of research question three regards the identification variables that may predict students' choice of a science related college major. For females and males in AP physics, no factors identified within this study were found to be significant predictors (see Table 25). However, significant models were identified for non AP females (p<.001) and non AP males (p=.003). In order to determine whether individual variables influenced the likelihood of choosing a science-related college major, a logistic regression analysis was conducted.

Table 25

Regression for College Major Predictors

	AP Females	Non AP Females	AP Males	Non AP Males
Null Model				
-2LL	7.72	95.27	17.23	22.18
Step 1				
Variable Entered		R1		RFCAT
-2LL		71.40		8.32
Chi-Square		23.87		13.86
Significance		.001		.003
Step 2				
Variable Entered		MSE		
-2LL		21.39		
Chi-Square		50.01		
Significance		.002		
Final Model				
Chi Square		73.88		13.86
Significance		.000		.003
Nagelkerke's R2		.874		.773

Results indicate that none of the variables used in this study predict college major choice for AP students, regardless of gender. However, two predictor variables were identified as significant for the group of non AP females. The attitude factor R1 (p=.001) and mathematics self-efficacy (p=.002) predict a final model statistically significant at p<.001.

For the group of non AP males, one significant predictor, FCAT reading score, produced a model of significance p=.003.

Research Question Four

Research question four asks, "Is there a relationship between student involvement in school related activities and enrollment in upper level science?" Students' extra-curricular activities were divided into two groups, and coded EC1 and EC2. EC1 includes involvement in academic and non academic clubs, chorus, drama, and band. EC2 includes involvement in school sports (either team or individual), cheerleading, or dance and drill teams. No significant results were found for either AP or non AP females.

Initially, a portion of this study was intended to determine the effects of peer relationships on science related attitudes and self-efficacies, as well as determine if peer relationships play a significant role in the persistence of upper level science of high school females. Unfortunately, the instrument intended to measure the information was not approved by the school district, and submitted revisions to the objectionable questions were also denied. Therefore, a very general questionnaire regarding involvement in extra-curricular activities was generated and, upon district approval, the research question was revised. Although it is felt that extra-curricular activities may play an important role in science education research, the questions used on this portion of the survey were very general, and did not categorize activities, or participation in such activities, efficiently. Therefore, the results presented for research question four may not be an accurate measure of extra-curricular activities of students, nor an accurate representation of how activities correlate with AP physics enrollment of males or females.

Cross tabulation results presented in Table 26 show that for males, involvement in school related activities (p=.024) and school related sports (p=.034) are significant predictors of AP physics enrollment. Since neither predictor variable was a significant factor for female enrollment in AP physics, results may indicate evidence of association between extra-curricular factors and enrollment in AP physics for males.

Table 26

Chi-Square Results of Extra Curricular Activities

	EC1	EC2
AP Females (N)	18	14
Non AP Females (N)	37	30
Chi Square (df=1)	.50	.33
Significance (2-tailed)	.60[a]	.56
AP Males (N)	26	14
Non AP Males (N)	13	16
Chi Square (dr=1)	5.94	4.48
Significance (2-tailed)	.024[a*]	.034[*]

[a] Significance based on Fisher's exact test
[*] Significant at $p<.05$

CHAPTER FIVE: DISCUSSION

The purpose of this study was to examine factors that play a role in enrollment and achievement in advanced level high school science, as well as those that may affect college major and career choices of females. The need to understand how cognitive and motivational factors may be related to each other and to knowledge acquisition has been expressed extensively in educational studies. However, most prior research has focused on gender differences and has not examined factors that may differ between girls who choose higher level physical science courses and those who do not. The factors included in this study were considered relevant because of the numerous studies that have shown them all to play vital roles in the overall achievement and persistence of students in science.

Results of the current study agree with much of the previous research that has found the factors utilized for this investigation to be important in science achievement of all students, regardless of gender. As expected, significant differences were found between AP and non AP females for most of the variables, but very few differences were found between AP females and AP males, which contradict most of the past research claiming ability and motivational gender differences in science. Within this study, when significant differences were found between the AP and non AP groups of males and females for any factor, that factor was not considered to be a unique variable for female enrollment or achievement in AP physics.

The results of this study also disagree with a majority of the literature that has for the past 40 years reported factors such as lack of interest, self-confidence, and ability as being responsible for the under-representation of females in science. According to Jeffe (1995), such assertions imply that these personal characteristics are common to all females, and such inadequacies are historical. If this were true, many of the scientific breakthroughs that have benefited humankind probably would not have occurred. Unfortunately, many scientific achievements and contributions made by women have not always received the recognition they deserve, but that is not due to women's' lack of persistence in science over the past century.

Over the years, the enrollment of females compared to males in the physical sciences did not begin to decline until the early 1900's, and up until that point, women were found capable of competing successfully with males (Solomon, 1985). Enrollment of girls in high school and college continued to grow (Clifford, 1993), and females from all socioeconomic classes were more likely to attend and complete high school than males (Solomon). But when the American schools began to evolve, it was the environment of the schools, not the sex-related characteristic of the girls, which caused the decline of participation in science (Jeffe, 1995). With the focus of public education turning to vocationalism, the curriculum was geared toward future occupational needs of males and females. While schools focused on training females to be efficient homemakers, wives, and mothers, their math and science requirements were slackened (Jeffe), and as a result, opportunities in the labor market became narrowed. In later years, as demands for secretarial and other non manual labor increased, schools responded by channeling females into courses required for that market, which led to even greater curricular restrictions. Just when women were given more vocational opportunities, their educational opportunities were being narrowed (Jeffe). As a result, women found themselves on an educational track designed for their possible "socially accepted" roles such as teaching, secretarial, clerical, and domestic. In the later 1930's when women's occupational opportunities expanded a bit, science related fields were limited to lower status positions such as instructor and research assistant.

Opportunities for women in science related fields have not appeared to have changed much over the past 60 years. In addition to societal and cultural impediments, the sciences themselves have contributed to keeping women away. Between the results of this study, review of the literature, and prior research, it is believed that this is the area in which our attention should be focused if we want to increase female participation in advanced science.

This final chapter provides an overview of significant findings of the study, as well as how the findings relate to previous research. These relationships, however, must be interpreted with caution since terminology and methodological procedures of other studies were not always similar in nature to this study. To conclude the chapter, implications for policy and practice, and recommendations for theory and future research are proposed.

What Gender Differences?

The primary intent of this study was to examine how cognitive and motivational variables may interact with one another in an attempt to differentiate between females enrolled in AP physics and those not in AP physics. However, in order to do so, analyses comparing the genders also had to be considered, which produced some unexpected and surprising results. For example, findings from the current study indicate very few gender differences within either ability group for any of these variables, and for the few gender differences that were detected, females outscored the males in all areas except science FCAT scores.

Table 27 displays the statistically significant differences found between mean scores for the AP and non AP gender groups, and for the ability groups within the genders, for each of the 14 variables examined in this study.

Table 27

Significant Differences (p value) Between Selected Groups

	Gender Differences		Ability Differences	
Variable	AP males/females	Non AP males/females	AP/non AP females	AP/non AP males
Cognitive Factors				
Reading	---	---	<.001	---
Mathematics	---	---	.006	.004
Science	---	.032*	<.001	---
Motivational Factors				
R1	---	---	<.001	.001
R2	---	---	.004	.008
D1	---	---	---	---
D2	---	.004**	.014	.002
D3	---	.018**	---	.003
E1	---	---	---	---
E2	.03**	---	.010	---
E3	---	---	.031	---
Science self-efficacy	---	---	.004	.013
Math self-efficacy	---	---	.004	.002
Stereotypical views	<.001**	---	.002	---

* Males have higher mean score

** Females have higher mean score

Significant differences between mean scores were found in 17 cases for the ability groups (10 for AP/non AP females, and 7 for AP/non AP males. In all of these cases, AP students outscored non AP students. For the gender grouping, only two significant differences in mean scores were found between AP males and females, and three differences found between non AP males and females. Interestingly enough, the only instance in which males outperformed females was the science FCAT score for the non AP students.

These results clearly disagree with most previous research that claim males outperform females in these areas. Based on the current findings, it may be more beneficial for studies to concentrate more on the differences between ability groups within each gender rather than focus on gender issues that actually may be obsolete.

Research Questions

In this section, the four research questions of this study will be addressed. The first question focuses on significant differences between AP and non AP females, or between AP females and AP males, and the second question seeks to determine if any of the significantly different variables between the two female groups may be predictors of AP physics enrollment. The third question goes a step farther, seeking variables that may predict females' choice of a science related college major. Research question four involved students' extra-curricular activities and the role they may play in females' interest in pursuing upper level science courses in high school.

Student Group Differences

Of the four gender/ability groups involved in the current study, AP females had the highest mean score on 13 of the 14 cognitive and motivational factors employed in the research. The only variable in which AP males had a higher mean score was the mathematics FCAT score. However, the difference in mean scores was so small (.04), it would be fair to say that AP males and AP females did not differ. Additionally, significant differences were found between AP and non AP females for 11 of the 14 factors, but for six of these factors, the same differences were also found between AP and non AP males. Therefore, even though these factors appear to play important roles for advanced science achievement, they seem to influence choices for both genders and are not unique to females.

In the current study, the five factors that were significantly different between the two female groups, and possibly playing a role in females' choice of enrollment in AP physics, include reading and science ability, as measured by 10^{th} and 11^{th} grade FCAT scores, respectively; stereotypical views toward women in science, and two of the three epistemological beliefs factors (E2 and E3). While AP females had the highest mean scores on all of these, non AP females had the lowest score on reading and science ability and both epistemological beliefs factors.

Academic Ability

The major goal of this study was to identify factors unique to female participation in AP physics, and the academic areas of reading and science, as measured by FCAT scores, distinguished AP from non AP females. AP females had the highest mean score in both areas, while non AP females had the lowest mean scores in both areas.

It seems common sense that higher academic ability plays a role in higher educational and career aspirations, and that prior knowledge is an important factor in determining how well students learn new information. However, Singh et al., (2002) assert that by the time students reach high school, educational aspirations are already determined based at least partly on previous academic success. Results of the current study support such claims since students enrolled in AP physics were found to have higher FCAT mean scores in all three academic areas examined, as well as higher educational and career goals.

Of the three academic domains investigated, mathematics ability was the only area in which significant differences were found between AP and non AP students of both genders (females: $p=.006$, males: $p=.004$). Findings support claims that mathematics is a significant academic area affecting achievement in upper level science (e.g., Vanleuvan, 2004) for all students, and not just females. The current data does not support prior research that found mathematics ability to differ significantly between high ability males and females (e.g., Matsumoto, 1995), which often based results on highly selective data such as SAT scores (e.g., NCES, 2004). For the current study, very minor differences were detected between mathematics scores of males and females within both ability groups, which agrees with previous research that used more representative student samples and data (e.g., Catsambis, 1995)

Stereotypical Views

Of the four student groups in this investigation, the AP females held the fewest stereotypical views toward women in science (M=4.35) of any group, and scores for females were significantly correlated with enrollment in AP physics (r=.330, p<.01). Additionally, the difference in mean scores was statistically significant between the AP females and the AP males (M=3.80, p<.001), favoring females. Interestingly, the non AP females (M=3.87) also had a mean score higher than the AP males, though non significant, but the difference between AP and non AP females was statistically significant (p=.002). There was no significant difference found between the mean scores of AP and non AP males for this variable.

These results appear to be somewhat mixed and confusing, some of which support previous findings while other parts disagree. Since this is an area in which numerous research studies have focused solely upon and still have not been able to determine the exact causes of stereotypical views of students, it is well beyond the scope of this investigation to try to determine the "why" of previous published studies. Instead, the idea behind this study was if stereotypical views could be identified as a major factor that is hindering enrollment and achievement of females in AP physics, it would be an area worth of more in-depth investigation in future research. Stereotypical views toward science and their effects on female science enrollment and achievement are factors that are commonly included in science related attitude research. However, after a review of the literature, often claiming stereotypical views to be a major factor in gender differences (e.g., DeBacker and Nelson, 2000), it was decided that stereotypical views toward science may potentially be a very significant factor in this study and was therefore examined as a separate factor rather than as a component of attitude. Findings suggest that stereotypical views do indeed play an important role in science education, but possibly in a different way than originally thought.

Even in today's highly technical society, science, mathematics, and computer technology continue to be viewed as a male domain by much of society, and therefore, by many students (Tindall & Hamil, 2004). Since many past studies have discovered such stereotypical views toward science to be negatively correlated with science related achievement, persistence, and self-efficacy for girls (Ethington, 1991; Singh et al, 2002), it was considered a factor well worth investigating for this study. Most studies have found students of both genders to rate the physical sciences as masculine (Kahle & Meece, 1994), and males to possess greater stereotypical views toward the physical sciences, as well as science-related careers (e.g., Greenfield, 1997), and results of this study concur.

Epistemological Beliefs

Once again, the AP female group outscored all other student groups on each of the epistemological belief factors, while the non AP females had the lowest mean score on all three factors. This finding partially supports prior research that has found females to hold more sophisticated views than males in the area of knowledge stability (Bendixen et al., 1998) since it was found only for the AP female group. But perhaps more importantly, AP females were found to hold consistent views in all aspects of science related epistemological beliefs. Questions on the student survey were divided among the following three constructs:

- E1: Science is a coherent body of knowledge rather than a collection of isolated facts

- E2: Branches of physics are related by common principles
- E3: Some aspects of physics may need to be inferred instead of being measured directly

Significant positive correlations were found between factors E1 and E2 (r=.528, p=.017), and between E2 and D1(r=.628, p=.003). Factor D1 represents the view regarding the ability to learn science, and specifically measures whether students view the learning of science to be a gradual process by anyone willing to put in the effort, or as inherent trait determined by genetics. Research studies sometimes include this factor in the definition of epistemological beliefs, however, it has not always been supported as such (e.g., Hofer & Pintrich, 1997). Therefore, this factor was included in the readiness to learn section of attitude factors used in this study and is discussed in subsequent sections.

The mean scores between the two female groups were significantly different on factors E2 (p=.01) and E3 (p=.031), both of which were measurements relating to the complexity of physics knowledge. However, neither of these factors was found to be predictors of female enrollment. There were no significant differences found between the two male ability groups, which suggest that epistemological beliefs may play a part in female enrollment in AP physics. In addition, this was one of the few areas in which a significant difference was found between AP females and AP males. For factor E2, a significant difference (p=.03) was found between the mean scores of the genders in AP physics, in favor of the females. No significant differences were found between the mean scores of non AP males and females on any of the three factors. Interestingly, non AP males had slightly higher means on factors E1 and E2 than AP males.

Epistemological beliefs refer to ideas about the origin, nature, and processes of knowledge (Hammer, 1994), and views within academic domains can range from naïve to sophisticated (Hofer & Pintrinch, 1997). For example, the naïve student views knowledge acquisition as a simple process of collecting isolated facts believed to be the absolute truth, while the more sophisticated view regards knowledge acquisition as a complex process of gradually acquiring and inter-relating information. Within the educational setting, beliefs about the learning tasks at hand may guide the behavior of students, as well as subsequent performance. As research emerged on the topic of epistemological beliefs with regard to specific areas of knowledge, studies have begun to focus on student beliefs about knowledge within particular academic domains (e.g., Hofer, 2000).

Most of the reviewed research, however, examines epistemological beliefs with respect to various cognitive learning outcomes such as strategy use and academic achievement, but neglect other essential motivational factors (Buehl & Alexander, 2001). Therefore, the intent of this study was to include the epistemological belief factor in order to examine its effect on student learning in conjunction with academic ability as well as achievement motivations. This model is not meant to be comprehensive, but instead, represent a step in exploring how students' epistemological beliefs toward science relate to various ability and motivational factors.

Much of the previous research has found that even though females generally do not consider themselves to have the ability to perform well in the physical sciences, they tend to receive higher class grades (Halpern et al., 2007). This could be related to previous claims that students with more sophisticated epistemological beliefs usually outperform those with a more naïve outlook (Schommer, 1994), which has recently been supported by Lan and Skoog (2003) who found that with the exception of self-efficacy, epistemological beliefs had the strongest relationship with science learning. According to Hammer (1994), when students view learning science as a simple process of collecting and memorizing facts, they tend to use rote learning to memorize facts and definition, be more impulsive, and jump to quick answers. Conversely, when students view learning science as a complex, gradual process, they are more apt to engage in more meaningful learning by using a variety of higher level strategies such as organization and elaboration. Additionally, students with more sophisticated views toward learning science are comfortable even if no definitive answer is found, while the naïve student may become frustrated and give up (Kardash & Howell, 1996). The findings of the present study, again, somewhat support these findings. For the AP female group, E2 was positively correlated with science ability ($r=.473$, $p=.035$). However, the only other significant correlation found with ability was for non AP males, whose E1 mean score correlated with mathematics ($r=.544$, $p=.013$).

Additional Findings

The motivational factors analyzed in this research study included attitude, stereotypical views toward women in science, science and math self-efficacy, and epistemological beliefs toward science. Although they have all been held somewhat accountable for the lower enrollment rates and underachievement of females in advanced level science, stereotypical views and attitude toward science appear to stand out in the literature as playing the most prominent role in the perceived science education problem. Keeping in mind that the definitions, as well as the methods of measurement, of motivational factors changes from study to study, the results of the current study disagree with findings that claim girls' under-representation in science is due to such factors.

It was somewhat difficult to compare the results of this study to that of previous research concerning motivational variables such as self-efficacy, or science attitude for several reasons. First, many studies have focused on motivational change between students in elementary school and those in middle school, or between students in middle school and high school (e.g., Farenga & Joyce, 1998; Jones et al., 2000), most of which agree that motivation and aspirations to excel in science become more negative as students progress through the grades. Many other studies have focused exclusively on gender differences in science related attitude and self-efficacy, with most supporting the finding that males have a more positive science related attitude than females (e.g., Catsambis, 1995).

Attitude

In the current study, the AP female group had the highest mean score of the four student groups on all five of the attitude factors, and the non AP girls outscored their male counterparts on all five factors as well. Therefore, it appears that females view science just as relevant, if not more so, than males, and do not appear to have a negative attitude toward the learning of science. It must be noted, however, that the questions contained in the survey related to science in general, and did not specifically question students' attitudes about the relevance or learning of physics. For this study, science-related attitude was divided into the two categories of relevance (R factors) and readiness to learn (D factors). The relevance questions are designed to measure student attitude concerning the relevance of science to everyday life, and the readiness to learn questions are used to measure student attitude toward learning science. These two categories were then subdivided into the following five factors, each consisting of either two or three questions:

- R1: Science is relevant to everyone's life
- R2: Studying science should be enjoyable and self-satisfying
- D1: Science can be learned through effort
- D2: Understanding science favors those who seek alternative sources of information
- D3: Understanding science favors those with a prepared mind

Although few studies were found in the literature that paralleled the intent of this study, findings support those of Weinburgh (1995), who found high performing girls to have more positive related attitudes than all levels of boys but disagrees with the finding that at the general ability level, boys have more positive science related attitudes than girls.

A second relevant finding is that although no significant differences were found between AP females and AP males on any of the attitude factors, there were significant differences found between AP and non AP females on both relevance factors, and on one learning factor (D2). Factor R2 asks students to rate the experience of learning science as either enjoyable or frustrating. AP females had a higher mean score (4.15 out of 5) than did

AP males (M=4.04), and non AP females had a higher mean score (M=3.56) than their male counterparts (M=3.47). Although neither of these differences were significantly different, statistically significant differences were found between the mean scores of AP and non AP females (p=.004) as well as between the mean scores of AP and non AP males (p=.008).

The claim that girls attribute successful science achievement to luck or effort while boys credit their success to ability (e.g., AAUW, 1992; Graham, 2001) is also refuted by the results of the current study. For factor D1, which asks the opinion of students on whether talent or effort is most responsible for science learning, the mean score of females was 3.53, compared to 3.31 for males. This shows that, overall, females regard effort as playing more of a role in learning than inherent talent for learning science.

These findings also support previous studies that claim the attitudes of high ability girls and boys are more alike than those of high ability and average ability girls (Kahle & Lakes, 1983; Silverman, 1986). At first glance, the fact that significant differences were detected between AP and non AP females for three of the five attitude factors may lead to the conclusion that attitude plays a role in advanced level science enrollment of females. But, upon further inspection of the results, it was found that the same three factors were significantly different for AP and non AP males as well. This may suggest that although the factors of relevance and willingness to learn science are common to advanced level students, they cannot be considered factors unique to female enrollment. In addition, a significant difference was also found between AP and non AP males on a fourth attitude factor (D3), therefore, willingness to learn science may play a larger role in male rather than female enrollment in advanced science.

Results from years of research has documented that success in science is at least partially dependent on a positive science-related attitude (e.g., Catsambis, 1995; Simpson & Oliver, 1990). But, the term "attitude" encompasses a multitude of behaviors and has been applied to several contexts with a variety of meanings. Most instruments used to measure student attitude aim to evaluate favorable or unfavorable feelings toward something, but the inadequacies associated with the closed item questionnaire design most often used, may be blamed for contradictory results (Kobella, 1989). Reliable and valid measures of student attitude are a must in assessing change, yet according to Kobella, the absence of a systematic plan for establishing validity is a common flaw of most attitude-measuring instruments. Therefore, the questions used for the questionnaire in this study were taken from the Views About Science Survey (Halloun, 1997), which incorporates the Contrasting Alternatives Design, allowing students to choose answers that range from the expert view to the folk, or naïve view. The questions selected were not intended to measure the extent of how much students like or dislike science, but rather, were designed to measure attitude pertaining to the specific areas of relevance and learning science.

Self-efficacy

The results of the current study found females of both ability levels to possess higher self-efficacy than males for both academic domains reviewed. For science self-efficacy, AP females scored an average of 7.08 on a scale of 1 through 8, while AP males' mean score was 6.92. For the non AP groups regarding science self-efficacy, the mean female score was 6.25, compared to 6.15 for males. The same pattern held true for math self-efficacy, where AP girls outscored AP boy by .34 points, and non AP girls outscored non AP boys by .52 points. Although none of the differences between genders were significant, they are inconsistent with most prior research that claims this to be another area in which boys outperform girls (e.g., Marsh & Yeung, 1998).

Predictors of Female AP Physics Enrollment

In each of the four models produced through logistic regression analysis for female enrollment, two predictor variables were identified, with reading ability as the most significant predictor in all four. Science ability, one epistemological belief factor (E1), and stereotypical views were all found to be individual significant predictors when reading ability was held constant, which is consistent with the factors found to be significantly different between AP and non AP females. However, the best model (according to the Nagelkerke's R^2 value) was found with the interaction of E1 and science ability as the second factor in addition to reading ability. In the current study, logistic regression analyses were used to determine predictor variables. Although logistic regression does not produce a percentage of variance explained within each model, Nagelkerke's R^2 was used in these analyses to measure the strength of association between variables. The following section discusses each of the significant variables, and how these findings relate to the current literature pertaining to female enrollment in advanced level science.

Academic Ability

It was found that the reading FCAT score (p<.001) was the most predictive factor for females in all four significant models produced. This result was further confirmed by the significant correlations found between female enrollment in AP physics and reading FCAT score (r=.441, p<.001), and science FCAT score (r=.582, p<.001). Further, there were no correlations detected between male enrollment in AP physics in either science or reading ability (see Table 28).

Table 28

Correlations Among Selected Variables by Gender

	Enrollment in AP Physics	
	Females	Males
Reading FCAT	.441***	
Science FCAT	.582***	
Mathematics FCAT	.354**	.412**
R1	.407***	.494***
R2	.371**	.381**
D1	.261*	
D2	.318**	.490***
D3		.421**
Stereotypical views	.398**	
Science major	.330**	

*Significant at p<.05, **Significant at p<.01, ***Significant at p<.001

In a preliminary regression analysis, all three FCAT scores were entered into a logistic regression as a single block, which was found to be a significant predictor of AP physics enrollment for females. Scores were then entered as individual factors to determine whether the interaction effect of all three or individual effects had the most influential predictive power

Reading

In the current study, the determination of reading ability as the most significant factor predicting female AP physics enrollment supports the fairly consistent literature that reports the understanding of science is dependent on proficient reading skill (Flick & Lederman, 2002), and when effective learning strategies are used in conjunction with comprehensive reading, increased cognitive engagement and understanding are promoted (Wade, Buxton, & Kelly, 1999). Additionally, success in science has previously been linked to text learning (McNamara et al., 1996) which, in turn, requires students to employ competent reading skills for comprehension of science texts (Wade et al.). This is further supported by the high to moderate correlations found in this study for student groups between reading and science FCAT scores (see Appendix H). Another plausible speculation that connects the three domains of science, reading, and mathematics would be consistent with research that has shown poor reading skills limit students' problem solving abilities, especially in higher level mathematics and science classes where problems are often word based (Helwig, Rozeck-Tedesco, Tindal, Heath, & Almond, 1999; Wang & Goldschmidt, 1999).

The differences found between AP and non AP females in reading scores may lie in the area of study or reading strategies, or in learning styles, neither of which were explored in this study. Therefore, it appears that study strategies such as summarizing, outlining, and questioning should be an integral part of science instruction beginning in elementary grades. All students should be encouraged to find strategies that work best for them, and learn to use them consistently when reading a science textbook. The connection between reading and physics achievement may also be linked to motivational factors, since reading a science textbook is often a student's choice (McCrudden, Perkins, & Putney, 2005; Wigfield et al., 2004), and the amount of self-initiated reading has been related to the prediction of science knowledge (Sweet, Guthrie, & Ng, 1998; West & Stanovich, 1995). Schiefele (1996) found that students with a higher interest in subject domains use effective learning strategies more often, which promote text understanding. When students are motivated in an academic area, they are more likely to read more often both inside and outside of the school setting, strive to improve their reading skills, and build upon their knowledge base in that academic domain through reading (Wigfield & Guthrie, 1997). Benware and Deci (1984), claim that when students read due to intrinsic motivation, they are better able to establish relationships between the text and prior knowledge, and show a better understanding of the material. Reading may also assist in mastering the technical language necessary for science understanding, especially for the more complex information contained in the advanced level courses (Erick & Samford, 1999).

Prior science knowledge

Science ability, as measured by FCAT scores, was a second significant factor for female enrollment in AP physics when reading ability was held constant. As seen in Table 28, this result is supported by the high positive correlation between the two variables for females (r=.582, p<.001). For males, science ability was also included as a predictor in one of the two models produced for AP physics enrollment, but only after the two attitude factors of D2 and R1 were held constant. It must be noted, however, for all four student groups, the mean science FCAT scores were significantly lower than mean scores in the other academic domains of mathematics and reading. For AP and non AP females, mean science scores were .8 and 1.29 points below those of mathematics, respectively; and .55 and .57 below those in reading. For males, the same pattern for science scores held true. Males enrolled in AP physics scores 1.04 points higher in mathematics, and .52 points higher in reading, while the non AP males scores .85 points higher in math and .35 points higher in reading. This finding was unexpected, since the participants had taken the science portion of the FCAT in two consecutive years, and the cause for such low mean scores is still not clear.

One explanation may be that since a passing grade on the reading and mathematics portions of the FCAT is a requirement for high school graduation, students consider those areas to be more important. However, the results of the science portion had no effect on student graduation, and therefore some students may have taken it a little less seriously. A second explanation may be that because of the high stakes placed on the mathematics and reading portions concerning school funding and rating, more emphasis is placed on preparing students for those two sections of the exam by the administration and teachers of every subject area, whereas preparation for the science portion of the exam is usually the sole responsibility of the science teachers. A third explanation may be that students, regardless of gender, have lower achievement rates in science than in the other two subject areas, which has been the concern of educators for the past three decades.

Although it was not the purpose of this study to identify factors that may identify low science FCAT achievement, it may be a place to start in future studies, especially when that portion of the test begins to become more influential for students, teachers, schools, and districts.

Stereotypical Views

If females, in general, hold less stereotypical views than males toward science, why are there fewer females enrolling in advanced level science and pursuing science related careers? Results of males possessing more stereotypical views toward science appear to be common throughout the literature, but make one wonder why then, if females, regardless of ability level, don't consider science to be a male-dominated domain, they are not enrolling in science majors and seeking science related careers at the same rate as males.

In their 1998 study, Farenga and Joyce examined the views toward science of high ability 9-13 year olds, and found the normality of scientists to be the primary predictor of science course selection for girls, but not for boys. Results of the current study agree somewhat with these findings as well. When reading ability was held constant in the logistic regression analyses, one model for AP physics enrollment for females identified stereotypical views as a significant predictor. But the role of stereotypical views toward science for male enrollment in AP physics was not as clear. Contrary to most of the reviewed literature concerning the views of males, the stereotypical view toward women in science was a primary predictor in one of the two models produced for the enrollment of males in AP physics. This could possibly be rationalized by the idea that it's natural for males to be more interested in fields considered to be male dominated, and therefore, will more readily enroll in the physical sciences over females. Females, on the other hand, may view the sciences as areas in which women are capable of excelling, but the reality of the potential difficulty of balancing a science career with the domestic responsibilities often expected of them, may hold many back.

Even though females do not consider science to be as highly male dominated as males, it still appears to play a meaningful role in their reluctance to enter the scientific field, especially in physics and engineering. Such views are thought to be influenced by several biological, developmental, environmental, and socio-cultural factors. Although the extent of the role each of these factors play in the decision of females remains unclear, we do know that some of the affects are from the different social roles society has built into our culture (Tindall & Hamil, 2004).

Epistemological Beliefs

Reading ability was the primary predictor of female enrollment in AP physics for this study, although there were no significant correlations found between reading FCAT scores and any of the epistemological belief factors for any of the four groups. But, for females, factor E1 was a second significant predictor of enrollment in AP physics. In one of the four models, reading ability was followed by factor E1, producing a Nagelkerke's R^2 of .779. More importantly, another model showed that the interaction effect of E1 and science FCAT score, in addition to reading ability, produced the most predictive model with a Nagelkereke's R^2 of .903. Since very few studies have focused on the relationship between epistemological beliefs and academic ability of females, it may be an area in which additional research would prove to be beneficial.

The claim that more sophisticated epistemological beliefs lead to higher academic achievement (Kardash & Howell, 1996) has been taken a step further and connected specifically to reading ability. Tsai (1999) found that students holding more sophisticated views generated more ideas of greater complexity from text reading, used higher level reading strategies (Schraw et al, 2002), and held fewer misconceptions. Previous literature has also linked epistemological beliefs to motivational factors used in this study as well. Bandura (1997) claims that perceptions of what knowledge is, viewed in relation to students' beliefs about their own abilities, may affect self-efficacy. This has been supported by subsequent research (e.g., Hoffer, 1999; Wigfield & Eccles, 2000) which has found student beliefs about the nature of knowledge in a specific domain affects perceptions of the difficulty of the learning task. While no correlations were found between any of the epistemological belief constructs and science self-efficacy for either female group, significant correlations were found between factor E3 and science self-efficacy (r=.416, p=.031) for AP males, and between factor E1 and science self-efficacy (r=.467, p=.038) for non AP males. However, none of these factors were found to be significant predictors of AP physics enrollment for males.

Additional Findings

Although reading ability, prior science knowledge, one epistemological belief factor (E1), and stereotypical views were the only predictors of female enrollment in AP physics found through logistic regression, significant positive correlations were found for several other variables. For females, significant correlations between enrollment in AP and the attitude factors of R1, R2, D1, and D2 were found (see Table 28), which happened to be the four factors that were significant predictors for males. This tells us that regardless of gender, AP physics students hold higher positive science related attitudes than those students not enrolled in AP physics. Therefore, attitude may still play an important part in female enrollment in higher level science classes, which agrees with studies that claim positive science attitude is related to higher level course selection and achievement (Reynolds & Walberg, 1992; Singh et al, 2002).

Other factors examined in this study which have often been related to female enrollment in advanced science courses include self-efficacy (O'Brien et al., 1999), and mathematics ability (Vanleuvan, 2004). For females, a significant difference between the AP and non AP groups for science related self-efficacy ($p=.004$), as well as mathematics self-efficacy ($p=.004$) was found. Again, these results may at first appear to show that self-efficacy in both of these academic domains to be important in female AP physics enrollment. However, significant differences were also found between AP and non AP males (science: $p=.013$, mathematics: $p=.002$), which agrees with claims that self-efficacy is a critical component of success science achievement (Lopez & Bieschke, 1991). Since differences were found for both gender groups, it appears that self-efficacy in both of the domains is greater for higher achieving students, regardless of gender.

Although mathematics ability was not a predictor of AP enrollment for either gender, Table 28 shows that a significant correlation was found between the two variables for males ($r=.412$, $p<.01$) and females ($r=.354$, $p<.01$), maintaining the importance of mathematics achievement for successful performance in upper level science.

Predictors of an Anticipated Science Major

There was no significant difference between the number of AP females and AP males planning a science related college major, however, a statistically significant difference was found between AP and non AP females. Of the four groups of students, AP females had the highest percentage (85%) of students planning a science related major, followed by AP males (63%), non AP females (51.3%) and non AP males (40%). Through logistic regression analyses, there were no factors identified to be predictors on an anticipated science-related major for either AP group. However, for non AP girls, one model was produced which showed the R1 (science is relevant to everyone's life) to be the most significant factor, followed by mathematics self-efficacy. Nagelkerke's R^2 for this model was .874. For non AP males, the analysis provided one model with reading FCAT score found as the only predictor, producing a Nagelkerke's R^2 of .773. These results disagree with previous studies that have found high ability girls to possess lower career aspirations than their male counterparts (e.g. Kelly & Hall, 1994), and that males, in general, have higher science career interests than girls (Miller & Budd, 1999). Instead, current results support research that has found participation in upper level classes to be linked to motivation to pursue a science related career (e.g. Helmke, 1989; Farenga & Joyce, 1998). Although results are similar for both high ability males and females, the correlation between taking advanced science and the desire to pursue a science career suggests that early detection is critical in encouraging girls to pursue further studies in male dominated fields.

Mau, Domnick, and Ellsworth (1995) found a high correlation between educational aspirations of females and the pursuit of non traditional careers such as engineering, which may explain the findings of the present study in which females were more likely to be enrolled in AP physics if their educational aspirations were to pursue a science related college major. Yet, since similar results were also found for males, it would appear that intentions toward a science major or career may be a significant consideration for enrolling in advanced level science classes in high school for both genders.

Despite the fact that there were no predictor variables found for either of the AP groups, stereotypical views toward women in science ($r=.43$, $p<.05$) and science self-efficacy ($r=.43$, $p<.05$) were the only two factors that correlated significantly with an anticipated science major choice for AP females (see Table 29). O'Brien and Fassinger (1993) found that women with more liberal gender role attitudes were more likely to choose a non-traditional occupation such as those associated with science and math. For AP males, in addition to no factors being found through logistic regression as predictors of anticipated science college major, there were also no factors that were significantly correlated.

Table 29

Significant Correlations for Science College Major

	Intended Science Related Major Females	
	AP	Non AP
R1		.367*
R2		.346*
D2		.318*
SSE	.429*	
Stereotypical views	.505*	

*Significant at $p<.05$

Academic Achievement

Social cognitive theory claims career outcomes may be influenced by ability (Lent et al., 1994), and prior research has often documented clear relationships between the two (Benbow & Armjand, 1990). Singh and colleagues (2002) assert that by the time students reach high school, educational aspirations are determined based partly on previous academic success, and academic ability has been documented to be positively related to traditionality of career choice (Fassinger, 1990) and persistence in nontraditional majors (Benbow & Armjand). Additionally, it has been shown that prior knowledge is important in determining how well information is learned (e.g., O'Reilly & McNamara, 2002), which may be a determinant in career choices of students. However, Farenga and Joyce (1998) claim that even girls who perform well in the areas of high school mathematics and science are less likely to pursue a career in science.

Results of the current study found that although none of the academic factors had a direct affect on pursuing a science related college major and career, academic ability did play a paramount role in females' decisions to enroll in AP physics during high school. Reading and science ability as measured by FCAT scores were both found to be predictors of AP enrollment, and 85% of the AP girls anticipated a science related major.

Current findings do not agree with previous research that has found mathematics ability to play a role in students' selection of science related college majors (e.g., Trusty, 2002). Lee (1987) found mathematics performance to have the strongest direct effect on a science major choice in addition to gender. Although the higher achieving students were those enrolled in AP physics, and the AP physics students had a higher percentage of students planning to major in a science related field than their non AP counterparts, mathematics did not have a direct effect on science major choice within the logistic analyses for any of the four groups. However, mathematics ability, although not a predictor, was significantly correlated with AP enrollment for females ($r=.354$, $p<.01$), partially supporting findings that mathematics achievement affects upper level science achievement and related careers (Trusty, 2002; Vanleuvan, 2004). Results also support Benbow and Arjmand's (1990) suggestion that ability is positively related to non-traditional majors for females, and is related to nontraditional career choices (Fassinger, 1990).

Attitude and Stereotypical Views Toward Science

Despite the fact that the majority of the results concerning attitude in this study disagree with the common consensus of most of the literature that claims attitude toward science to be much lower for females than for males (e.g., Steinkamp & Maehr, 1984), and lower attitudes limit the number of career aspirations in the field of science since they are more predictive of science course selection for girls than for boys (Farenga & Joyce, 1998), science attitude did play a more important role for females than for males in planning the pursuit of a science based college major. Although there were no significant findings to link attitude with a science related college major, there were significant correlations found for non AP females for factors R1 (relevance of science, $p<.05$), R2 (enjoyment of studying science, $p<.05$), and D2 (achievement depends on personal effort, $p<.05$). This result was confirmed through logistic regression analysis which found factor R1 to be the most significant predictor of an anticipated science major for non AP females. Additionally, there were no predictors or significant correlations found for any of the attitude factors for a science college major for either of the male ability groups.

The fact that four of the five attitude factors were strongly correlated with enrollment in AP physics and that non AP females choosing a science major had higher attitude values than those choosing majors outside of science may support earlier theories that some girls consider science achievement to be too much work (Kahle & Lakes, 1983) or that science is an area more suited to males (Linn & Hyde, 1989; Wigfield & Eccles, 2000). Studies have also found that attitude toward science is fostered by many factors inside and outside of the school setting, and plays a significant role in persistence in science for girls (Farenga & Joyce, 1998). But since ability in all three academic domains was also correlated with enrollment, results may support Hertel's 1995 finding that attitude toward science is developed early due to positive/negative academic experiences.

Concerning stereotypical views, results of this study remained fairly consistent with current literature that suggest students who hold more stereotypical views toward science are less likely to pursue a science related career (e.g., Handley & Morse, 1984). Females in both ability groups held fewer stereotypical views toward women in science careers than the males. The group of AP females had the highest percentage of students planning a science related college major (85%), and the non AP females had a higher percentage of students planning a science related major than the non AP male group. Although stereotypical views was not a predictor of a science major, the two variables were significantly correlated for AP females ($r=.505$, $p=.023$). These results disagree with Kelly and Hall (1994) who found high ability girls had lower career aspirations that high ability boys, and Handley and Morse who claim high ability girls perceive the role of scientist to not conform to their social sphere of possible career options. For the non AP females, stereotypical views did not significantly correlate with an anticipated science major, nor was it a predictor determined by logistic regression. It was, however, a significant predictor of females' choice to enroll in AP physics. The AP male group had higher career aspirations than the non AP males, and although there was a negative, non significant correlation bound between stereotypical views and anticipated science major, it was a significant predictor for male enrollment in AP physics.

Many important career decisions are made during adolescence, and these decisions affect the rest of a person's life. Therefore it is important to understand the individual and social factors that play into the process of adolescent career development. O'Brien and Fassinger (1993), as well as Ahrens and O'Brien (1996), found that young women who selected traditionally male careers had high levels of ability and agency. Ability was measured by ACT scores, GPAs, and the number of math classes taken in high school; and agency was measured by scores on math self-efficacy, career decision making self-efficacy, and masculine items of the Bem Sex Role Inventory. Much of the reviewed literature has also found that despite holding less stereotypical views about which careers are appropriate for females and males, secondary students still exhibit significant gender differences in their preferences, with males expressing higher interest (e.g., Miller & Budd, 1999). However, many of these studies have divided students by gender and ethnicity, rather than gender and ability. For example, Catsambis (1995) found more 8th grade white males aspired to science careers than African-American females.

For females, interest in science and continued science course taking patterns has been found to be closely related to perceived usefulness in future career choices (Riesz, McNabb, & Stephen, 1997), but not many studies have focused on factors that are related to male career choice. Perhaps it has been assumed that males feel free to pursue either traditionally male or female career paths freely and logically, or inherently choose male dominated occupations more often. Or maybe male dominated occupations are viewed as superior to female dominated careers, whether by nature or income possibility, and therefore the struggle of males who limit themselves to the pursuit of traditionally male occupations has not been explored as often as the struggle of females who limit themselves solely to the pursuit of traditionally female careers.

There have been many studies that have focused on career aspirations of females (e.g., Farmer, 1985), but few that have specifically examined factors that predict mathematics or science related college major choice (e.g., Lips, 1992). Even fewer studies examining such factors were longitudinal in nature, which is necessary to determine if predictors found at the high school level are valid for a completed degree in science related fields. Analyses of the current data support the theory that students planning a career in a science related field are more likely to enroll in advanced level science classes in high school. Although a high percentage of females in AP physics intend to major in a science related field, over 50% of non AP females have the same intention, which indicates the need of additional studies. The data used for this portion of the analysis was very general, and did not specify the sub domain of intended science majors of students. For example, no distinction was made between plans to major in engineering or marine biology. Therefore, it is not known if more females in AP physics are choosing majors in the physical sciences while non AP females are choosing biological sciences, or vice versa.

Other possible factors that were not explored in this study, but could play a role in stereotypical views toward science and science related careers are socioeconomic level and hurdles imposed by societal sex role expectations. Rojewski and Yang (1997) found socioeconomic status to be the most significant indicator of low occupational aspirations, and McCandless, Lueptow, and McKee (1989) claim traditional gender stereotypes are more common in high income families. In addition, Betz (1994) found lack of support from both inside and outside of the educational environment may aid in women avoiding technical fields. Continuing research is necessary to explore how each individual factor affect views on science based careers of students in middle school, high school, adolescents who have dropped out of high school, as well as college students who are majoring in science and those who have changed their major from a science field to a non-science area. Science has traditionally discouraged female participation. Many more females than males leave the field, especially in physics. High school and college classes are competitive, and usually do not accommodate a variety of learning styles (Tindall & Hamil, 2004). What's worse is that there is still an overall denial of gender biases not only in the schools, but in society as well. When such biases discourage girls from entering science fields at an early age, they do not even consider it as an option by the time they reach high school (Graham, 2001). According to Shamai (1994), stereotyping limits students future decisions regarding various aspects of their lives, including choice of profession, and can potentially trap both sexes in traditional professions.

Science and Mathematics Self-Efficacy

The role of self efficacy in female career choice is significant throughout most of the literature (e.g., Crombie et al., 2005; Ethington, 1988), and results of the current study support such findings to some extent. Although science self-efficacy was significantly correlated with science majors for AP females, it did not play a role in non AP females' college major choice, nor was it significantly correlated with enrollment in AP physics for females. However, of all the variables investigated in this study, the attitude factor R1 (science is relevant to everyone's life) and mathematics self-efficacy appear to have had the greatest influence on aspirations of non AP females to continue in science in college. Science self-efficacy was significantly correlated with science major for AP females ($r=.429$, $p<.05$), but for non AP females, there was a significant negative correlation found ($r=-.549$, $p<.001$). Mathematics self-efficacy was a predictor variable for an anticipated science major for non AP females which supports previous findings that a deficit in mathematics self-efficacy among females is a key contributor to lowered interest in advanced science classes as well as in science and engineering related careers (Ethington, 1988; Hyde et al., 1990). It may be possible that although self efficacy does not significantly affect college major intentions, it may play a more important role in the actual choice made by college students.

According to social-cognitive theory, a person's beliefs about her or his ability to perform a task successfully have been shown to relate to a variety of perceived career options (Betz & Hackett, 1983), consideration of mathematics or science related majors (Lent, Brown, & Larkin, 1986), and persistence in science and engineering majors (Schaefers et al., 1997). In addition, self efficacy expectations may play a mediating role in the relationship between ability and career outcomes. For example, Hackett and Betz (1989) showed that mathematics self-efficacy mediated between the relationship between mathematics achievement and choice of a science versus a non-science major. Since this study did not include mathematics achievement of students, there is no way of knowing if this claim is supported. However, mathematics self efficacy was a major predictor of an anticipated science major for non AP females. Lent, Lopez, and Bieschke (1991) found that although students' ability measured through ACT scores were related to their choice of a science related career, this relationship was non significant when controlling for self-efficacy, thereby suggesting that self-efficacy mediated the relationship. In this study, none of the ability factors were found to be predictors of a science major for females, and for males, reading ability was the only predictor and none of the academic or self-efficacy factors were significantly correlated with their anticipated college major choice.

Summary

Many studies have been devoted to addressing the issue of women's low numbers in nontraditional fields in general. However, to understand predictors of women's involvement in advanced science related fields, research efforts must also examine the higher level career aspiration of women who have already selected and persisted in these majors. The independent effects of ability, attitude and stereotypical views, and self-efficacy on various outcomes concerning a science related college major have been clearly established as important. However, empirical investigations of the ways in which these variables may work together are needed in order to provide a more thorough understanding of women's under-representation in technical fields.

Motivation to learn science can be increased and improved through curriculum that focuses on creating meaning and relevance. When academic tasks are seen as relevant to the attainment of self chosen future goals, these goals lend both intrinsic and extrinsic value to that task (Miller, DeBacker, & Greene, 1999). For example, Meece, Wigfield, and Eccles (1990) found that students valuing of mathematics was the best predictor of intent to continue taking mathematics courses. By helping students identify future goals that are personally meaningful and help them understand how the study of science can aid them in achieving such goals, educators can potentially create a learning environment that is both intrinsically and extrinsically motivating.

Extra Curricular Activities

For this study, extracurricular activities were divided into EC1, which included academic and non academic clubs, drama, and band; and EC2 included sports, cheerleading, and dance and drill teams. Involvement in both groups of extracurricular activities was found to play a much more significant role for males than for females. Both EC1 and EC2 were predictors of AP physics enrollment for males, but neither were predictors for females. As shown in Table 30, EC1 significantly correlated with E3 (p=.024), and R2 (p=.014), and EC2 positively correlated with reading FCAT score (p=.047) for non AP males. For AP males, EC1 correlated significantly with mathematics self-efficacy (p=.015) and science self efficacy (p=.013). The only significant, positive correlation found for females was between EC1 and mathematics self efficacy (p=.046) for the non AP group. There were no positive correlations found for AP females.

Most of the reviewed literature concerning participation of students in extracurricular activities on school performance has generally been agreed upon as beneficial (Eccles & Barber, 1999; Mahoney & Statten, 2000). However, none of the reviewed studies divided students into gender/ability groups to determine differences, and often extracurricular activities were referred to as peer relationships (e.g., Mannell & Kleiber, 1997). But, peer relationships, especially at the high school level, often influence students' motivation to participate in extra curricular activities. Mannell and Kleiber (1997) found that as children grow older, relationships with peers become increasingly more important, and peers significantly influence choices in extracurricular activities during adolescence (Robertson & Shannon, 2002). For example, Hoff and Ellis (1992) showed that peers are particularly influential for sports participation for both males and females, and participation in school related activities have been found to be predictors of higher academic achievement and greater education aspirations (Eccles et al., 2003; Marsh & Kleitman, 2002).

Table 30

Correlations for Extracurricular Activities for Student Gender/Ability Groups

	Males		Females
	AP	Non AP	Non AP
EC1: Academic and Non academic clubs, band, drama			
E3		.503*	
R2		.538*	
Math self-efficacy	.465*		.322*
Science self-efficacy	.470*		
EC2: Sports, cheerleading, dance and drill teams			
RFCAT	.449*		

* Significance level at $p<.05$

Peer relationships have been connected to self-efficacy, attitude, involvement in science based activities, science course selection, science based career aspirations (Cooper et al., 1999; Marsh & Kleitman, 2002), and greater improvement in problem solving skills (Weissberg et al., 1997). Such claims were only partially supported by this study, where mathematics and science self efficacies of non AP males was significantly correlated with EC1, and mathematics self efficacy was correlated with EC1 for non AP females. In addition, EC1 and EC2 were predictors of AP physics enrollment for males, but not for females.

Structured activities have been found to provide students an opportunity to develop skills beneficial in academic and social settings, as well as promote subsequent educational and occupational attainment (Eccles et al., 2003). Participation in structured activities provide students with more positive connections to school (Gilman, 2001), and long term educational outcomes (Mahoney, 2000). Having a sense of belonging, such as that often felt by students involved in structured school activities, and being liked by others increases a student's sense of competence and satisfaction with friendships, family, and school experiences (Kaplan & Maehr, 1999). High self-satisfaction, in turn, is associated with increased self-efficacy (Gilman et al., 2000), and positive school experiences such as higher educational aspirations, increased enrollment in advanced classes, higher class grades, and more time spent on homework (Cooper et al., 1999). Astin (1996, 1999) asserts that of the three factors found to have the greatest impact on cognitive outcome; academic involvement, involvement with faculty, and involvement with peers, involvement with peers has the greatest influence on students' academic achievement.

Participation in team sports has been related to increased educational aspirations and higher levels of post secondary education (Marsh & Kleitman, 2002). Students involved in athletics in 10th grade were found to like school more at the 10th and 12th grade levels, had a higher 12th grade GPA, and were more likely to be attending college at age 21 (Eccles et al., 2003). However, there were no correlations found for either males or females in this study to support this claim. The only correlation found for participation in sports was to reading ability for the non AP males.

There were no studies found that were designed to specifically connect extracurricular activities to science achievement, enrollment in advanced level science courses during high school, or enrollment in a science based career. But females, in general, have been found to have a more positive image of themselves involved in science if their friends shared their views (Kahle & Lakes, 1983). This claim, however, is not supported by this research since there were no connections found for females between participation in extracurricular activities and enrollment in AP physics. This could possibly be due to the assertions that unfortunately, girls have fewer friends interested in science (Kelly, 1988), and girls have fewer science related conversations or activities with friends outside of school (Jovanovic & King, 1998).

A more valid and reliable instrument is needed to further research this portion of the study in order to determine effects extracurricular activities may have on science class enrollment, especially for females. It should evaluate data concerning extracurricular activities by more specific categories, such as science club, mathematics club, etc., and study the affects of each variable on science course enrollment. The reviewed literature also claims that it may be important to further research the possible connection between peer-related activities and science major undergraduates since many of these students change majors during their first and second year of college (Duncan & Dick, 2000).

Conclusion

From the results of past international testing in the domain of science, achievement of both males and females pose a concern, since American students consistently score below students of most other countries. This claim is supported by the current results that found prior science knowledge, as measured by science FCAT scores, to be the lowest of the three academic domains examined for both males and females. Results of this study provide support for the argument that learning must be viewed as a multidimensional process involving the interplay of cognitive and motivational variables. Results have also contributed to our understanding of how cognitive and motivational factors are related to each other pertaining to the enrollment of students in upper level science, and enrollment in science related college majors.

Even though this study was not initially focused on gender differences between students, it appears that the traditionality of male and female societal roles plays an important part in science course selection, and the differences found between male and female groups for this study displayed some surprising results. Disproportionately lower representation of women in male dominated science fields cannot be explained by women's lack of interest, ability, or motivation to succeed in these fields. To imply that women historically have been less interested or less able to succeed in science than men is simply not substantiated given the historical evidence. In fact, results of this study show that females in advanced level physics have higher reading and mathematics ability, better attitude, higher self-efficacy in both mathematics and science, and better epistemological views toward learning science than their male cohorts. Additionally, the non AP females outscored their male counterparts on many of the factors as well.

Between the two genders within the AP physics group, females outscored males on 13 of the 14 factors used in this study. The only variable on which AP males had a higher mean was science FCAT score. However, that difference was not statistically significant. The same pattern held true for the non AP females and males. The only statistically significant differences were found for D2 (learning science requires seeking information from alternative sources) and D3 (learning science requires a prepared mind), both of which favored females. In addition, science FCAT score was found to be a significant predictor of AP enrollment for both males and females. Therefore, the gender differences favoring males in most previous research was not present in this investigation concerning academic ability or motivational factors.

The main concern in science education should not continue to focus on gender differences, but instead, should consider determining why fewer females enroll in advanced physical science. In order to do that, it is necessary to look at the differences between females that pursue science, and those who do not. Between the two ability groups of females, significant differences were found on 11 of the 14 factors: all three FCAT scores, three of the five attitude factors, two of the three epistemological factors, both self-efficacy factors, and stereotypical views toward science. However, many of the same differences were apparent between the two male ability groups. This may show that most of the factors used in this study are important for advanced science enrollment for all students. But, the factors that were found to be exclusively significantly different between the two ability groups of females, reading FCAT, E2, E3, and stereotypical views, may be the key to increasing female enrollment in AP physics.

Overall, this investigation confirmed many of the proposed relations between cognitive and motivational factors, and enrollment in advanced level physical science.

Collectively, the findings from this study contribute to the literature in three significant ways. First, this study offers a potential model of the relationships among the constructs that can be used to guide future investigations. Given the significance of these identified relations, this model appears to be a plausible representation of the relations between the variables used. Future work can expand on these relationships and develop the model more fully. Second, the results suggest specific avenues for future research. For instance, reading ability, science ability, epistemological beliefs, and stereotypical views toward science were strongly related to females' enrollment in AP physics. This suggests that the relations between these cognitive and motivational factors may be more complex than initially expected. Third, this investigation replicated previous findings with respect to cognitive and motivational variables that are significantly related to advance science participation for both genders. However, data collected from the females in this study disagree with many studies that have found to have less ability or lower attitudes toward science than males at either the high or average ability levels.

Limitations

Although the results of this study indicated that the investigated cognitive and motivational variables were meaningfully related and to the enrollment of students in AP physics, certain limitations must be kept in mind when interpreting the findings. First, the motivational predictors were self-reported measures of attitude, epistemological beliefs, self-efficacy, and stereotypical views. Even though the measure of academic ability was predictive and fairly reliable, it would have been preferable to use more items to assess those constructs to possibly strengthen it.

Feedback from the sample under study is not a part of quantitative research, which tends to take a fairly narrow perspective on individuals' experiences by isolating a few variables while controlling for other potentially important factors, rather than taking an approach that allows for more realistic representation of life experiences (Creswell, 1998). However, the potential to identify trends through exploratory research, and generalize findings to the population of interest required a quantitative design rather than the smaller samples and more intrusive design of qualitative research. Therefore, strengths and weaknesses of a correlational design were inherited in this study.

As an exploratory tool to yield useful information concerning the nature of phenomena, a correlational design is appropriate when simple causal effect relationships are being explored. In addition, such a design can give a sense of direction and provide sources of hypotheses that can subsequently be tested. However, the inherent disadvantages of such a design must be taken into account. First, there is a lack of control in that the researcher cannot manipulate the independent variable or randomize subjects. All possible alternate or external influences were not accounted for in the design of the study. Background characteristics such as stress, family relationships, and support, and other aspects of social identity such as disabilities, sexual orientation, and faculty support, all of which were not taken into account, may also affect achievement and motivation (Chung, 2001; Park, 2002). Also, ethnicity and socioeconomic status are often stated in literature to play a role in the variables investigated, but they were not utilized in this study.

Using FCAT scores as a measure of academic ability in the domains of reading, mathematics, and science may be another limitation included in the design of this study. Since the data used did not provide an analysis of which questions on the FCAT test were answered correctly or incorrectly by students, it is not known where specific differences between groups in any of the three areas may lie. For example, it's possible that girls outperformed boys on questions in the areas of biology and life science, while the boys answered more chemistry and physical science questions correctly. Secondly, the sample of students in this study had taken the science portion of the FCAT in 10th grade and again in 11th grade, since this was when the state made the requirement transition. This could possibly have been an advantage. But conversely, the scores on the science portion were still much lower than scores on the reading or mathematics portions of the test. Some possible explanations may be that the science portion is not nearly as high stakes as the other two portions, and emphasis on teaching science FCAT material has not been a part of the curriculum in other subject areas, as it is with reading and mathematics. The responsibility of reviewing science material students learned in middle school lies solely with the science teachers. Since following a curriculum that covers too much material in too little time is difficult enough for most upper level science teachers, taking time out to review previously taught material in other areas of science may not be a priority for teachers. In addition, students are aware of the fact that there are no repercussions if they do not do well on the test, so many may feel they don't need to study. However, much more time preparing for the mathematics and reading sections is important, since students must pass these two sections in order to graduate from high school.

In addition to the research design, other limitations are present concerning the sample and the student questionnaire. Collecting data from unknown participants requires confidence that their interpretation of the instrument's items matched the intensions of the instruments. In order to address this limitation, survey questions were selected from previously validated instruments except for the questions pertaining to extracurricular activities. Limitations related to the sample include sample size, power, and bias due to the fact that the sample was selected from two high schools in the same school district. Although there were only 106 participants, each of the four gender/ability groups met the minimum number of participants needed for adequate power (Cohen, 1992). But, concerning the study being conducted within a single school district, the population under study and the institutional climate is important for determining the applicability of the findings to students from high schools in different areas. Considering Seminole County Schools students consistently receive higher FCAT achievement scores than many other Florida school districts (Florida Department of Education, 2007), the results of the study may not hold true for other 12th grade students throughout the state, since they may hold different motivational and career goals.

There are other miscellaneous limitations due to the sample used in this study as well. First, the non AP students were not all enrolled in the same elective science classes. However, it could be argued that this does not necessarily affect factors pertaining to student learning or motivational factors concerning science. But the fact that students have varied backgrounds and experiences with science and mathematics may require more specific research studies. Experiences at the elementary and middle school levels in these domains have previously been found to play a crucial role. For example, the educational level and experience of science teachers in the lower grades may influence students' choice of science course selection in high school. Since this country has experienced a shortage of science teachers for the past couple of decades, students at the elementary and middle school levels may have teachers who are neither certified in science, have majored in science, or simply are not interested in science.

Despite the disadvantages associated with this study, results have nonetheless contributed to our understanding of how cognitive and motivational factors are related to each other, and the enrollment of both males and females in advanced physical science courses in high school.

Implications for Classroom Practices

Despite the limitations noted previously, results show that most of the cognitive and motivational variables examined in this study are important for AP physics enrollment of both males and females, and the conclusion drawn that reading FCAT score, stereotypical views toward science, and epistemological factor E1 (Science is a coherent body of knowledge rather than a collection of isolated facts) were specifically important for females.

Since Title IX, male and female students are supposed to receive equal treatment in all areas of education. However, differences among groups of students are still apparent throughout the school environment. Influenced by social and cultural roles, students' participation in activities and academics are often based on what peers, parents, and society deem gender appropriate. And, because many science classrooms may still traditionally focus on male values and learning styles such as competitions versus cooperative learning, girls often respond with a lack of effort and persistence.

Older science instruction methods emphasized lectures to present scientific information and encouraged students to memorize facts, but today, emphasis focuses more on problem solving, inquiry based lab activities and rejection of science as just a body of facts (Stuart & Henry, 2002). Despite these positive developments in science instruction, high school and college students continue to perform poorly in science, and maintain high rates of failure (Covallo & Laubach, 2000). Science related epistemological beliefs of students play an important part in how they view their science classroom. Students who hold more naive beliefs may benefit more from the structured, traditional learning environment, while those with more sophisticated views may become frustrated and bored in such a classroom. Students with more constructive views toward science learning prefer opportunities to solve real problems, interact and discuss with peers, and have more control of their learning activities (Tsai, 2000). Therefore, it is important for teachers to assess and address epistemological beliefs of students early in order to provide a more productive science classroom for all students.

Educators must allow students to explore and develop scientific concepts while completing meaningful activities. According to Lawson (2000), the science learning process can by enhanced by presenting assessment items, such as concept maps or quizzes, to students at the completion of laboratory experiences, since it is through inquiry based laboratory activities that students have the best opportunities to develop and retain scientific information. Not only are students constantly faced with problem-solving situations, they are provided opportunities to connect, correct, expand, and apply scientific terms and definitions associated with the concepts being explored. Educators need to consider ways that they can positively influence the climate experienced by females concerning the studying of the physical sciences.

Although there have been numerous approaches to attitude change including conditioning, modeling, and motivation, the vehicle responsible for attitude change in all approaches is persuasion, which is defined as any change in attitude that results from exposure to communication such as classroom instruction (Petty & Cacioppo, 1986). In order to develop girl friendly classrooms, teachers need to ask the same type and levels of questions to all students, and provide girls with the same type of feedback given to boys. By creating a special rule or situation for only girls rather than for all students who may need assistance, teachers reinforce a gender stereotype. Additionally, teachers must not allow males to dominate lab activities or classroom discussions, and should put greater emphasis on verbal strengths, where girls often excel (National Science Teachers Association, 1996). Although some negative attitudes and stereotypical views toward science may be formed at home or through socialization, research has shown the critical role of teachers and schools in encouraging girls to study mathematics and science (Gavin & Reis, 2003). Teachers should also be encouraged to challenge any stereotypical ideas students' hold concerning science and gender appropriate careers, and intervene at an early stage to make science more exciting, enjoyable, and relevant to aspects of everyday life.

Since evidence has been found that early prediction of science persistence is possible, it is necessary to provide students with positive science-related experiences that may be crucial to later decisions to continue in physical science courses. Interventions during elementary and middle school may be particularly advantageous for increasing persistence rates in high school and beyond. It is critical for teachers from elementary to high school to foster cooperative learning and be sure that all students are actively involved in labs and discussions. Group discussion to clarify scientific concepts and cooperative group activities provide a positive social stimulus, especially for females (Johnson, Johnson, & Smith, 1991). In addition, teachers in all levels of science should connect science to other academic domains and to the real world by using metaphors, and examples that avoid stereotypes. Science literacy and knowledge of the technical language are necessary to acquire more complex information (Erick & Samford, 1999), and have been associated with discussion sessions in cooperative groups which stimulate the thought process (Johnson et al.).

The middle school years have been found to be a particularly important time for girls concerning participation and achievement in mathematics and science. Student performance can be improved by developing positive expectations for competency in these areas, and efforts should be made by teachers and counselors to help students set realistic expectations and achieve those goals (Lockheed, Thorpe, Brooks-Gunn, Casserly, & McAloon, 1985). In addition, student academic ability, an important determinant of pursuing future science courses, is well established by middle school. Therefore, teachers and counselors at the middle school level should encourage capable students to enroll in higher levels of mathematics and science.

This study can serve educators at the elementary, middle and high school levels by describing the strengths and needs of a group of students who could otherwise, be left out of a science-based curriculum. Continued research regarding factors that have the potential of being changed, enhanced, or modified by educational practices can lead to better curricular and instructional practices to support science learning of all students.

Further Research

Overall, this investigation confirmed many of the proposed relations between cognitive and motivational factors and enrollment in advanced level physical science. Collectively, the findings from this study contribute to the literature in three significant ways. First, this study offers a potential model of the relationships among the constructs that can be used to guide future investigations. Given the significance of these identified relations, this model appears to be a plausible representation of the relations between the variables used. Future work can expand on these relationships and develop the model more fully.
Second, the results suggest specific avenues for future research. For instance, reading ability, science ability, epistemological beliefs, and stereotypical views toward science were strongly related to females' enrollment in AP physics. This suggests that the relations between these cognitive and motivational factors may be more complex than initially expected. Third, this investigation replicated previous findings with respect to cognitive and motivational variables that are significantly related to advanced science participation for both genders. However, females in this study were not found to have less ability or lower attitudes toward science than males at either high or average ability levels, as suggested in many prior research studies.

Although there have been mixed feelings among educators, students, and parents about the significance that has been placed on high stakes state tests such as the FCAT, monitoring student scores throughout elementary and middle school could prove to be a significant factor in identifying students capable of excelling in advanced level science in high school and college. Achievement scores could also be used to guide students, especially females, into the trio of core sciences: Biology, Chemistry, and Physics. Even though progress has been made during the 1990's, the AAUW specifically recommends that teachers and counselors encourage girls to take mathematics and science classes at the challenging honors or AP level.

Since cognitive and motivational differences between the genders may not have as much of an effect as previously thought, these factors may not account for girls' lower enrollment numbers in AP physics. Therefore, the physics program itself should be examined for ways to improve its effectiveness and appeal. Research is needed to identify current practices that are either helpful or harmful for females, as well as identify new practices which could help females gain more interest in AP physics.

There appears to be more factors than those used in this study that my affect participation of females in advanced science courses. Suggestions for future research on this topic include a qualitative research design, which could help to gain insight into personal motivations of both males and females who elect an advanced physics class in high school. Such a design could also help researchers highlight how gender, social class, and ethnicity may work together along with the significant variables identified in this study, to either promote or hinder participation and achievement in science. Using a one on one approach could provide useful insight into the personal variables that affect high school course taking. Extended research is also suggested to include females enrolled in a science college major in order to explore their academic motivation and career developments.

A longitudinal study should be used in order to follow student progress in science throughout elementary, middle, and high school, which could be informative in determining the effectiveness of intervention strategies. Longitudinal studies could also aid in studying the relationship on the motivational factors used in this study, and school subject choice. Research should focus on development and changes in motivational variables, and ways to enhance them. Such designs could document student changes in these factors, as well as high school courses chosen, post secondary fields of interest, and eventual career attainment. A longitudinal study could also be beneficial in future research to determine how FCAT scores at the 8th grade level may change by 10th grade, and how these scores related to other variables.

Prior findings indicate that high school females, who are as bright and capable as male students, have a tendency to play down their potential and abandon the study of physics on the basis of false perceptions of their abilities. Since epistemological beliefs and science attitude begin to develop before middle school, and appear to be firmly in place by high school, there is a lack of research focusing on how these factors develop in younger students. Studies that incorporate an action or intervention component may reveal other existing or perceived epistemological barriers to the study of science, and identify critical moments when academic or motivational variables begin to change.

Finally, incorporating alternative research designs by extending this study to multiple high schools within several school districts may aid in generalizing results to a broader population. In addition, a larger sample would eliminate some of the sample size limitations encountered in the current study.

APPENDIX A: SEMINOLE COUNTY SCHOOLS RESEARCH REQUEST FORM

Seminole County Public Schools
400 East Lake Mary Blvd
Instructional Support Services Department
Sanford, FL 32773
407.320.0022

Researcher: Darlene M. DePalma	Date:07/15/2006	Phone # (407) 924-9106

Address: 5103 Tangerine Avenue Winter Park, FL 32792	Sponsor (University/Agency): University of Central Florida Professor: Dr. David Boote

Proposed date for start of on-site operations: August 14, 2006	Expected date of termination of on-site operations: November 14, 2006	Target date for receipt of your results/discussion to this office: January 2007

Title of Research (topic):
An Analysis of Predictors of Enrollment and Successful Achievement for Girls in High School Advanced Placement Physics Classes.

Statement of Problem or need to be addressed:
Statistics regarding the enrollment of females in advanced level physics, as well as related college majors and careers, have not significantly improved even after 30 years of research. In an attempt to positively impact the number of females participants in upper level science, this study seeks to identify cognitive and motivational variables that may benefit one another in their convergence to promote participation and achievement of females in science.

School/Department Involvement (Indicate # of school sites by level)		School/Department Personnel Involved (e.g., teachers, administrators, guidance counselors, etc.)			
# of each school level	School or Department Name	Type of Personnel	#	Time Required	Activity Involved
1	Winter Springs High School	Teachers counselors	6 1	1 class period 30 minutes	Administer questionnaire Provide transcripts
1	Oviedo or Lake Mary High School, if necessary				
Student transcripts		To obtain FCAT scores in reading, math, and science, as well as determine math and science courses taken since 7th grade.			

Signature of Researcher:____________________ Please Print Name:______________________	Signature of Sponsor:______________________ Please Print Name:________________________
Item	Purpose
Student transcripts	To obtain FCAT scores in reading, math, and science, as well as determine math and science courses taken since 7th grade.
Signature of Researcher:____________________ Please Print Name:______________________	Signature of Sponsor:______________________ Please Print Name:________________________

ENCLOSURE CHECKLIST (One copy of each of the following must accompany this request)	
	Completed research permission request form.
	An abstract of the research (3 page limit)
	Evidence of a review of the relevant literature and previous resarch.
	Instruments to be used.
	Procedures to be used to ensure confidentiality of subjects.
	Parental permission form and/or subject permission form.

APPENDIX B: PRINCIPAL PERMISSION LETTER

Dear Principal,

I am a physics teacher at Winter Spring High School as well as a doctoral student in the College of Education at the University of Central Florida, under the supervision of faculty member Dr. David Boote. I am conducting research on participation and achievement of high school girls in upper level science for my dissertation, the results of which may help Seminole County teachers and counselors increase the participation of girls in advanced science courses in the future.

Participants will include 12^{th} grade male and female students enrolled in Advanced Placement physics classes, 12^{th} grade females in standard physics, and 12^{th} grade females in an elective science course. I will be obtaining the types of math and science courses completed, as well as final grades in those courses earned since 7^{th} grade, as well as FCAT scores in reading, mathematics, and science from student transcripts, I will also be asking students to complete questionnaires concerning their views about science. There are 74 questions to be answered, and I do not anticipate that it will take more than one class period. Following the first quarter grading period, I will also be asking participating teachers for report card grades for the Advanced Placement students only.

The identity of all participants will be kept confidential, and results will only be reported in the form of group data. There are no known risks or immediate benefits to the participants. All disruptions to the classroom environment and requirements of classroom teachers will be minimized to the greatest extent possible. No compensation is offered for participation. Group results of this study will be available in January of 2007 upon request. If you have any questions about this research project, please contact me at (407) 924-9106 or Dr. Boote at (407) 823-4160. Questions or concerns regarding participants' rights may be directed to the UCFIRB Office, University of Central Florida, Office of Research, Orlando Tech Center, 12443 Research Parkway, Suite 207, Orlando, FL, 32826. The hours of operation are 8:00 am until 5:00 pm Monday through Friday, except on UCF official holidays. The phone number is (407) 823-2901.

I would appreciate it if you would please return this form to me at Winter Springs High School. Thank you for your time and consideration in this matter.

Sincerely,

Darlene M. DePalma

___I have read the procedure described above.

___I voluntarily give my permission for my school ______________________________ and students to participate in Darlene DePalma's study of the participation of girls in advance level science courses.

____/_______________________

Principal Date

I would like a copy of the research procedure: Yes No (Please circle one)

APPENDIX C: TEACHER PERMISSION

Dear Science Teacher,

I am a physics teacher at Winter Spring High School as well as a doctoral student in the College of Education at the University of Central Florida, under the supervision of faculty member Dr. David Boote. I am conducting research on participation and achievement of high school girls in upper level science for my dissertation, the results of which may help Seminole County teachers and counselors increase the participation of girls in advanced science courses in the future.

Participating students include 12th grade male and female students enrolled in Advanced Placement physics classes, 12th grade females in standard physics, and 12th grade females in an elective science course. I will be asking participating teachers to distribute and collect student assent forms and parental consent forms. In addition, students will be asked to complete questionnaires concerning their views about science. There are 74 questions to be answered, and I do not anticipate that it will take more than one class period. Following the first quarter grading period, I will be also be asking for report card grades for the AP students only. I understand the value of your time and will do everything possible to keep classroom disruptions and procedures asked of you minimized to the greatest extent possible.

The identity of all participants will be kept confidential, and results will only be reported in the form of group data. Once all data is collected, student names will be replaced with numbers, and deleted. There are no known risks or immediate benefits to the participants, and no compensation is offered for participation. Group results of this study will be available in January of 2007 upon request. If you have any questions about this research project, please contact me at (407) 924-9106 or Dr. Boote at (407) 823-4160. Questions or concerns regarding participants' rights may be directed to the UCFIRB Office, University of Central Florida, Office of Research, Orlando Tech Center, 12443 Research Parkway, Suite 207, Orlando, FL, 32826. The hours of operation are 8:00 am until 5:00 pm Monday through Friday, except on UCF official holidays. The phone number is (407) 823-2901.

I would appreciate it if you would please return this form to me at Winter Springs High School. Thank you so much for your time and anticipated participation in this study.

Sincerely,

Darlene M. DePalma

___I have read the procedure described above.

___I voluntarily give my consent for my science classes to participate in this study

____________________	____________________	____________
Teacher	School	Date

APPENDIX D: PARENTAL CONSENT FORM

Dear Parent/Guardian:

In addition to teaching honors and Advanced Placement Physics at Winter Springs High School, I am also a doctoral student in the College of Education at the University of Central Florida under the supervision of Dr. David Boote. For my dissertation, I will be conducting research on participation and achievement of high school girls in upper level science. The results of this study may help Seminole County teachers and counselors increase the participation of girls in advanced science courses in the future.

I will be obtaining types of math and science courses completed since 7^{th} grade, as well as FCAT scores in reading, mathematics, and science from student transcripts. I will also be asking the students to complete a questionnaire concerning their views about science, which will require approximately one class period. The identity of all participants will be kept confidential to the extent provided by law, and results will only be reported in the form of group data.

You and your child have the right to withdraw consent for participation at any time without consequence. There are no known risks or immediate benefits to participants, and no compensation is offered for participation. Group results of this study will be available in January, 2007 upon request. If you have any questions about this research project, please contact me at (407) 320-8750, ext. 58845, or my faculty supervisor, Dr. Boote at (407) 823-4160. Questions or concerns about research participants' rights may be directed to the UCFIRB office, University of Central Florida Office of Research, Orlando Tech Center, 12443 Research Parkway, Suite 207, Orlando, Fl 32826. The hours of operation are 8:00 am until 5:00 pm, Monday through Friday except on University of Central Florida official holidays. The phone number is (407) 823-2901.

Please have your child return this form to his or her teacher. Thank you very much for your time and consideration in this matter.

Sincerely,
Darlene DePalma

_____I have read the procedure described above and voluntarily give my consent for my

child ____________________________________, to participate in the study.

____ _______________
Parent/Guardian Date

APPENDIX E: STUDENT ASSENT FORM

Dear Science Student:

In addition to being a physics teacher at Winter Springs High School, I am also a doctoral student in the College of Education at the University of Central Florida, under the supervision of faculty member Dr. David Boote. I am conducting research for my dissertation concerning high school girls in science, and am interested in determining factors that contribute to participation, achievement, and persistence.. The results of this study may help Seminole County teachers and counselors increase the participation of girls in higher level science classes in the future.

You will be asked to complete a questionnaire concerning your views toward science, which will require approximately one class period. In addition, FCAT scores and previous math and science courses in which you have been enrolled will be recorded from transcripts. The identity of all participants will be kept confidential to the extent provided by law, and results will only be reported in the form of group data. Once all data is collected, names will be deleted.

You have the right to decline or withdraw consent for your participation at any time without consequence. There are no known risks or immediate benefits to the participants, and no compensation is offered. Group results of this study will be available in January, 2007 upon request. If you have any questions about this research project, please contact me at (407) 320-8750, ext. 58845, or my faculty supervisor, Dr. Boote, at (407) 823-4160. Questions or concerns about research participants' rights may be directed to the UCFIRB office, University of Central Florida Office of Research, Orlando Tech Center, 12443 Research Parkway, Suite 207, Orlando, FL 32826. The hours of operation are 8:00 am until 5:00 pm, Monday through Friday except on University of Central Florida official holidays. The phone number is (407) 823-2901.

Please return this form to your science teacher and thank you very much for your time and anticipated participation.

Sincerely,
Darlene M. DePalma

___ I have read the above information and voluntarily agree to participate in the study

___ I do not wish to participate in this study

____ ________________
Student Signature Date

Please print name: ____

Science teacher's name: ____

APPENDIX F: UCFIRB APPROVAL FORM

THE UNIVERSITY OF CENTRAL FLORIDA
INSTITUTIONAL REVIEW BOARD (IRB)

IRB Committee Approval Form

#06-3804

PRINCIPAL INVESTIGATOR(S): Darlene M. DePalma
(Supervisor – David Boote, Ph.D.)

PROJECT TITLE: An Analysis of Predictors of Enrollment and Successful Achievement for Girls in High School Advanced Placement Physics Classes

[**X**] New project submission
[ ] Resubmission of lapsed project #_____
[ ] Continuing review of lapsed project #
[ ] Continuing review of #
[ ] Study expires
[ ] Initial submission was approved by expedited review
[ ] Initial submission was approved by full board review but continuing review can be expedited
[ ] Suspension of enrollment email sent to PI, entered on spreadsheet, administration notified ______

Chair
[✓] Expedited Approval

Dated: 9/18/2006
Cite how qualifies for expedited review:
minimal risk and #7

[ ] Exempt

Dated: ____________
Cite how qualifies for exempt status:
minimal risk and __________

[ ] Expiration
Date: 9/17/2007

IRB Reviewers:

Signed: ______________________
Dr. Tracy Dietz, Chair

Signed: [signature]
Dr. Craig Van Slyke, Vice-Chair

Signed: ______________________
Dr. Sophia Dziegielewski, Vice-Chair

Complete reverse side of expedited or exempt form
[ ] Waiver of documentation of consent approved
[ ] Waiver of consent approved
[ ] Waiver of HIPAA Authorization approved

NOTES FROM IRB CHAIR (IF APPLICABLE): ______________________

APPENDIX G: STUDENT QUESTIONNAIRE PACKET

Dear Student:

This questionnaire will be used in a dissertation research study to determine how factors may affect science course choices and achievement by high school students. Your participation is voluntary, and if you choose not to participate or to withdraw from the study at any time, there will be no penalty, and it will not affect your grade in this class. Your identity will not be disclosed. Once all data is recorded, student names will be deleted and replaced with a number.

When finished, please return this questionnaire to your teacher.

Name: ____

1. Please circle your gender (a) male (b) female

2. Please circle your class level
(a) Elective science
(b) Standard physics
(c) Advanced Placement physics

Directions:
Questions present a given issue with two viewpoints, (a) and (b), that you need to contrast on a 5 point scale. Circle the response that best represents how you feel. For example:

Learning physics requires:
(a) serious effort.
(b) a special talent

Your answer choices are:

1. Mostly (a), rarely (b)

2. More (a) than (b)

3. Equally (a) and (b)

4. More (b) than (a)

5. Mostly (b), rarely (a)

What would each of the 5 choices mean?

1. Learning physics requires mostly serious effort and rarely a special talent

2. Learning physics requires more serious effort than a special talent

3. Learning physics requires as much a serious effort as a special talent

4. Learning physics requires more of a special talent than serious effort

5. Learning physics requires mostly a special talent and rarely serious effort

Questions 1through 6 are about your current science class. Please respond in ways that reflect what you *actually do* in this course, and how your feel about it.

(1)	(2)	(3)	(4)	(5)
Mostly a	More a than b	Equally a and b	More b than a	Mostly b

1. For me, studying science is — 1 2 3 4 5
   (a) an enjoyable experience
   (b) a frustrating experience

2. Learning science requires — 1 2 3 4 5
   (a) a serious effort
   (b) a special talent

3. When I experience a difficulty while studying science — 1 2 3 4 5
   (a) I seek help, or give up trying
   (b) I try to figure it out on my own

4. I go over the main body of a science chapter — 1 2 3 4 5
   (a) before the chapter is covered in class
   (b) after the chapter is covered in class

5. I attempt to solve homework problems — 1 2 3 4 5
   (a) before they are worked out in class
   (b) after they are worked out in class

6. Discussing science material with classmates — 1 2 3 4 5
   (a) gets me confused
   (b) helps develop my reasoning skills

Questions 7 through 12 are about the way you would like things to be done in your science courses. Please respond in ways that reflect your own preferences, regardless of how things are done in these courses.

(1)	(2)	(3)	(4)	(5)
Mostly a	More a than b	Equally a and b	More b than a	Mostly b

7. In everyday life, science courses can be: 1 2 3 4 5
   (a) helpful to me when adequately presented
   (b) of no use to me no matter how presented

8. Science courses should enable me: 1 2 3 4 5
   (a) to relate science to the way I think about certain things in the natural world
   (b) to learn about science independently of how I think about the natural world

9. Material in my science course should be covered in ways that help me: 1 2 3 4 5
   (a) do well on exams
   (b) develop my reasoning skills

10. I would like to study science in order to satisfy; 1 2 3 4 5

    (a) my own interests
    (b) what certain people expect of me

11. My understanding of topics in my science courses should depend on: 1 2 3 4 5
    (a) how much effort I put into studying
    (b) how well the teacher explains things

12. Learning about course topics from sources other than the textbook would: 1 2 3 4 5
    (a) get me confused
    (b) enrich my knowledge

Questions 13 through 19 are about scientists and their way of doing science. The questions are not about your science courses. Please answer these questions in a way that reflects what you think science is about.

(1) Mostly a	(2) More a than b	(3) Equally a and b	(4) More b than a	(5) Mostly b

13. Various branches of physics, like mechanics and electricity, are: 1 2 3 4 5
    (a) related by common principles
    (b) separate and independent

14. When faced with a natural event that occurs for the first time in a given place, scientists: 1 2 3 4 5
    (a) check to see if it is similar to an event that took place elsewhere
    (b) look for ways that distinguish this particular event from other events

15. Once they come up with new information, scientists: 1 2 3 4 5
    (a) check to see if it fits with the rest of their knowledge
    (b) ascertain it merits independently of their knowledge

16. When they investigate a particular event in the natural world, scientists: 1 2 3 4 5
    (a) look for all possible aspects that might be attributed to the event under investigation
    (b) concentrate on particular aspects that they consider relevant to the purpose of the study

17. Scientists say that electrons and protons exist in an atom because: 1 2 3 4 5
    (a) they have seen these particles in their actual form with some instruments
    (b) they have made observations that can be attributed to such particles

(1) Mostly a	(2) More a than b	(3) Equally a and b	(4) More b than a	(5) Mostly b

18. In order to decide whether two different objects may behave the same way in the natural world, scientists check whether the two objects: 1 2 3 4 5
    (a) are similar in all respects
    (b) are subject to similar conditions

19. Scientists say that the Earth and Moon attract one another because: 1 2 3 4 5
    (a) they have detected and measured their mutual attraction with some instruments
    (b) the Moon's revolution around the Earth can be explained in terms of such attraction

Thank you for your time in completing this portion of the questionnaire.

Please continue to the next section

Math and Science Questionnaire

This is not a test. There are no right or wrong answers.

Your answers will be kept confidential and will only be used for this research study. Your answers will not be used in any way to refer to you as an individual.

This is a chance for you to look at how you think and feel about yourself and the subjects of mathematics and science. It is important that you are honest and that you give your own views about yourself, without talking to others.

On the following pages, there are a series of statements that are more or less true (or more or less false) descriptions of you. Please use the following 8-point response scale to indicate how true or false each item is as a description of you. In a few instances, an item may no longer be appropriate to you, though it was at an earlier period of your life. In such cases, respond to the item as you would have when it was appropriate.

Use the following scale to indicate how each statement is a description of you. Please do not leave any statements blank.

1	2	3	4	5	6	7	8
Definitely False	Mostly False	False	More False than True	More True than False	Mostly True	True	Definitely True

1	2	3	4	5	6	7	8
Definitely False	Mostly False	False	More False than True	More True than False	Mostly True	True	Definitely True

Statement	False							True
1. I am hopeless when it comes to mathematics classes	1	2	3	4	5	6	7	8
2. I get good marks in science classes	1	2	3	4	5	6	7	8
3. I learn things quickly in math classes	1	2	3	4	5	6	7	8
4. Overall, I have a lot to be proud of	1	2	3	4	5	6	7	8
5. I can do things as well as most people	1	2	3	4	5	6	7	8
6. Work in science classes is easy for me	1	2	3	4	5	6	7	8
7. Most things I do, I do well	1	2	3	4	5	6	7	8
8. I am hopeless when it comes to science classes	1	2	3	4	5	6	7	8
9. Compared to others my age, I am good at math	1	2	3	4	5	6	7	8
10. I learn things quickly in science	1	2	3	4	5	6	7	8
11. Work in math classes is easy for me	1	2	3	4	5	6	7	8
12. Compared to others my age, I am good at science	1	2	3	4	5	6	7	8
13. I receive good grades in math	1	2	3	4	5	6	7	8
14. I have always done well in science classes	1	2	3	4	5	6	7	8
15. It is important for me to do well in math	1	2	3	4	5	6	7	8
16. It is important for me to do well in science	1	2	3	4	5	6	7	8
17.I am satisfied with how well I do in math	1	2	3	4	5	6	7	8
18. I am satisfied with how well I do in science	1	2	3	4	5	6	7	8

Science Careers

The purpose of these questions is to assess attitude toward science careers and family responsibilities. This questionnaire is not a test, and there are no right or wrong answers. Please read each statement carefully and then respond using the following scale:

SA - Strongly Agree
A = Agree
N =Neither Agree nor Disagree
D = Disagree
SD = Strongly Disagree

1. It is very difficult for a woman to combine a career as a scientist and with a family life.	SA	A	N	D	SD
2. If a woman chemist or physicist takes time away from her career to have children, she will never catch up again.	SA	A	N	D	SD
3. A woman who is really dedicated to a career in science or mathematics would not be able to devote much time or energy to her family.	SA	A	N	D	SD
4. Both women and men can find the time they need for the concentrated work that a career in science and mathematics requires, even if they are involved in an intimate relationship.	SA	A	N	D	SD
5. A woman who is considering a career as a scientist or a mathematician should probably not plan to have children.	SA	A	N	D	SD
6. For women, there is nothing incompatible about planning both a family and a top-level scientific career.	SA	A	N	D	SD
7. Most women who are scientists find that, with a little ingenuity and support, they can happily combine their career with having a family.	SA	A	N	D	SD

8. Do you plan on attending college after high school graduation? yes no

9. If yes, what is your intended major?

10. What career do you plan to pursue?

After School Activities Survey

Please indicate activities in which you have participated from 9th grade through 12th grade by checking the appropriate box.

In School Activity	9th	10th	11th	12th
History club				
Math club				
Science club				
Foreign Language club				
Other subject club				
Debate				
Chorus/band/orchestra				
Drama				
Science fairs				
Honor Society				
Student newspaper				
Student govenment				
Yearbook				
Peer tutoring				
School team sports				
School individual sports				
Cheerleading				
Drill team				
Other spirit teams				

Out of School Activities	9th	10th	11th	12th
Non school team sports				
Music/dance/art lessons				
Community service				
Youth groups (4-H, Scouting)				
Hobby clubs				

APPENDIX H: CORRELATIONS AMONG VARIABLES

Significant Correlations Among Variables for AP Females:

Reading FCAT:	D3 ($r=.465$, $p<.05$)
Science FCAT:	D1 ($r=.563$, $p<.01$) R2 ($r=.641$, $p<.01$) D3 ($r=.594$, $p<.01$) E2 ($r=.473$, $p<.05$)
R2:	D3 ($r=.612$, $p<.01$) SSE ($r=.464$, $p<.05$) MSE ($r=.550$, $p<.05$)
E2:	E1 ($r=.528$, $p<.05$) D1 ($r=.628$, $p<.01$)
SSE:	MSE ($r=.640$, $p<.01$)

Significant Correlations Among Variables for Non AP Females:

Reading FCAT:	Mathematics FCAT ($r=.427$, $p<.01$) Science FCAT ($r=.443$, $p<.01$)
Mathematics FCAT:	Science FCAT ($r=.432$, $p<.01$) MSE ($r=.339$, $p<.05$)
Science FCAT:	Stereotypical views ($r=.352$, $p<.05$)
D2:	R1 ($r=.362$, $p<.05$) R2 ($r=.695$, $p<.01$) SSE ($r=.693$, $p<.001$)
R2:	SSE ($r=.774$, $p<.001$)
Stereotypical Views:	E2 ($r=.321$, $p<.05$) MSE ($r=.325$, $p<.05$)

Significant Correlations Among Variables for AP Males:

Reading FCAT:	Mathematics FCAT (r=.441, p<.05) Science FCAT (r=.492, p<.05) D3 (r=.490, p<.01)
Science FCAT:	Mathematics FCAT (r=.436, p<.05)
R2:	R1 (r=.452, p<.05) D2 (r=.554, p<.01)
SSE:	MSE (r=.566, p<.01) E3 (r=.416, p<.05)

Significant Correlations Among Variables for Non AP Males:

Reading FCAT:	SSE (r=.516, p<.05)
Mathematics FCAT:	MSE (r=.520, p<.05) E1 (r=.544, p<.05)
R2:	D2 (r=.541, p<.05) E1 (r=.446, p<.05) SSE (r=.604, p<.01)
SSE:	D2 (r=.577, p<.01) MSE (r=.617, p<.01) E1 (r=.467, p<.05)

REFERENCES

Ahrens, J. A. & O'Brien, K. M. (1996). Predicting gender-role attitudes in adolescent females: Ability, agency, and parental factors. *Psychology of Women Quarterly, 20*, 409-417.

Aldridge, J., & Goldman, R. (2002). Gender equity and eduction. In S. Dragen (Ed.), Current issues and trends in education. Boston: Allyn and Bacon.

American Association of University Women. (1991). *Summary: Shortchanging girls, shortchanging America*. Washington, DC.

American Association of University Women. (1992). *The AAUW report: How schools shortchange girls*. Washington, DC.

American Association of University Women. (1999). *Gender gaps: Where schools still fail our children*. New York: Marlowe.

Anderman, E. M., & Maehr, M. L. (1994). Motivation and schooling in the middle grades. *Review of Educational Research, 64*, 287-309.

Armstrong, J. (1985). A national assessment of the participation and achievement of women in mathematics. In S. F. Chipman, L. R. Brush and D. M. Wilson (Eds.), *Women and mathematics: Balancing the equation*. Hillsdale, N.J.: Erlbaum.

Astin, A. (1996). Involvement in learning revisited: Lessons we have learned. *Journal of College Student Development, 37*(2), 123-133.

Astin, A. (1999). Student involvement: A developmental theory for higher education. *Journal of College Student Development, 40*(5), 518-529.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*, 191-215.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice Hall.

Bandura, A. (1997). *Self-efficacy: The exercise of control.* New York: W. H. Freeman.

Battista, R. R. (1990). Personal meaning: Attraction to sports participation. *Perceptual and Motor Skills, 70*, 1003-1009.

Benbow, C. P., & Arjmand, O. (1990). Predictors of high academic achievement in mathematics and science by mathematically talented students: A longitudinal study *Journal of Educational Psychology, 82*(3), 430-441.

Benbow, C. P., & Stanley, J. C. (1980). Sex differences in mathematical ability: Fact or artifact? *Science, 210*(4475), 1262-1264.

Benbow, C. P., & Stanley, J. C. (1983). Sex differences in mathematical ability: More facts. *Science, 222*(4627), 1029-1031.

Bendixen, L. A., Schraw, G., & Dunkle, M. E. (1998). Epistemic beliefs and moral reasoning. *The Journal of Psychology, 132*(2), 187-200.

Benware, C. A., & Deci, E. L. (1984). Quality of learning with an active versus passive motivational set. *American Educational Research Journal, 21*, 755-765.

Betz, N. E. (1994). Career counseling for women in the sciences and engineering. In W. B. Walsh & S. H. Osipow (Eds.), *Career counseling for women.* Hillsdale, NY: Erlbaum.

Betz, N. E., & Hackett, G. (1983). The relationship of mathematics self-efficacy expectations to the selection of science based college major. *Journal of Vocational Behavior, 23*, 329-345.

Blakemore, J. E. O., & Centers, R. E. (2005). Characteristics of boys' and girls' toys. *Sex Roles, 53*, 619-633.

Britner, S. L., & Pajares, F. (2001). Self-efficacy beliefs, motivation, race, and gender in middle school science. *Journal of Women and Minorities in Science and Engineering, 7,* 271-285.

Brooks, J. G., & Brooks, M. G. (1993). *In search of understanding: The case for the constructivist classroom.* Alexandria, VA: Association for Supervision and Curriculum Development.

Buehl, M. M. & Alexander, P. A. (2001). Beliefs about academic knowledge. *Educational Psychology Review, 13*, 385-418.

Buehl, M. M., Alexander, P. A., & Murphy, P. K. (2002). Beliefs about schooled knowledge: Domain general or domain specific? *Contemporary Educational Psychology, 27*, 415-449.

Byars, A., & Hackett, G. (1998). Applications of social cognitive theory to the career development of women of color. *Applied and Preventive Psychology, 7*, 255-267.

Callahan, C. M., Tomlinson, C. A., Reis, S. N., & Kaplan, S. N. (2000). TIMSS and high ability students: Message of doom or opportunity for reflection? *Phi Delta Kappan, 1*(10), 787-790.

Cannon, J. R., & Sharmann, L. C. (1996). Influence of a cooperative early field experience on preservice elementary teachers' science self-efficacy. *Science Education, 80*, 419-436.

Carey, S., Evans, R., Honda, M., Jay, E., & Unger, C. (1989). An experiment is when you try it and see if it works: A study of grade 7 students' understanding of the construction of scientific knowledge. *International Journal of Science Education, 11*, 514-529.

Carpenter, T. P., Lindquist, M. M., Mathews, W., & Silver, E. A. (1983). Results of the third NAEP mathematics assessment: Secondary school. *Mathematics Teacher, 76*, 652-659.

Catsambis, S. (1995). Gender, race, ethnicity, and science education in the middle grades. *Journal of Research in Science Teaching, 32*(3), 243-257.

Cavallo, A., & Laubach, T. (2001). Students' science perceptions and enrollment decisions in differing learning cycle classrooms. *Journal of Research in Science Teaching, 38*, 1029-1062.

Chan, C. K., & Sachs, J. (2001). Children's belief about learning and understanding of science texts. *Contemporary Educational Psychology, 26*, 192-210.

Charlesworth, R., & Lind, K. K. (2003). *Math and science for children* (4th ed.). Albany, NY: Delmar.

Chinman, M. J., & Linney, J. A. (1998). Toward a model of adolescent empowerment: Theoretical and empirical evidence. *Journal of Primary Prevention, 18*(4), 393-413.

Chung, R. H. (2001). Gender, ethnicity, and acculturation in intergenerational conflict of Asian American college students. *Cultural Diversity and Ethnic Minority Psychology, 7*, 376-386.

Clifford, G. J. (1993). *School/teacher/universe: Toward a new framework for the history of higher education in the United States.* Paper presented at the annual meeting of the American Educational Research Association, Atlanta, GA.

Cohen, J. (1992). A power primer. *Psychological Bulletin, 112*(1), 155-159.

Connolly, J., Hatchette, V., & McMaster, L. (1999). Academic achievement in early adolescence: Do school attitudes make a difference? *Education Quarterly Review, 6*(1), 20-29.

Cooper, H., Valentine, J. C., Nye, B., & Lindsay, J. J. (1999). Relationships between five after school activities and academic achievement. *Journal of Educational Psychology, 91*, 369-378.

Creswell, J. Q. (1998). *Qualitative inquiry and research design: Choosing among five traditions*. Thousand Oakes, CA: Sage.

Crombie, G., Sinclair, N., Silverthorn, N., Byrne, B. M., Dubois, D. L., & Trinneer, A. (2005). Predictors of young adolescents' math grades and course enrollment intentions: Gender similarities and differences. *Sex Roles: A Journal of Research, 52*(5-6), 351.

Davis, K. S. (1999). Why science? Women scientists and their pathways along the road less traveled. *Journal of Women and Minorities in Science and Engineering, 5*, 129-153.

DeBacker, T. K., & Nelson, R. M. (2000). Motivation to learn science: Differences related to gender, class type, and ability. *Journal of Educational Research, 93*, 245-254.

Desimone, L. (1999). Linking parent involvement with student achievement: Do race and income matter? *Journal of Educational Research, 93*, 11-31.

Dimitrov, D. M. (1999). Differential effect of ability, response format, and strands of learning outcomes. *School Science and Mathematics, 99*(8), 445.

Dishion, T. J., McCord, J., & Poulin, E. (1999). When interventions harm: Peer groups and problem behavior. *American Psychologist, 54*(9), 755-764.

Dresel, M., Ziegler, A., Broome, P., & Heller, K. A. (1998). Gender differences in science education; The double-edged role of prior knowledge in physics. *Roeper Review, 21*(2), 101-117.

Driscoll, M. P., Moallem, M., Dick, W., & Kirby, E. (1994). How does the textbook contribute to learning in a middle school science class? *Contemporary Educational Psychology, 19*, 79-100.

Duncan, H., & Dick, T. (2000). Collaborative workshops and student academic performance in introductory college mathematics courses: A study of a Treisman model math excel program. *School Science and Mathematics, 100*(7), 365-373.

Dweck, C., & Leggett, E. (1988). A social-cognitive approach to motivation and personality. *Psychological Review, 95*, 256-273.

Eccles, J. S. (1994). Understanding women's educational and occupational choices. *Psychology of Women Quarterly, 18*, 585-609.

Eccles, J. S., & Barber, B. L. (1999). Student council, volunteering, basketball, or marching band: What kind of extracurricular involvement matters? *Journal of Adolescent Research, 14*(1), 10-43.

Eccles, J. E., Barber, B. L., Stone, M. & Hunt, J. (2003). Extracurricular activities and adolescent development. *Journal of Social Issues, 59*(4), 865.

Eccles, J., & Gootman, J. A., (Eds.). (2002). *Community programs to promote youth development.* Washington, DC: National Academy Press.

Erick, C., & Samford, K. (1999). Techniques for new teachers. *The Science Teacher, 66*, 34-37.

Ethington, C. A. (1988). Differences among women intending to major in quantitative fields of study. *Journal of Educational Research, 81*(6), 354-359.

Ethington, C. A. (1991). A test of a model of achievement behaviors. *American Educational Research Journal, 28*(1), 155-172.

Fan, R. M., Wagner, H. L., & Manstead, A. S. R. (1995). Anchoring, familiarity, and confidence in the detection of deception. *Basic and Applied Social Psychology, 17*, 83-96.

Farmer, H. S. (1985). Model of career and achievement motivation for women and men. *Journal of Counseling Psychology, 32*, 363-390.

Farenga, S. J., & Joyce, B. A. (1998). Intentions of young students to enroll in science courses in the future: An examination of gender differences. *Science and Education, 83*, 55-75.

Fassinger, R. E. (1990). Causal models of career choice in two samples of college women. *Journal of Vocational Behavior, 36*, 225-248.

Fennema, E. & Sherman, L. (1977). Sex related differences in mathematics, achievement, spatial visualization, and sociocultural factors. *American Educational Research Journal, 14*, 51-71.

Fine, G. A. (1987). *With the boys.* Chicago: University of Chicago Press.

Finson, K. D. (2002). Drawing a scientist: What we do and do not know after fifty years of drawings. School Science and Mathematics, 102(7), 335-345.

Flick, L. B., & Lederman, N. G. (2002). Finding opportunity to learn. *School Science and Mathematics, 102*, 377-379.

Florida Department of Education, (2004). *FCAT Assessment and accountability briefing book*. Retrieved May 1, 2007, Florida Department of Education Web site: http://fcat.fldoe.org/pdf/fcataabb.pdf

Florida Department of Education. (2006). *FCAT scores and reports*. Retrieved June 30, 2006 from http://firn.edu/doe/sas/fcat/fcatscor.htm

Florida Department of Education, (2007). *District Reports.* Retrieved August 15, 2007 from http://fcat.fldoe.org/mediapacket/2007

Fouad, N. A., & Smith, P. L. (1996). A test of a social cognitive model for middle school students: Math and science. *Journal of Counseling Psychology, 43*, 338-346.

Frankel, J., & Wallen, N. (2000). *How to design and evaluate research in education.* Boston: McGraw-Hill.

Fredericks, J. A., & Eccles, J. S. (2002). Children's competence and value beliefs from childhood through adolescence: Growth trajectories in two male sex-typed domains. *Developmental Psychology, 38*, 519-533.

Gadzella, B. M., & Davenport, J. (1985). Achievement and attitudes in mathematics. *College Student Journal, 19*, 398-403.

Gallagher, S.A. (1989). Predictors of SAT mathematics scores of gifted male and gifted female adolescents. *Psychology of Women Quarterly, 13*(2), 191-203.

Gallenstein, N. L. (2005). Engaging young children in science and mathematics. *Journal of Elementary Science Education, 17*(2), 27.

Gavin, M. K., & Reis, S. M. (2003). Helping teachers to encourage talented girls in mathematics. *Gifted Child Today, 26*(1), 32.44.

Gilman, R. (2001). The relationship between life satisfaction, social interest, and frequency of extracurricular activities among adolescent students. *Journal of Youth and Adolescence, 30*(6), 749-756.

Gilman,R., Huebner, E. S., & Laughlin, J. (2000). A first study of the multidimensional students' life scale with adolescents. *Social Indicators Research, 52,* 135-160.

Ginsburg, H. P., & Baron, J. (1993). Cognition: Children's construction of mathematics. In R. J. Jensen (Ed.), *Research ideas for the classroom: Early childhood mathematics*. New York: Macmillan.

Graham, M. (2001, April). *Increasing participation of female students in physical science class* [Electronic version]. Unpublished master's thesis, Saint Xavier University.

Greenfield, T. A. (1997). Gender and grade level differences in science interest and participation. *Science Education, 81*, 259-276.

Greenwood, M. R. C., & Kovacs North, K. (1999). Science through the looking glass: Winning the battles but losing the war? *Science, 286*(5447), 2072-2028.

Guthrie, J. T., Wigfield, A., & VonSecker, C. (2000). Effects of integrated instruction on motivation and strategy use in reading. *Journal of Educational Psychology, 29*, 331-341.

Guzzetti, B. J., & Williams, W. O. (1996, September). Changing the pattern of gendered discussion: Lessons from science classrooms. *Journal of Adolescent and Adult Literacy, 40*, 38-47.

Gwilliam, L. R., & Betz, N. E. (2001). Validity of measures of math and science related self-efficacy for African Americans and European Americans. *Journal of Career Assessment, 9*, 261-281.

Hackett, G., & Betz, N. E. (1989). An exploration of the mathematics self-efficacy/ mathematics performance correspondence. *Journal for Research in Mathematics Education, 20*, 263-271.

Halloun, I. (1997). Views about science and physics achievement: The VASS story. In E.F. Redish & J.S. Rigden (eds.). *The changing role of physics departments in modern universities*. Proceedings of ICUPE. pp. 605-613. College Park, Maryland: American Institute of Physics Press.

Halloun, I. (2001). *Student views about science: A comparative survey*. Retrieved March 15, 2006, from Arizona State University Web site: http://modeling.asu.edu/R&E/IHalloun/VASS-2001Monograph.pdf

Halloun, I., & Hestenes, D. (1998). Interpreting VASS dimensions and profiles. *Science and Education, 7*(6), 553-577.

Halpern, D. F., Benbow, C. P., Geary, D. C., Gur, R. C., Hyde, J. S., & Gernsbacher, M. A. (2007). The science of sex differences in science and mathematics. *Psychological Science in the Public Interest, 8*(1), 1-51.

Halpern, D. F., & LaMay, M. L. (2000). The smarter sex: A critical review of sex differences in intelligence. *Educational Psychology Review, 12*, 229-246.

Hammer, D. (1994). Epistemological beliefs in introductory physics. *Cognition and Instruction, 12*(2), 151-183.

Han, L., & Hoover, H. D. (1994, April). *Gender differences in achievement test scores.* Paper presented at the annual meeting of the National Council on Measurement in Education, New Orleans, LA. (ERIC Document Reproduction Service No. ED 369 816)

Handley, H. M., & Morse, L. W. (1984). Two year study relating adolescents' self-concept and gender role perceptions to achievement and at6titude toward science. *Journal of Research in Science Teaching, 21*, 599-607.

Harlan, J. D., & Rivkin, M. S. (2004). *Science experiences for the early childhood years: An integrated approach* (8th ed.). Upper Saddle River, NJ: Pearson Education, Inc.

Harp, S. F., & Mayer, R. E. (1997). The role of interest in learning from scientific text and illustrations: On the distinction between emotional interest and cognitive interest. *Journal of Educational Psychology, 89*(1), 92-102.

Harris, L. J. (1981). Sex-related variations in spatial skill. In L. S. Liben, A. H. Patterson, & N. Newcombe (Eds.), *Spatial representation and behavior across the life span.* New York: Academic Press.

Haussler, P. & Hoffmann, L. (2002). An intervention study to enhance girls' interest, self-concept, and achievement in physics classes. *Journal of Research in Science Teaching, 39*, 870-888.

Hedges, L. V., & Nowell, A. (1995). Differences in mental test scores, variability, and numbers of high-scoring individuals. *Science, 269*, 41-45.

Helmke, A. (1989). Mediating processes between children's self-concept of ability and mathematical achievement: A longitudinal study. In H. Mandel, E. decorate, N. Bennett, & H. F. Friedrich (Eds.), *Learning and instruction* (pp. 537-549). Oxford: Pergamon Press.

Helwig, R., Rozeck-Tedesco, M. A., Tindal, G., Heath, B. & Almond, P. J. (1999). Reading as access to mathematics problem solving on multiple choice tests for 6th grade students. *Journal of Educational Research, 93*, 113-125.

Hertel, T. (1995). *Does coeducational instruction influence girls' interest in physics?* Frankfurt, Germany: Lang.

Hofer, B. K. (1999). Instructional context in the college mathematics classroom: Epistemological beliefs and student motivation. *Journal of Staff, Program, and Organizational Development, 16*, 73-82.

Hofer, B. K. (2000). Dimensionality and disciplinary differences in personal epistemology. *Contemporary Educational Psychology, 25*, 378-405.

Hofer, B. K., & Pintrich, P. R. (1997, Spring). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research, 67*, 88-140.

Hoff, A. E., & Ellis, G. D., (1992). Influence of agents of leisure socialization on leisure self-efficacy of university students. *Journal of Leisure Research, 24*, 114-126.

Hyde, J. S., Fennema, E., & Lamon, S. J. (1990). Gender differences in mathematics performance: A meta-analysis. *Psychological Bulletin, 107,* 139-155.

Hyde, J. S., & Linn, M. C. (1988). Gender differences in verbal ability: A meta-analysis. *Psychological Bulletin, 104*, 53-69.

Jeffe, D. B. (1995). About girls' "difficulties" in science: A social, not a personal matter. *Teachers College Record, 97*(2), 206-226.

Jinks, J., & Morgan, V. L. (1996). Students' sense of academic efficacy and achievement in science: A useful new direction for research regarding scientific literacy? *Electronic Journal of Science Education, 1*(2). Retrieved March 24, 2006 from http://unr.edu/homepage/jcannon/ejse/jinksmor.htm

Johnson, S. L. (1999). Discovering the potential of gifted girls: The biological and physical science interests of gifted kindergarten girls. *School Science and Mathematics, 99*(6), 302-312.

Johnson, R. T., Johnson, P. W., & Smith, K. (1991). *Active learning: Cooperation in the college classroom.* Edina, MN: Interaction Book.

Jones, G. (1991). Gender differences in science competitions. *Science Education, 75*(2), 159-167.

Jones, M. G., Howe, A., & Rua, M. J. (2000). Gender differences in students' experiences, interests, and attitudes toward science and scientists. *Science Education, 84*, 180-192.

Jovanovic, J., & King, S. S. (1998). Boys and girls in the performance based science classroom: Who's doing the performing? *American Educational Research Journal, 35*(3), 447-496.

Kahle, J., & Lakes, M. K. (1983). The myth of equality in science classrooms. *Journal of Research in Science Teaching, 20*(2), 131-140.

Kahle, J. B., & Meece, J. (1994). Research on gender issues in the classroom. In D. L. Gabel (Ed.), Handbook of research on science teaching and learning. New York: Macmillan.

Kaplan, A. & Maehr, M. L. (1999). Enhancing the motivation of African American students: An achievement goal theory perspective. *Journal of Negro Education, 68*, 23-41.

Kardash, C. M., & Howell, K. L. (1996). *Effects of epistemological beliefs on strategies of employed to comprehend dual positioning text*. Paper presented at the annual meeting of the American Educational Research Association, New York.

Kardash, C. M., & Howell, K. L. (2000). Effects of epistemological beliefs and topic-specific beliefs on undergraduates' cognitive and strategic processing of dual positioning text. *Journal of Educational Psychology, 92*(2), 524-535.

Kardash, C. M., & Scholes, R. J. (1995). Effects of pre-existing beliefs and repeated readings on belief change, comprehension and recall of persuasive text. *Contemporary Educational Psychology, 20*, 201-221.

Kelly, A. (1988). Sex stereotypes and school science. A three year follow up. *Educational Studies, 14*, 151-163.

Kelly, K., & Hall, A. (1994). Effects of academic achievement and gender on occupational aspirations and career interests. In N. Colangelo, S. Assouline, & D. Ambroson (Eds.), *Talent development*. Dayton OH: Ohio Psychology Press.

Kimball, M. M. (1989). A new perspective on women's math achievement. *Psychological Bulletin, 105*(2), 198-214.

Kirk, D., & MacPhail, A. (2002). Teaching games for understanding and situated learning: Rethinking the Bunker-Thorpe model. *Journal of Teaching in Physical Education, 21*, 177-192.

Kobella, T. R. (1989). *Changing and measuring attitudes in the science classroom*. National Association for Research in Science Teaching: Reston, VA.

Kobella, T. R., & Crawley, F. E. (1985). The influence of attitude on science teaching. *School Science and Mathematics, 89*(7), 541-551.

Kupermintz, H., & Roesier, R. W. (2001, April). *Another look at cognitive abilities and motivational processes in science achievement*. Paper presented at the meeting of the American Educational Research Association, Seattle, WA.

Laine, C. H., Bullock, T. L., & Ford, K. L. (1998). In search of content area reading instruction: The role of science classrooms. *Educational Research, 21*(3), 3-16.

Lan, W., & Skoog, G. (2003). *The relationship between high school students' motivational and metacognitive factors in science learning and their science achievement.* Unpublished doctoral dissertation, TexasTechnical University.

Larson, R. W., & Verma, S. (1999). How children and adolescents spend time across the world: Work, play, and developmental opportunities. *Psychological Bulletin, 125*, 701-736.

Lawson, A. (2000). A learning cycle approach to introducing osmosis. *The American Biology Teacher, 62*, 189-196.

Lee, V. E. (1987). *Identifying potential scientists and engineers: An analysis of the high school-college transition.* (Report No. SE-049-463). Washington, DC: Congress of the U.S., Office of Technology Assessment. (ERIC Document Reproduction Service No. ED308063).

Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice, and performance. *Journal of Vocational Behavior, 45*, 79-122.

Lent, R. W., Brown, S. D., & Larkin, K. C. (1986). Self efficacy in the prediction of academic performance and perceived career options. *Journal of Counseling Psychology, 33*(3), 265-269.

Lent, R. W., Lopez, F. G., & Bieschke, K. J. (1991). Mathematics self-efficacy: Sources and relation to science-based career choices. *Journal of Counseling Psychology, 38*, 424-430.

Lenth, R. V. (2001). Some practical guidelines for effective sample size determination. *The American Statistician, 55*, 187-193.

Linn, M. C. (1990, July). *Gender, mathematics and science: Trends and recommendations.* Paper prepared for the Council of Chief State Officers, Summer Institute, Mystic, CT.

Linn, M. C., & Hyde, J. S. (1989). Gender, mathematics, and science. *Educational Researcher, 18*(8), 17-27.

Linn, M., Lewis, C., Tsuchida, I., & Songer, N. (2000). Beyond fourth grade science. Why do U.S. and Japanese students diverge? *Educational Researcher, 29*(3), 4-14.

Linn, M. C. & Peterson, A. C. (1985). Facts and assumptions about the nature of sex differences. In S. S. Klein (Ed.), *Handbook for achieving sex equality through education (*pp. 53-77). Baltimore: Johns Hopkins University Press.

Lips, H. M. (1992). Gender and science related attitudes as predictors of college students' academic choices. *Journal of Vocational Behavior, 40*(1), 62-81.

Lockheed, M., Thorpe, M., Brooks-Gunn, J., Casserly, P., & McAloon, A. (1985). *Understanding sex/ethnic related differences in mathematics, science, and computer science for students in grades four to eight*. Princeton: Educational Testing Service.

Long, J. S. (1997). *Regression models for categorical and limited dependent variables*. Thousand Oaks, CA: Sage.

Lord, T. & Rupert, J. (1995). Visual-spatial aptitude in elementary education majors in science and math tracks. *Journal of Elementary Science Education, 7*(2), 47-59.

Mahoney, J. L. (2000). School extracurricular activity participation as a moderator in the development of antisocial patterns. *Child Development, 71*, 502-516.

Mahoney, J. L., & Statten, H. (2000). Leisure activities and adolescent anti-social behavior: The role of structure and social context. *Journal of Adolescence, 23,* 113-127.

Mannell, R. C., & Kleiber, D. A. (1997). *A social psychology of leisure.* State College, PA: Venture Publishing, Inc.

Marsh, H. W. (1990). Causal ordering of academic self-concept and academic achievement: A multiwave, longitudinal panel analysis. *Journal of Educational Psychology, 82*, 646-656.

Marsh, H. W. (1992). Content specificity of relations between academic achievement and academic self concept. *Journal of Educational Psychology, 84*(1), 35-42.

Marsh, H. W., Barnes, J., Cairns, L., & Tidman, M. (1984). The self description questionnaire (SDQ): Age effects in the structure and level of self-concept for preadolescent children. *Journal of Educational Psychology, 76*, 940-956.

Marsh, H. W. & Kleitman, S. (2002). Extracurricular school activities: The good, the bad, and the nonlinear. *Harvard Educational Review, 72*(4), 464-514.

Marsh, H. W., & Yeung, M. A. (1998). Longitudinal structural equation models of academic self-concept and achievement: Gender differences in the development of math and English constructs. *American Educational Research Journal, 35*, 705-738.

Matsumoto, A. R. (1995, April). *Gender differences in mathematics performance: A comparison of meta-analyses.* Paper presented at the annual meeting of American Educational Research Association, San Francisco.

Mau, W. C., Domnick, M., & Ellsworth, R. A. (1995). Characteristics of female students who aspire to science and engineering or homemaking occupations. *Career Development Quarterly, 43*, 323-337.

McCandless, N.J., Lueptow, L.B., & McKee, M. (1989). Family socioeconomic status and adolescent sex-typing. *Journal of Marriage and the Family*, *51*(3), 627-635.

McCrudden, M. T., Perkins, P. G., & Putney, L. G. (2005). Self efficacy and interest in the use of reading strategies. *Journal of Research in Childhood Education, 20*(2), 119-133.

McNamara, D. S., Kintsch, E., Songer, N. B., & Kintsch, W. (1996). Are good texts always better? Interactions of text coherence, background knowledge and levels of understanding in learning from text. *Cognition and Instruction, 14*(1), 33-76.

Meech, J. L., & Jones, C. (1996). Gender differences in motivation and strategy use in science: Are girls rote learners? *Journal of Research in Science Teaching, 33*(4), 393-406.

Meece, J. L., Wigfield, A., & Eccles, J. S. (1990). Predictors of math anxiety and its influence on young adolescents' course enrollment intentions and performance in mathematics. *Journal of Educational Psychology, 82*, 60-70.

Miller, L. & Budd, J. (1999). The development of occupational sex role stereotypes, occupational preferences, and academic subject preferences in children at ages 8, 12, and 16. *Educational Psychology, 19*(1), 17-35.

Miller, R. B., DeBacker, T. K., & Greene, B. A. (1999). Perceived instrumentality and academics: The link to task valuing. *Journal of Instructional Psychology, 26*(4), 250.

Morrell, P. D., & Lederman, N. G. (1998). Students' attitudes toward school and classroom science: Are they independent phenomena? *School Science and Mathematics, 98*, 76-82.

Mullis, I. V. S., & Jenkins, L. B. (1988). *The science report card: Elements of risk and recovery.* Princeton, NJ: Educational Testing Service.

National Center for Education Statistics. (2004). *Student effort and educational progress. Postsecondary persistence and progress*. Available at http://nces.ed.gov/programs/coe/2004/section3/indicator19.asp

National Council of Teachers of Mathematics (NCTM). (2000). *The principles and standards for school mathematics*. Reston, VA.

National Education Goals Report. (1995). *Volume one: National Data* (Publication No. 20402-9328). Washington, DC: US Government Printing Office.

National Science Board. (2004). Retrieved June 20, 2005 from http://www.nsf.gov/nsb/

National Science Foundation. (2002). *Science and Engineering Degrees: 1966-2000*. NSF report 02-327. Arlington, VA: NSF.

National Science Foundation. (2006). *Doctorates awarded to women.* Retrieved June 2, 2007, from http://www.nsf.gov/statistics/nsf06308/pdf

National Science Teachers Association, (1996). *NSTA pathways to the science standards: Guidelines for moving the vision into practice*. Washington, DC.

Nauta, M. M., Epperson, D. L., & Kahn, J. H. (1998). A multiple-groups analysis of predictors of higher level career aspirations among women in mathematics, science, and engineering majors. *Journal of Counseling Psychology, 45*(4), 483-496.

Neathery, M. F. (1997). Elementary and secondary students' perceptions toward science: Correlations with gender, ethnicity, ability, grade, and science achievement. *Electronic Journal of Science Education, 2*(1). Retrieved November 26, 2005 from http://unr.edu/homepage/jcannon/ejse/neathery.html

Neber, H., & Schommer-Aikens, M. (2002). Self-regulated science learning with highly gifted students: The role of cognitive, motivational, epistemological, and environmental variables. *High Ability Studies, 13*(1), 59-74.

Neuschatz, M. & McFarling, M. (2003). *Broadening the base: High school physics education at the turn of a new century*. AIP Report R-439. Available at http://www.aip.org/statistics/trends/reports/hsreport2003.pdf

Norusis, M. J. (1990). *SPSS advanced statistics student guide.* SPSS Inc., Chicago, IL.

Nosek, B. A., Banaji, M. R., & Greenwald, A. G. (2002). Math = male, me = female, therefore math [not equal to] me. *Journal of Personality and Social Psychology, 83*, 44-59.

Oakes, J. (1990). Opportunities, achievement, and choice: Women and minority students in science and mathematics. In Cazden, C. B. (Ed.), *Review of Research in Education, 16*, 153-222.

O'Brien, K.M. & Fassinger, R.E. (1993). A causal model of the career orientation and career choice of adolescent women. *Journal of Counseling Psychology*, *40*(4), 456-469.

Olejnik, S. F. (1984). Planning educational research: Determining the necessary sample size. *Journal of Experimental Education, 53*(1), 40-48.

O'Reilly, T., & McNamara, D. S. (2002). *What's a science student to do?* Proceedings of the Twenty-fourth Annual Meeting of the Cognitive Science Society, 726-731. Retrieved June 6, 2005, from http://csep.psyc.memphis.edu/istart/docs/OReilly_McNamara_cogsci.PDF

Ormerod, M. B., & Duckworth, D. (1975). *Pupils attitudes to science: A review of research*. Slough, England: National Foundation for Educational Research in England and Wales.

Osgood, D. W., Anderson, A. L., & Shaffer, J. N. (2004). Unstructured leisure in the after school hours. In J. L. Mahoney, J. S. Eccles, & R. W. Larson (Eds.), *Organized activities as contexts of development: Extracurricular activities after school and community programs.* Mahwah, NJ: Lawrence Erlbaum and Associates.

Pajares, F., & Graham, L. (1999). Self-efficacy, motivation constructs, and mathematics performance of entering middle school students. *Contemporary Education Psychology, 24*, 124-139.

Paris, S. G., Lipson, M., & Wixson, K. (1983). Becoming a strategic reader. *Contemporary Educational Psychology, 8*, 293-316.

Park, A. H. (2002). The intersection of racism and sexism in the career experiences of Asian American professional women. *Dissertation Abstracts International, 63*(02), 510A, (UMI No. 3043404).

Paulsen, M. B., & Well, C. T. (1998). Domain differences in the epistemological beliefs of college students. *Research in Higher Education, 39*, 365-384.

Paunonen, S. V., & Ashton, M. C. (2001). Big five predictors of academic achievement. Journal of Research in Personality, 35, 78-90.

Pedhazur, E. J. (1997). *Multiple regression in behavioral research,* (3rd ed.). Orlando, FL: Harcourt Brace.

Petty, R. E., & Cacioppo, J. T. (1986). *Communication and persuasion.* New York: Springer-Verlag.

Phillips, K. A., Barrow, L. H., & Chandrasekhar, M. (2002). Science career interests among high school girls one year after participation in a summer science program. *Journal of Women and Minorities in Science and Engineering, 8,* 235-247.

Powell, D. A. (2002). *Quantitative research methods II.* Unpublished manuscript.

Pressley, M. (2002). Comprehension strategies instruction: A turn-of-the-century report. In C. C. Block & M. Pressley (Eds.), *Comprehension instruction: Research-based best practices* (pp. 11-27). NY: Guilford Press.

Qian, G., & Alvermann, D. (1995). Role of epistemological beliefs and learned helplessness in secondary school students' learning science concepts from text. *Journal of Educational Psychology, 87*, 282-292.

Radcliffe, R., Caverly, D. C., Peterson, C. L., Emmons, M. (2004). Improving textbook reading in a middle school science classroom. *Reading Improvement, 41*(3), 145-156.

Rand, D., & Gibb, L. (1989). A model program for gifted girls in science. *Journal for the Education of the Gifted, 12*(2), 142-155.

Research America. (2004). *2004 Annual Report.* Available at http://www.researchamerica.org/publications/annualreport/annualreport2004/pdf

Reynolds, A. J., & Walberg, H. J. (1992). A structural model of science achievement and attitude: An extension to high school. *Journal of Educational Psychology, 84*, 371-382.

Reynolds, N. G., & Conaway, B. J. (2003). Factors affecting mathematically talented females' enrollment in high school calculus. *Journal of Secondary Gifted Education, 14*(4), 218-228.

Riesz, E. D., McNabb, T. F., & Stephen, S. L. (1997). Gender patterns in science attitudes and achievement: Report of a longitudinal study. *Journal of Women and Minorities in Science and Engineering, 3*, 161-183.

Robertson, B. J., & Shannon, C. S. (2002, May). *Sources of leisure education: Youth in school and custody settings.* Proceedings of the 10th Canadian Congress on Leisure Research. Edmonton, AB, pp. 238-287.

Rock, D. A., & Pollack, J. M. (1995). *Psychometric report for NELS: 88 base year through second follow-up* (NCES Publication No. 95 382). Washington, DC: U.S. Department of Education.

Rojewski, J.W. & Yang, B. (1997). Longitudinal analysis of select influences on adolescents' occupational aspirations. *Journal of Vocational Behavior*, *51*, 375-410.

Sadker, M., & Sadker,D. (1994). *Failing at fairness: How America's schools cheat girls.* New York: Macmillan.

Sadker, M., Sadker, D., & Klein, S. (1991). The issue of gender in elementary and secondary education. in Cazden, C. B. (Ed.), *Review of Research in Education, 17,* 269-334.

Schaefers, K. G., Epperson, D. L., & Nauta, M. M. (1997). Women's career development: Can theoretically derived variables predict persistence in engineering majors? *Journal of Counseling Psychology, 44*, 173-183.

Schiebinger, L. (1999). *Has feminism changed science?* Cambridge, MA: Harvard University Press.

Schiefele, U. (1996). Topic interest, text representation, and quality of experience. *Contemporary Educational Psychology, 21*, 3-18.

Schiefele, U. (1999). Interest and learning from text. *Scientific Studies of Reading, 3*(3), 257-280.

Schommer, M. (1994). Synthesizing epistemological belief research: Tentative understandings and provocative confusions. *Educational Psychology Review, 6*, 293-319.

Schommer-Aikens, M., Mau, W., Brookhart, S., & Hutter, R. (2000). Understanding middle school students' beliefs about knowledge and learning using a multidimensional paradigm. *Journal of Educational Research, 94*, 120-128.

Schraw, G., Bendixen, L. D., & Dunkle, M. E. (2002). Development and validation of the Epistemic Belief Inventory (EBI). In B. K. Hofer, & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 261-275), Mahwah, NJ: Earlbaum.

Seminole County Public Schools (2007). Retrieved June 16, 2007 from the Web site: http://www.scps.k12.fl.us/

Shamai, S. (1994). Possibilities and limitations of a gender stereotypes intervention program. *Adolescence, 29*(115), 665-680.

Sholl, M. J. (1989). The relation between horizontality and rod-and-frame and vestibular navigational performance. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 15*, 110-125.

Simpson, R. D., & Oliver, J. S. (1990). A summary of major influences on attitude toward and achievement in science among adolescent students. *Science Education, 74,* 1-18.

Singh, K., Granville, M. & Dika, S. (2002). Mathematics and science achievement: Effects of motivation, interest, and academic engagement. *Journal of Educational Research, 95*(6), 323-332.

Skaalvik, E. M., & Rankin, R. J. (1995). A test of the internal/external frame of reference model at different levels of math and verbal self-perception. *American Educational Research Journal, 32*, 161-184.

Snow, R. E. (1989). Toward assessment of cognitive and conative structures in learning. *Educational Researcher, 18*(9), 8-14.

Soloman, B. M. (1985). *In the company of educated women.* New Haven: Yale University Press.

Spencer, S. J., Steele, C. M., & Quinn, D. M. (1999). Stereotype threat and women's math performance. *Journal of Experimental Social Psychology, 35*, 4-28.

Sperry-Smith, S. (2001). *Early childhood mathematics* (2nd ed.). Needham Heights, MA: Allyn & Bacon.

Spiro, R. J., & Jehng, J. C. (1990). Cognitive flexibility and hypertext: Theory and technology for the linear and multidimensional traversal of complex subject matter. In D. Nex, & R. J. Spiro (Eds.), *Cognition, education, and multimedia* (pp. 163-205). Hillsdale, NY: Lawrence Erlbaum Associates.

Sprague, M. M. & Cotturone, J. (2003, March). Motivating students to read physics content. *The Science Teacher*, 24-29.

Sprigler, D. M., & Alsup, J. K. (2003). An analysis of gender and the mathematical reasoning ability sub-skill of analysis-synthesis. *Education, 123*(4), 763.

Stake, J. E., & Nickens, S.D. (2005). Adolescent girls' and boys' science peer relationships and perceptions of the possible self as scientist. *Sex Roles: A Journal of Research, 52*(1-2), 1-18.

Steele, C. M. (1997). A threat in the air: How stereotypes shape intellectual identity and performance. *American Psychologist, 52*(6), 613-629.

Steele, C. M., & Aronson, J. (1995). Stereotype threat and the intellectual test performance of African Americans. *Journal of Personality and Social Psychology, 69*(5), 797-811.

Steinkamp, M. W., & Maehr, M. (1984). Affect, ability and science achievement: A quantitative synthesis of correlational research. *Review of Educational Research, 53*, 369-396.

Stuart, M. D., & Henry, R. W. (2002). Plastinated specimens can improve the conceptual quality of Biology labs. *The American Biology Teacher, 64*, 130-134.

Sweet, A. P., Guthrie, J. T., & Ng, M. (1998). Teacher perceptions and student reading motivation. *Journal of Educational Psychology, 90*, 210-224.

Tabachnick, B. G., & Fidell, L. S. (1996). *Using multivariate statistics* (3rd ed.). New York: Harper Collins.

Terwilliger, J. S., & Titus, J.C. (1995). Gender differences in attitudes and attitude changes among mathematically talented youth. *Gifted Child Quarterly, 39*, 29-35.

Tindall, T., & Hamil, B. (2004). Gender disparity in science education: The causes and consequences, and solutions. *Education, 125*(2), 282.

Tobias, S. (1990). *They're not dumb, they're different: Stalking the second tier*. Tuscon AZ: Research Corporation.

Tobias, S. (1994). Interest, prior knowledge, and learning. *Review of Educational Research, 64*, 37-54.

Trusty, J. (2002). Effects of high school course-taking and other variables on choice of science and mathematics college majors. *Journal of Counseling and Development, 80*(4), 464-474.

Tsai, C. (1998). An analysis of scientific epistemological beliefs and learning orientations of Taiwanese eighth graders. *Science Education, 82*(4), 473-489.

Tsai, C. (1999). The progression toward constructivist epistemological views of science: A case study of the STS instruction of Taiwanese high school female students. *International Journal of Science Education, 21*(11), 1201-1222.

Tsai, C. (2000). Relationship between student scientific epistemological beliefs and perception of constructivist learning environments. *Educational Research, 42*(2), 193-206.

U.S. Department of Education, (n.d.). *The nations report card.* Retrieved August 12, 2006 from http://nationsreportcard.gov/science-2005/s0102.asp

U. S. Department of Education, (2004). *Trends in educational equity of girls and women: 2004.* Retrieved October 15, 2005, from National Center of Education Statistics Website: http://nces.ed.gov/pubs2005/2005016.pdf

U.S. Department of Labor (2007). Retrieved October 1, 2007, from http://www.bls.gov

Vanayan, M., White, N., Yuen, P., & Teper, M. (1997). Beliefs and attitudes toward mathematics among third- and fifth-grade students: A descriptive study. *School Science and Mathematics, 97*(7), 345-351.

Vanleuvan, P. (2004). Young women's science/mathematics career goals from seventh grade to high school graduation. *Journal of Educational Research, 97*(5), 248.

Voyer, D. (1996). The relation between mathematical achievement and gender differences in spatial abilities: suppression effect. *Journal of Educational Psychology, 88,* 563-571.

Wade, S. E., Buxton, W. M., & Kelly, M. (1999). Using think-alouds to examine reader-text interest. *Reading Research Quarterly, 34*(2), 194-216.

Wainer, H., & Steinberg, L. S. (1992). Sex differences in performance on mathematics section of the Scholastic Aptitude Test: A bidirectional validity study. *Harvard Educational Review, 62*(3), 323-336.

Walberg, H. J. (1981). A psychological theory of educational productivity. In F. H. Farley & H. Gordon (Eds.), *Psychology and education.* Chicago: Chicago National Society for the Study of Education.

Wang, J. & Goldschmidt, P. (1999). Opportunity to learn, language proficiency, and immigrant status effects on mathematics achievement. *Journal of Educational Research, 90*(2), 103-110.

Wang, J., & Goldschmidt, P. (2003). Importance of middle school mathematics on high school students' mathematics achievement. *Journal of Educational Research, 97*(1), 3-18.

Ware, N. C., & Lee, V. E. (1988). Sex difference in choice of college science majors. *American Educational Research Journal, 25*, 593-614.

Weinburgh, M. (1995). Gender differences in student attitudes toward science: A metaanalysis of literature from 1970 to 1991. *Journal of Research in Science Teaching, 32*(4), 387-398.

Weissberg, R. P., Barton, H. A., & Shriver, T. P. (1997). The social competence promotion program for young adolescents. In G. W. Albee & T. P. Gullotta (Eds.), *Primary prevention works* (pp. 268-290). Thousand Oaks, CA: Sage.

West, R. F., & Stanovich, K. (1995). Knowledge growth and maintenance across the life span: The role of print exposure. *Developmental Psychology, 31,* 811-826.

Wigfield, A., & Eccles, J. S. (2000). Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology, 25*, 68-81.

Wigfield, A., & Eccles, J. S. (2002). The development of competence beliefs and values from childhood through adolescence. In A. Wigfield & J. S. Eccles (Eds.), *Development of achievement motivation* (pp.92-120). San Diego, CA: Academic Press.

Wigfield, A., Eccles, J. S., & Pintrich, P. R. (1986). *Development between the ages of 11 and 25*. In D.C. Berliner, & R. C. Calfie (Eds.), Handbook of educational *psychology,* (pp. 148-185). New York: Simon and Schuster MacMillan.

Wigfield, A., Guthrie, J. T., Tonks, S., & Perencevich, K. C. (2004). Children's motivation for reading: Domain specificity and instructional influences. *Journal of Educational Research, 97*(6), 299-309.

Zelden, A. L., & Pajares, F. (2000). Against the odds: Self-efficacy beliefs of women in mathematical, scientific, and technological careers. *American Educational Research Journal, 37*, 215-246.

Ziegler, A., Finsterwald, M., & Grassinger, R. (2005). Predictors of learned helplessness among average and mildly gifted girls and boys attending initial high school physics instruction in Germany. *The Gifted Child Quarterly, 49*(1), 7-18.