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Shari Lynn Britner
Science Self-Efficacy of African American Middle School Students:
Relationship to Motivation Self-Beliefs, Achievement,
Gender, and Gender Orientation.

By

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Doctor of Philosophy Degree

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Science Self-Efficacy of African American Middle School Students: Relationship to Motivation Self-Beliefs, Achievement, Gender, and Gender Orientation.

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An abstract of a dissertation submitted to the Faculty of the Graduate School of Emory University in partial fulfillment of the requirements for the degree of Doctor of Philosophy

Division of Educational Studies

2002
Abstract

Motivation researchers have established that students' self-efficacy beliefs, the confidence they have in their academic capabilities, are related to academic outcomes. Self-efficacy has been amply researched in mathematics and language arts and nearly exclusively with White students. African American students and the area of science have each received scant attention. Typically, gender differences favor boys in mathematics and girls in language arts. Researchers have also found that these differences may be a function of gender orientation beliefs. The purpose of this study was to extend findings in science self-efficacy and to African American middle school students. I sought to determine whether self-efficacy assessed at differing levels of specificity (lab skills versus science grades) would each predict science achievement assessed at corresponding levels, to discover whether mean scores in academic motivation and achievement would differ by gender, and to determine whether these differences are a function of gender orientation (N = 268). Science grade self-efficacy was positively associated with the grades obtained by boys and by girls. For girls, grades were also associated positively with science self-concept and negatively with value of science. For reasons resulting from problematic instructional practices, lab skills self-efficacy was not associated with lab grades. Girls reported stronger science self-efficacy and received higher grades in science class. Gender orientation beliefs did not account for these differences, but masculinity and femininity were each associated with science grade self-efficacy, suggesting that androgyny is an adaptive orientation for the science self-efficacy beliefs of African American students. Findings are interpreted within the framework of A. Bandura's (1986) social cognitive theory.
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CHAPTER 1
INTRODUCTION

Those who teach science have come to a universal observation: Students' behavior is influenced by the values they hold, the motivation they possess, the beliefs they bring from home to the classroom, and the myriad attitudes they have formulated about school, science, and life in general. The key to success in education often depends on how a student feels toward home, self, and school.

(Simpson, Koballa, Oliver, & Crawley, 1994, p. 211)

Theoretical Framework

In the history of American psychology, attention to the self has cycled between the center and the margin (Pajares & Schunk, 2001). Self-beliefs played a central role in the writings of William James (1892/1981), who, foreshadowing later self-constructs, posited that successful experiences raise self-esteem and failures lower it and that self-esteem, in turn, has a strong influence on human behavior. Psychoanalysts Sigmund Freud (1923/1960) and Carl Jung (1960) were also interested in the role of the self and self-processes, although this interest was tempered by their belief in the influence of biological determinants. Erik Erikson (1963) focused on the self in his charting of the developmental stages of ego identity. Attention to self-constructs was pushed to the margin as psychologists with a behaviorist orientation shifted the central focus of psychological theory to observable, measurable behaviors. During the time that behaviorist views dominated psychology, theories of the self were kept alive by a few psychologists and theorists, but self-concepts were less prominent than behavioristic interpretations of human behavior (Pajares & Schunk, 2001).
Behaviorist psychologists held the center until the humanist revolt of the 1950s turned attention back to inner processes and self-constructs. Humanistic psychologists turned away both from the psychoanalytical emphasis on abnormality and from the behaviorists' restricted view of human functioning. They again placed the self center-stage with emphasis on the importance of healthy self-concepts. The most prominent voice in the humanistic movement was that of Abraham Maslow (1954), whose theory of self-actualization emphasized maximizing each individual's potential for growth.

During the 1980s psychologists became more interested in cognitive processes and an information-processing view of human functioning (Pajares & Schunk, 2001). Although these psychologists emphasized internal processes, they shifted the study of the self from self-perceptions to a "colder," more cognitive perspective. Since then, however, the self-concept has enjoyed a resurgence of interest among educational psychologists. One of the most prominent of the new theorists was Albert Bandura (1977), who rejected behavioristic and deterministic explanations of human behavior because they failed to account for self-determined behavior.

Bandura (1986) described human functioning as characterized by five uniquely human capabilities: symbolizing, forethought, vicarious learning, self-regulation, and self-reflection. The most important of these capabilities is self-reflection, which plays a critical role in determining behavior. According to social cognitive theory, behavior, cognitive factors, and environmental events influence each other. Of all cognitive and other personal factors, Bandura (1986) contended that self-efficacy, which he defined as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances" (p. 391), is the most influential arbiter in human functioning.
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. Thus, it is often a better predictor of success than are actual abilities. Self-efficacy affects behavior by influencing people's behavioral choices, the amount of effort they expend, and the persistence they exhibit in the face of failure.

Statement of the Problem

Most self-efficacy research in academic contexts has been conducted in language arts and mathematics. Mathematics self-efficacy predicts mathematics performance and mediates between gender and achievement (Pajares & Miller, 1994). Boys and girls report equal confidence in their mathematics ability during elementary years, but, by middle school, boys begin to rate themselves more efficacious than do girls (Wigfield, Eccles, & Pintrich, 1996). In general, self-efficacy research in the domain of mathematics supports Bandura's contention that self-efficacy is a strong predictor and mediator of performance.

In writing, as in mathematics, self-efficacy predicts performance across grade levels (Pajares & Johnson, 1994; Pajares, Miller, & Johnson, 1999). Some gender differences in writing self-efficacy are evident, with girls reporting higher confidence in their writing abilities than do boys (Pajares & Valiante, 1997). This gender difference favoring girls was not evident in a study using students from Grades 3, 4, and 5, even though the girls were rated as better writers by their teachers (Pajares et al., 1999). However, the girls did describe themselves as better writers than the boys, thus raising the issue of response bias. The research on perceived ability in writing confirms the findings from the domain of mathematics on the usefulness of the self-efficacy construct in predicting subsequent achievement.
Few investigations of confidence in science as a predictor of science achievement are available, and much of what is available is conceptually or methodologically problematic. Bandura (1986) argued that perceptions of ability must be carefully matched to the criterial outcomes used. Self-efficacy assessments often lack specificity of measurement and consistency with available outcome measures, thus making it difficult to evaluate the influence of self-efficacy (Pajares, 1996b; Pajares & Miller, 1995).

In addition, some researchers have used student self-reports of their previous science grades as the achievement measure (Jinks & Morgan, 1996), which may be less reliable than grades obtained from teachers or from school records (Cassady, 2001). Significant correlations between science self-efficacy and science achievement are found, however, when standardized performance measures are used (Andrew, 1998; Britner & Pajares, 2001). To date, only Britner and Pajares have compared the science self-efficacy of middle school students to an objective measure of science achievement.

Social and biological changes during the middle school years influence students' self-beliefs. In early adolescence, students' self-concepts of ability often begin to decrease (Wigfield, Eccles, Maclver, Reuman, & Midgley, 1991). This drop is particularly apparent during Grades 6 and 7 (Anderman & Maehr, 1994). Many students regain this loss in self confidence during the later adolescent years, but others continue to decline and do not regain previous levels of self-beliefs (Wigfield et al., 1991).

Historically, there has been less research on the motivational psychology of African American students than of White students (Graham, 1994). Research on self-efficacy in African American students is even more scarce. In her review of the literature published prior to 1990 on motivation in African American students, Graham (1994) found only 18 studies on ability self-concept (none used the term self-efficacy):
All were race-comparative. Graham (1994, 1995) criticized existing motivation research on African Americans for being based on a deficit model and for being too narrowly focused on socioeconomic factors and comparisons with White students. She encouraged more research based on theoretical principles and suggested that insights resulting from studies of motivation in African American students need not be applied only to African American students but can also inform the psychology of human behavior.

Despite Graham's (1994) call for research focusing on in-group differences in the relationships among motivation variables in African American students, little new research on academic self-efficacy in African American students is available. Edelin and Paris (1995) investigated the calibration between African American students' self-efficacy and their performance in mathematics and in school. They reported that the majority of the students in their sample had accurate perceptions of ability. Among the students with poor calibration, boys were more likely to be overconfident and girls underconfident. In a study of African American students in Grades 4 to 6, achievement motivation was significantly correlated with reading and mathematics achievement (Schultz, 1993). Given the paucity of information on the academic self-efficacy of African American students, there is clearly a need for further research in this area.

Purpose of the Study

Although there has been a great deal of research on self-efficacy in mathematics and writing, little has been conducted in the area of science, with even less information available on the relationship between science self-efficacy and science achievement. In addition, as I outlined earlier, previous studies have suffered from methodological limitations, thus self-efficacy research designed in accordance with established protocols is needed. Finally, little research has been conducted investigating the self-efficacy of
African American students (Graham, 1994; Pajares, 1997), with even less research available on possible gender differences in science self-efficacy. Given the importance of science in the curriculum and as a gateway to future careers, more information on science self-efficacy would enhance the efforts of educators to support both girls and boys in developing their full potential.

Gender differences in self-efficacy have been found favoring boys in mathematics and favoring girls in writing. Less is known, however, about gender differences in science self-efficacy. Moreover, researchers have reported that gender differences observed in writing self-efficacy beliefs may actually be a function of gender orientation rather than gender.

The primary objective of this study was to determine whether self-efficacy beliefs assessed at two levels of specificity would each make an independent contribution to the prediction of science achievement measured at two corresponding levels of specificity when other variables that have been found to predict achievement indexes in mathematics and language arts are controlled. Specifically, I tested the hypothesis that self-efficacy assessed at the task-specific level of confidence (i.e., that one possesses the skills to succeed in a laboratory activity) would predict success in that activity. Conversely, self-efficacy assessed at the domain-specific level of confidence to achieve a given grade in science would predict academic achievement in science class. I also investigated whether mean scores in motivation and achievement in science would differ by gender. Finally, I sought to discover whether gender differences in academic motivation and achievement were actually a function of gender orientation rather than gender.

Research Hypotheses
The research hypotheses for this study are informed by the theoretical tenets of social cognitive theory and are designed to build on results of earlier investigations dealing with self-efficacy in academic settings. Research hypotheses were as follows:

1. Science lab self-efficacy will make an independent contribution to the prediction of science laboratory performance of African American middle school students when previous achievement, science self-concept, science anxiety, self-efficacy for self-regulation, and value of science are included in the statistical model.

2. Science grade self-efficacy will make an independent contribution to the prediction of the science grade of African American middle school students when previous achievement, science self-concept, science anxiety, self-efficacy for self-regulation, and value of science are included in the statistical model.

3. Mean scores in the science motivation and achievement of African American middle school students will differ by gender.

4. Gender differences in science self-beliefs and achievement will be rendered nonsignificant when gender orientation beliefs are controlled.

Limitations of the Study

A limitation of this study is that the data collected consists of self-reports by students on statements that may or may not precisely correspond to their unique self-beliefs. There is also the danger that students may not honestly answer the questions. The limitations of self-report data should be kept in mind as findings are presented and interpreted. To minimize this problem, students were assured that their responses would remain confidential and that only aggregate data would be reported.

Another limitation is the difficulty of comparing lab grades from students taught by different teachers. Variability in how teachers determined lab grades could be a factor
in the results obtained. This was addressed by having teachers indicate which of the
abilities identified in the Lab Skills Self-Efficacy scale were salient to the labs conducted
in their classrooms.

This investigation was conducted with African American middle school students
in an urban school district, thus caution is urged in generalizing to other populations or
settings. However, this also represents a strength of the present study, as there is a dearth
of research on self-efficacy among African American students.

Significance of the Study

Although there is a rich data base on self-efficacy in other academic areas, the
present study is the first race-homogeneous investigation to examine the role played by
the self-efficacy beliefs of African American middle school students in the area of
science. Thus, there are two areas of significance. The first is the importance of self-
beliefs in science education. The nature of conceptual change has been a key focus of
science education research as well as science education reform efforts, evident in the
current emphasis on constructivism and inquiry learning. Much science instruction and
learning depends on conceptual change, the progress from incomplete or inaccurate
knowledge that children may possess to more complete or accurate knowledge and
conceptual understanding that is the goal of science instruction. Pintrich, Marx, and
Boyle (1993) criticize science instruction based on an entirely cognitive model,
suggesting instead that motivational and contextual factors interact with cognitive
processes to effect conceptual change. Students as active, generative learners is at the
center of science education reform. If, as suggested by Bandura (1986), students with
high self-efficacy engage in deeper cognitive processing strategies, show greater
persistence, and attempt appropriately challenging tasks more often than those with low
self-efficacy, then confidence in science should facilitate the kind of conceptual change that is the goal of science instruction.

Because self-efficacy influences academic achievement, a drop in confidence during the middle school years can have a negative influence on students' futures. These issues are especially critical in the areas of mathematics and science, as low achievement can foreclose future career possibilities. A failure to take science and mathematics courses because of low self-efficacy can block the pursuit of careers in mathematics and science (Zeldin & Pajares, 2000).

The second area of significance is the underrepresentation of women and minorities in advanced science courses and in science-related careers (National Center for Educational Statistics, 2000, 2001). African American students have participated in science courses at lower rates than have White students (Oakes, 1990) and therefore have been less likely to pursue science-related careers. Oakes outlined three factors critical to success in scientific fields: Two of these, achievement and course-taking choices, are doubtlessly influenced by science self-efficacy (Pajares, 1997; Zeldin & Pajares, 2000). Thus, educators working with African American students require information about science self-efficacy and the relationships among other motivation constructs. Again, this is especially important during the middle school years when students are making decisions that could have long-lasting effects.

Women and girls are also underrepresented in science, although that gap is diminishing (Eisenberg, Martin, & Fabes, 1996; National Center for Educational Statistics, 2000, 2001). Female students are more likely than male students to take biology and equally likely to take chemistry. Male students, however, continue to take a greater total number of science courses and enroll in more advanced science courses.
Gender differences in achievement persist in spite of improvements in the science performance of female students. Among 17-year-old students the percentage of young women scoring at or above 300 on NAEP science assessments has increased by 26% between 1977 and 1996, whereas the percentage of young men scoring at this level has increased only 9%. In spite of their more rapid rate of increase, however, female students still score 20% lower than do male students. Given that lower self-beliefs and attitudes toward science may affect girls' persistence and achievement in science courses (Weinburg, 1995), information on these affective factors will help educators encourage girls to fully develop their potential in science-related endeavors.

These disparities in enrollment and achievement continue in post-secondary institutions. Women and minority students are found in fewer numbers at each level of preparation for scientific careers, from undergraduate study to postdoctoral research (Erwin & Maurutto, 1998; National Center for Educational Statistics, 2000, 2001). As Weiner (1990) so aptly noted, "school motivation cannot be divorced from the social fabric in which it is embedded" (p. 621). This social fabric has had powerful effects on the participation of girls and minority students in science classes and science-related careers. African American students take fewer science courses, particularly advanced science courses, than do White students (National Center for Educational Statistics, 2000, 2001). They also have lower achievement, scoring lower on National Assessment of Educational Progress (NAEP) tests, especially in more complex tasks such as applying information and analyzing data.

Given that social and cultural factors influence who becomes a scientist, the field of science chosen, and the questions pursued, scientists representing all social groups would enhance both the field and the research process (Pearson & Bechtel, 1989).
Questions selected for investigation, as well as those neglected, are socioculturally and politically influenced. Expanding the scientific community to include scientists of both genders and diverse ethnicities will promote the development of a science that is responsive to the needs of all segments of society.

During the middle school years, children undergo a period of rapid change, a period that offers great potential for intervention on the part of science educators. Educators must encourage and support the development of students’ self-efficacy beliefs as well as the development of science knowledge and skills, as positive self-efficacy beliefs enable students to fully express their competencies, abilities, and skills. To achieve this, educators must have access to information on the predictive utility of science self-efficacy and on the relationship among other student self-beliefs related to science.
CHAPTER 2
REVIEW OF LITERATURE

In this chapter I examine the literature on motivation constructs and their effects on science achievement in African American middle school students. I begin with a brief overview of Bandura's (1986) social cognitive theory, followed by a more extensive explanation of self-efficacy and the relationship between self-efficacy and achievement. I then review literature on other variables related to achievement and their relationship to self-efficacy. I conclude with a discussion of research on motivation variables in African American students.

Social Cognitive Theory

Bandura (1986) described human functioning as characterized by five uniquely human capabilities: symbolizing, forethought, vicarious learning, self-regulation, and self-reflection. Through the use of symbols, people transform experiences into behavioral models from which they generate multiple courses of action. Choosing among these options, after consideration of possible consequences, involves forethought. Often the consequences foreseen arise not from direct experience, but from vicariously observing the actions, and resulting consequences, of other people. With the aid of self-regulatory mechanisms, people carry out the plan of action they have chosen. Finally, Bandura identifies self-reflection, in which people reflect on their experiences and on their thought processes, as the most uniquely human characteristic.

Bandura (1986) delineated a clear vision of these cognitive functions as the means by which people affect their environments, control their courses of action, and maintain
some role in shaping their future. The most important of these human capabilities is self-reflection, which plays a critical role in determining behavior. Bandura described behavior as both socially learned and influenced by thought processes. Individuals learn behavior and the consequences of behaviors from direct personal experience and through social interactions. The interpretation of these experiences and observations forms the system of self-beliefs that influences future actions. Human behavior results from the interaction of this system of self-beliefs and external environmental influences. Triadic reciprocity, this reciprocal interaction among behavior, environmental factors, and the individual's system of self-beliefs, is at the heart of Bandura's social cognitive theory. Triadic reciprocity is the means by which human beings affect their environment and direct their behavior.

Social Cognitive Theory and Self-Efficacy

Of all cognitive and other personal factors influencing behavior, Bandura (1977, 1986) contended that self-efficacy is the most influential arbiter in human functioning. He defined self-efficacy as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances" (1986, p. 391). Self-efficacy functions as a mediator of the effects of prior achievement, knowledge, and skills on subsequent achievement. Thus, it is often a better predictor of success than are actual abilities. This helps explain why people with similar abilities may have different levels of achievement. Self-efficacy affects behavior by influencing people's behavioral choices, the amount of effort they expend, and the persistence they exhibit in the face of failure. People tend to choose activities and to set goals based on what they believe they can accomplish. The most beneficial beliefs are those slightly beyond the actual capabilities of the individual in a given situation. These optimistic beliefs lead to
appropriate challenges with a high probability of success, leading to increased mastery and continued positive self-efficacy beliefs.

Four sources of information contribute to the development of an individual's self-efficacy beliefs (Bandura, 1997): enactive mastery experience, vicarious experience, social persuasion, and physiological and affective states. Information from these sources does not directly influence an individual's self-efficacy: It is an individual's interpretation of this information that results in an increase or decrease in self-efficacy. Many factors, personal, situational, and cultural, have an effect on the interpretation of these experiences.

*Enactive mastery experiences,* in which individuals interpret the results of their performance, have the strongest influence because they provide the most direct evidence of whether one has the capability needed to succeed at a task (Bandura, 1997). Experiences interpreted as successful generally raise confidence and experiences interpreted as unsuccessful generally lower it. People who have a strong belief that they can succeed will more often persevere in the face of difficulty, thereby increasing their chances of attaining a successful outcome, an outcome which then provides further support for a positive sense of self-efficacy. People who do not believe that they will succeed often make fewer and briefer attempts at a task, thus decreasing their chances of success, further eroding their already low self-efficacy. However, it must be remembered that it is the interpretation of these events that has the strongest effect on self-efficacy.

The second source of information is *vicarious experience* (Bandura, 1997). People observe the success or failure of others and use this information to evaluate their own likelihood of success at the same or similar tasks. This source of information is particularly salient in novel situations and when the model is perceived to possess
characteristics similar to the observer. Coping models, in which the model demonstrates perseverance and self-confidence, are the most effective models in increasing self-efficacy in the observer.

Social persuasions, which include exposure to the verbal and nonverbal judgments that others provide, are also an important source of information (Bandura, 1997). Typically, positive messages encourage the development of self-efficacy, and negative messages hinder its development. Social persuasion alone may not produce a positive sense of self-efficacy, but may operate in concert with other sources of self-efficacy to increase self-confidence. Parents influence their children's interpretation of mastery experiences (Frome & Eccles, 1998) in that the self-perceptions of ability formed subsequent to mastery experiences are influenced by both children's and parents' interpretations.

Physiological indicators such as anxiety and heightened arousal add a fourth source of information (Bandura, 1997). Negative physical states, or those interpreted as negative, may inhibit performance and increase the likelihood of a poor outcome, thus contributing to lower self-efficacy.

People construct their self-efficacy beliefs through the integration of information from these four sources (Bandura, 1997). The strength of the contribution made by each source varies depending on the domain in question and on the cognitive processing strategies of the individual. In addition, educational practices can support or undermine students' developing self-efficacy beliefs. These practices include strategy training, performance feedback, attributional feedback, goal setting, social comparison, and rewards (Schunk, 1985).
Since Bandura's (1977) introduction of the construct of self-efficacy, research findings have established the predictive utility of this construct as well as its role as a mediator of achievement (Bandura, 1997; Pajares, 1997; and see Multon, Brown, & Lent, 1991; Stajkovic & Luthans, 1998 for meta-analyses of research on the relationship between self-efficacy beliefs and achievement outcomes). In their review of research on motivation, Graham and Weiner (1996) concluded that self-efficacy was a more consistent predictor of behavior than were other motivation constructs.

Self-efficacy serves as a mediator between a student's abilities and subsequent academic performance (Schunk, 1985) in that they will avoid those academic tasks in which they lack confidence and choose those in which they feel they will succeed. When encountering difficulties with a task, students with high self-efficacy will exert more effort and persist longer than those with low self-efficacy. These differing levels of choice, effort, and persistence can facilitate results which then serve, in turn, to strengthen the positive or negative self-efficacy beliefs of the student.

Much of self-efficacy research in academic contexts has focused on mathematics, in part because of its importance in the academic curriculum but also because it is easier to design unambiguous criterial measurements in mathematics than is possible in other domains. Mathematics self-efficacy predicts mathematics performance among students in college, high school, and middle school (Graham, 2000; Pajares, 1996a; Pajares & Graham, 1999; Pajares & Kranzler, 1995; Pajares & Miller, 1994). It also predicts performance as well as does mental ability (Pajares & Kranzler, 1995), and it mediates between gender and achievement (Pajares & Miller, 1994). Boys and girls report equal confidence in their mathematics ability during the elementary years, but, by middle school, boys begin to rate themselves more efficacious than do girls (Meece, 1991;
Pajares & Graham, 1999; Wigfield et al., 1991, 1996). The predictive utility of self-efficacy beliefs holds true for gifted as well as for regular education students (Pajares, 1996a). In a three-year longitudinal study of middle school students, mathematics self-efficacy predicted end-of-year mathematics performance in Grades 6 through 8 for both gifted and regular education students (Graham, 2000). In general, self-efficacy research in the domain of mathematics supports Bandura's contention that self-efficacy is a strong predictor and mediator of performance.

In writing, as in mathematics, self-efficacy predicts performance across academic levels (Hackett, 1985; Pajares et al., 1999; Pajares & Johnson, 1994, 1996; Pajares & Valiante, 1997, 1999, 2001; Shell, Murphy, & Bruning, 1989). Self-efficacy to complete writing tasks correlates with achievement and increases as students progress through school (Grades 4, 7, 10), although self-efficacy to use grammar and compositions skills does not increase (Shell, Colvin, & Bruning, 1995). In writing, some gender differences are evident, with girls reporting higher confidence in their writing abilities than do boys (Pajares & Valiante, 1997). In other studies using students from Grades 3 through 8, gender differences in self-efficacy were not evident even though the girls were rated as better writers by their teachers (Pajares et al., 1999; Pajares & Valiante, 2001). The girls, however, described themselves as better writers than the boys, thus raising the issue of response bias. Pajares, Hartley, and Valiante (2001) found that writing self-efficacy accounted for 23% of the variance in middle school students' grade point averages. Overall, the research on perceived ability in writing confirms the findings from the domain of mathematics on the usefulness of the self-efficacy construct in academic contexts.
Among academic domains, there exists a hierarchy of self-efficacy beliefs, with domain-specific self-efficacy composed of more specific task self-efficacy beliefs. Bong (1997) has posited that among domains with similar characteristics, i.e., verbal or quantitative domains, there may be higher-order self-efficacy factors as well, with some resulting generality of self-efficacy judgments.

One caution on the measurement of self-efficacy bears noting. Bandura (1986) argued that reasonably precise judgments of capability matched to specific outcomes afford the greatest prediction and offer the best explanations of behavioral outcomes because these are the sorts of judgments that individuals call on when confronted with behavioral tasks. This is an especially critical issue in studies that attempt to establish causal relations between beliefs and outcomes.

Pajares and Miller (1995) showed that mathematics self-efficacy was predictive of mathematics performance to the degree that the belief assessed corresponded with the performance with which the belief was compared. For example, students' confidence to solve specific mathematics problems predicted their success in solving those problems, whereas their confidence to succeed in mathematics courses was more predictive of their choice of majors that required them to take mathematics-related courses.

Lent, Brown, and Gore (1997) found that global academic self-efficacy among college students correlated more highly with mathematics course self-efficacy than with problem-specific self-efficacy. These two broader measures of academic self-beliefs also correlated with the achievement measures (mathematics GPA and overall GPA), thus supporting Bandura's (1986) assertions that self-efficacy is most useful as a predictor when matched appropriately to the criterial measure.
All this is to say that the capabilities assessed in the self-efficacy measure and the
capabilities assessed in the outcome measure should be similar capabilities. Self-efficacy
assessments often lack the specificity of measurement and consistency with the criterial
task that optimizes the predictive power of self-efficacy beliefs, thus minimizing the
influence of self-efficacy (see Bandura 1986; Pajares, 1996b, 1997; Pajares & Miller,
1995). Self-efficacy measurements that are carefully matched with criterial measures and
administered in close temporal proximity are the most effective predictors of subsequent
achievement.

Self-Efficacy of Middle School Students

Social and biological changes during the middle school years influence students' self-beliefs. In early adolescence, students' self-concepts of ability often begin to
decrease (Wigfield et al., 1991, 1996). This drop is particularly apparent during Grades 6
and 7 (Anderman & Maehr, 1994; Pintrich & Schunk, 1996). This is not true of all
students, and many regain this loss in self-confidence during the later adolescent years.
Other students, however, continue to decline or do not regain previous levels of self-
beliefs (Wigfield et al., 1991).

There is some question about the relative decline in specific versus general
competency beliefs. Wigfield et al. (1991) reported a larger decline in self-efficacy in
specific domains than in general academic abilities. However, Zusho and Pintrich (2002)
suggested that self-efficacy judgments about specific tasks increase over time, but that
general competence perceptions for school academics and at the domain-specific level
steadily decline.

Wigfield and Eccles (1994) reported an initial drop in self-beliefs after the
transition to middle/junior high school, which increased over the seventh-grade year. The
characteristic decline in self-beliefs during early adolescence may be at least in part a function of the transition to middle/junior high school (Eccles, Wigfield, Flanagan, Miller, Reuman, & Yee, 1989; Harter, Whitesell, & Kowalski, 1992). This transition often introduces a larger social comparison group; a greater emphasis on grades and competition; and a larger, less personal environment. These environmental changes arrive at a time when young people are undergoing developmental changes and may not support the development of optimal self-beliefs. It may thus be that the change in school setting, as well as individual changes, contributes to the decline in self-beliefs.

These changes in perceived ability are not uniform across subject domains. In a study of 1,450 low to middle income students, Eccles et al. (1989) reported that self-perception of ability in mathematics showed a decline over the course of Grade 7, after the transition to middle school, whereas self-perception of ability in English steadily declined over the course of both Grade 6 and Grade 7.

In addition to changes in self-efficacy, anxiety about scholastic performance often increases following the transition to middle school (Harter et al., 1992). Anxiety was negatively correlated with perceived competence for students who changed schools, but was not significantly related to perceived competence for students who advanced to the next grade level within the same school.

Self-efficacy beliefs can have a long-term effect on the lives of middle school students. Their beliefs about their ability in science often influence future course-taking patterns that may in turn enable or foreclose future career options in science or technology. Similarly, the stereotyped ideas that science is not appropriate for certain groups, such as minorities or women, can turn students away from science at this critical juncture in their lives.
Self-Efficacy and Science Performance

Most research on science self-efficacy has been concentrated in two areas, science teaching self-efficacy (Cannon & Sharmann, 1996) and science self-efficacy as a predictor of career choices (Gwilliam & Betz, 2001; Luzzo, Hasper, Albert, Bibby, & Martinelli, 1999). Few investigations of confidence in science as a predictor of science achievement are available, and much of what is available is conceptually or methodologically problematic. For example, some researchers have used student self-reports of their previous science grades as the achievement measure (Jinks & Morgan, 1996), which may be less reliable than grades obtained from teachers or from school records (Cassady, 2001). Significant correlations between science self-beliefs and achievement have been found, however, when standardized or criterion-referenced performance measures were used. Andrew (1998) investigated first year college students in a nursing program and found a correlation of .49 between the students' science grades and their judgments of confidence that they could apply principles of science in common tasks.

Kupermintz and Roeser (2001) developed a measure of science self-efficacy in which high school students were shown multiple-choice and constructed-response items from standardized science tests and asked to rate their confidence that they could correctly answer the questions. Their self-efficacy ratings correlated with their subsequent performance ($r = .34$) on these items. Their grades in science class were also correlated with their science self-efficacy ($r = .40$). In this investigation, the instrument was appropriately matched with the subsequent achievement measures as suggested by Bandura (1997). The time lag between collection of the two measures is unclear, being reported as "first semester" for the self-efficacy measure and "second semester" for the
achievement measure. Given that this could be a time difference from a few days or weeks to months, it is unclear whether this investigation also met Bandura's criterion of close temporal proximity between self-efficacy and achievement measures.

A second weakness in the available research is that science self-efficacy has been operationalized in different ways by different researchers, making comparison across studies difficult. Science self-efficacy is individuals' confidence that they can successfully perform science-related tasks, but the tasks described have not been the same in all studies. Performance criteria have included the application of scientific principles, science-related academic tasks or classroom activities, and final grades earned in science class (Anderman & Young, 1994; Andrew, 1998; Jinks & Morgan, 1996; Pajares, Britner, & Valiante, 2000). In some cases, the terminology varies, making it difficult to determine if the construct being measured is self-efficacy. DeBacker and Nelson (2000) used the term perceived ability in science; however, the items were similar to self-efficacy items and seemed to be identifying the same construct (Sample item: "How easy or hard is learning science for you?"). In other cases, science self-efficacy items were combined with items measuring other constructs, such as science anxiety and science ability compared to other students (Meece & Jones, 1996) or with mathematics self-efficacy (Smith & Fouad, 1999). More research is needed in which the construct of science self-efficacy is clearly defined, operationalized as confidence to perform science tasks, and matched with corresponding outcomes.

Further complicating the issue, in their discussion of the role of self-efficacy in conceptual change, Pintrich et al. (1993) suggested that self-efficacy may operate in two ways. If self-efficacy operates to strengthen students' confidence in their own conceptions and ideas, it would actually serve to hinder conceptual change by making them more
resistant to new ideas. However, if self-efficacy represents students confidence that they can engage new ideas, evaluate them, and arrive at new conceptions, then self-efficacy would serve to facilitate conceptual change. Pintrich et al. suggested that science students' self-efficacy would be their confidence in "using the research methods of thinking (hypothesis testing, gathering evidence, considering alternative arguments, etc.) to effect a change in their own conceptions" (p. 186). They view self-efficacy as a mediator in the process of conceptual change. Further evidence was provided by a year-long investigation with students in a college physics course in which self-efficacy predicted both concept understanding and course achievement (Cavallo, Rozman, Larabee, & Ishikawa, 2001).

Britner and Pajares (2001) reported a correlation of .60 between Grade 7 students' confidence that they would do well in science class and their end-of-year science grades. This was the only investigation in which the science self-efficacy of middle school students was compared to an objective measure of science achievement. Clearly, there is need for more research on the predictive utility of science self-efficacy with middle school students.

Self-Efficacy Distinguished from Self-Concept

Self-concept, a construct conceptually similar to self-efficacy, also influences academic outcomes across domains (Skaalvik, 1997). Self-concept is a hierarchical system of self-beliefs, each level divided into more specific components of self-concept (Marsh, 1990). General self-concept is divided into non-academic self-concept and academic self-concept. Academic self-concept refers to the judgments of self-worth
associated with one's self-perception as a student across subjects. This academic self-concept is further divided into specific domain self-concepts, such as science self-concept, which in turn may be further divided into physical science self-concept or life science self-concept.

Self-concept beliefs differ from self-efficacy beliefs in that self-concept includes judgments of self-value (Bandura, 1986), whereas self-efficacy is a cognitive judgment of ability. Self-concept is thus a more inclusive construct as it includes descriptive, evaluative, and affective components (Bong & Clark, 1999). Social comparisons play a stronger role in formation of self-concept than they do in self-efficacy. Although some researchers use the terms interchangeably, self-efficacy is distinct from self-concept and, in fact, self-efficacy contributes to an individual's self-concept.

These differences between self-concept and self-efficacy are apparent in the items used to measure the two constructs. A science self-concept item such as "I am a good science student" differs in tone and substance from a self-efficacy item that asks "How sure are you that you can make appropriate predictions (hypotheses) about results of a laboratory activity?" Students may feel confident about their performance in science but may fail to take pride in their performance. For example, competent and confident science students may not invest their self-worth in their science capabilities if they do not value science. Conversely, students may lack confidence in an academic area but maintain a positive self-concept. Those for whom science has little meaning or value may well not suffer a loss of self-esteem simply because they are poor science students (see Pajares & Schunk, 2001 for a detailed explanation).

Research on self-concept differs from that on self-efficacy in that self-concept research involves more general measures, both of self-concept and of the criterial
measures with which it is compared; depends mostly on correlational data; and is operationally defined in different ways by different researchers (Bong & Clark, 1999). These differences contribute to the superior predictive utility of self-efficacy over self-concept, although some evidence indicates that science self-concept correlates with Scholastic Achievement Test scores \((r = .29)\) among adolescent students (Simpson & Oliver, 1990), and with science grade point average \((r = .43)\) in middle school students (Pajares et al., 2000).

In a longitudinal study of high school science attitudes and achievement, science self-concept predicted achievement in Grade 11 science (Oliver & Simpson, 1988). However, it must be noted that science self-concept was operationalized as the extent to which students believed that success was possible in science, and thus, may have been more similar to self-efficacy than to self-concept. The actual items used in the study were not available.

Although researchers report a lower correlation between self-concept and achievement, self-concept is usually associated more strongly with other constructs such as anxiety, apprehension, intrinsic motivation, and value (Pajares et al., 1999; Pajares & Miller, 1994; Pajares & Valiante, 1999). Atwater, Wiggins, and Gardner (1995) investigated the relationship between self-concept and attitudes toward science of urban, primarily African American, middle school students. General self-concepts among these students were high, consistent with previous research reviewed by Graham (1994). However, a different pattern emerged with science self-concept: Students with very positive attitudes toward science had high science self-concept and those with negative attitudes about science had lower science self-concepts.

**Relationship of Science Self-Efficacy and Science Performance**
Self-efficacy and self-concept act in concert with other variables, including attitudes, to influence academic achievement. Unfortunately, in many students, attitudes toward science begin to decline during middle school (Simpson, Koballa, Oliver, & Crawley, 1994). An attitude is "a predisposition to respond positively or negatively to things, people, places, events, or ideas " (p. 212). Attitudes toward science are thus the positive or negative feelings students hold toward the subject of science. *Attitudes toward science* should not be confused with *scientific attitudes*, which are the values and beliefs foundational to the pursuit of scientific knowledge. Attitudes, like self-concept, have an evaluative component. They not only influence achievement but are worthy educational objectives in their own right (Weinburgh & Englehard, 1994).

While attitudes influence behavior, there is no direct relation between attitude and a particular behavior at a given time: The effect of attitudes on behavior is moderated by other variables, including intentions, situations, abilities, and personal characteristics (Ajzen & Fishbein, 1980). Shrigley (1990) reviewed the literature on science-related behavior and attitudes and concluded that the majority of the research evidence supports a model of reciprocal interaction between attitudes toward science and science-related behavior, with measurement quality, matching of levels of attitude and behavior, environmental influences, ability and situational constraints all mediating the prediction of behavior from attitude reports. An advantage of this reciprocal model would be the possibility for educators to affect student outcomes in science by intervening in either the behavioral or the attitudinal aspect of the cycle.

The attitudes students hold about science affect their behavior, and ultimately their achievement, in science-related tasks or situations (Koballa & Crawley, 1985;
Weinburgh & Steele, 2000), although the relationship between attitude and behavior is probabilistic rather than deterministic, as other factors also influence behavior (Ajzen & Fishbein, 1980). Attitude is a convenient summary of a variety of beliefs about, and emotional responses to, science (Koballa & Crawley, 1985): Among these are science anxiety and the value placed on science.

*Science Anxiety*

Science anxiety refers to feelings of tension and stress that interfere with the construction of science knowledge; the development of science skills and abilities; and the use of science knowledge, skills, and abilities in life and academic situations (Mallow, 1981; Richardson & Suinn, 1972). In the foreword to *Science Anxiety* (Mallow, 1981), Tobias suggests that "emotions ranging from aesthetic satisfaction and the excitement of discovery to anxiety, fear, and frustration play a very important role in determining who succeeds at science" (p. xi). Anxiety is a particularly pernicious emotion: Although a moderate amount of anxiety may serve to increase performance, higher levels may cause science avoidance and interfere with higher-level thinking skills. Mallow has also suggested that anxiety may play a role in delaying the progression from concrete operational thought to formal operational thought if students are afraid to venture out of comfortable and safe thought processes. Pajares et al. (2000) reported that science anxiety was negatively associated with achievement ($r = .30$) and with science self-efficacy ($r = .37$) in middle school students.

Anxiety levels among middle school students may be affected by the transition from elementary to middle/junior high school (Harter et al., 1992). Among students with low confidence in their academic abilities, the transition to a new school environment resulted in increased anxiety: More confident students, however, reported less anxiety.
Anxiety is related to classroom environment among Grade 8 and 9 students (Fraser, Nash, & Fisher, 1983), particularly to factors such as clarity of classroom rules, frequency of science investigations, competition, and teacher control. These concerns may be exacerbated by changes in school environments as students make transitions between schools (Eccles et al., 1989; Harter et al., 1992).

**Value of Science**

Value of science is the degree to which students perceive science as being important, interesting, and enjoyable. According to expectancy-value theorists, students will be more likely to engage in activities when they value the outcome and less likely to engage in activities whose outcomes they do not value (Pajares, 1996b).

The importance component of value is students' judgments of the degree to which science is important (or unimportant) to them. These judgments may reflect the importance of science as it contributes to their understanding of the world around them or to the importance of science achievement to career goals. Although there is a general decrease in the perceived importance of academic achievement from elementary to high school, this also varies with subject domain (Eccles et al., 1989). Grade 6 and 7 students' evaluations of the importance of being good at mathematics declined steadily across both grade levels. The perceived importance of being good at English declined during the summer between the transitional years, but actually increased during the Grade 6 and Grade 7 academic terms.

Interest refers to students' general attitude towards and preference for science and aspects of the study of science. As do other motivational variables, interest influences students' choice of tasks, persistence, and processing strategies (Pintrich et al., 1993). There is a general decline in reported interest in academic subjects as students progress
from elementary school through middle school and into high school, although it is not uncommon for students to report increased interest in specific domains (Zusho & Pintrich, 2002). Enjoyment is the degree to which students enjoy participating in science-related activities. As is true with other motivation constructs, value has been found to be related to various academic performance indexes (Pajares & Graham, 1999; Pajares & Valiante, 2001).

Self-Efficacy for Self-Regulation

Self-efficacy for self-regulated learning is students' judgments of their capability to use various self-regulated learning strategies such as finishing their homework on time or arranging a suitable study environment at home (Pajares, in press-a; Zimmerman & Bandura, 1994). Because self-efficacy is such a powerful determinant of performance, self-efficacy for self-regulation exerts a strong influence on achievement (Pajares & Valiante, in press). Positive self-efficacy for self-regulation is correlated with academic achievement indexes in mathematics and language arts (Pajares, 2001; Pajares et al., 2000; Pajares & Graham, 1999; Pajares & Valiante, in press). Britner and Pajares (2001), however, did not find a correlation between self-efficacy for self-regulation and science grade point average of students in Grade 7. Gender differences are typically found in students' self-efficacy for self-regulation, with girls reporting higher levels of confidence to engage in self-regulatory behavior (Britner & Pajares, 2001; Pajares et al., 1999; Pajares & Valiante, 2001).

Gender

The relationship between gender and self-efficacy has also been a focus of self-efficacy research. In the area of mathematics, boys and girls report equal confidence during the elementary years, but, by middle school, boys begin to rate themselves more
efficacious than do girls (Wigfield et al., 1991). Conversely, in areas related to language arts, female students tend to exhibit stronger confidence (Pajares, in press-b). In academic areas related to mathematics, science, and technology, researchers report that male students at high school and college levels tend to be more confident than female students (Debacker & Nelson, 2000; Lent, Lopez, & Bieschke, 1991; Meece, 1991; Pajares & Miller, 1994; Simpson & Oliver, 1990) despite the fact that gender differences in achievement in these subject areas are diminishing (Eisenberg et al., 1996). In a year-long, inquiry-based physics course, significant gender differences were found in students' science self-efficacy (Cavallo et al., 2001). Male students began the course with significantly higher self-efficacy and achievement and ended the course higher in both. Britner and Pajares (2001), however, reported higher science self-efficacy as well as higher science grades among middle school girls than among middle school boys.

Gender differences in self-efficacy are confounded by a number of factors. First, many gender differences in academic self-beliefs are nullified when previous achievement indexes are controlled (Pajares, 1996b). A second confounding factor is the tendency of boys and girls to adopt a differing stance when responding to self-efficacy instruments. Researchers have observed that boys tend to be more self-congratulatory in their responses, whereas girls tend to be more modest (Wigfield et al., 1996). Andre, Whigham, Hendrickson, and Chambers (1999) investigated perceived competence and attitudes toward science among elementary school students. Among students in Grades 4-6, boys rated their physical science ability higher than did girls, but there were no gender differences in perceived ability in life science. This difference in perceived ability in physical science existed in spite of the fact that there were no significant differences between boys and girls in expected science grades, in amount of effort expended in
science, or in liking of science. Some scholars have suggested that boys and girls may use a different "metric" when providing confidence judgments, adding that these sorts of ratings may represent more of a promise to girls than they do to boys (Noddings, 1996; Pajares, 1997; Pajares & Schunk, 2001). If this is the case, actual differences in confidence may be distorted by such response biases (Wigfield et al., 1996).

Ancis and Phillips (1996) investigated possible antecedents of self-efficacy in undergraduate women. They examined the relationship between female students' perceptions of gender bias in their college experiences and their self-efficacy. After controlling for sex role attitudes, race, and the gender concentration within the students' majors, they found that perceived gender bias accounted for 11% of the variance in self-efficacy among these young women. They suggest that a negative, or negatively perceived, environment may affect the sources of self-efficacy information available to female undergraduates, including lack of opportunity for sufficient mastery experiences, negative social persuasions, lack of role models to provide positive vicarious experiences, and increased negative affect.

Traditionally, attitudes toward science, including valuing science, enjoying science class, and viewing science as appropriate, also influence girls' performance in science. Science has traditionally been viewed as a male domain, with girls participating less in extracurricular science activities as well as science courses and valuing science less. Jones, Howe, and Rua (2000) reported that these stereotyped beliefs are still active and influencing students, with an increasing impact in the early adolescent years. Boys have a generally more positive attitude toward science, although this pattern is reversed in biology, with girls having more positive attitudes toward biology (Weinburgh & Englehard, 1994). Girls' less positive attitudes toward science, particularly physical
science, persist even though they perform as well as boys and, in fact, often make better grades in science classes.

Weinburgh (1995) conducted a meta-analysis of literature published between 1970 and 1991 examining gender differences in student attitudes toward science and correlations between attitudes toward science and achievement in science. She found that boys of average ability had a more positive attitude toward science than did girls of average ability. However, among high-performance students, girls had a more positive attitude toward science. This gap was present in all areas of science, but was larger in general science and earth science than in biology and physics. Weinburgh found a generally positive correlation between attitudes toward science and science achievement, but particularly among low-performance girls.

Gender orientation

Gender stereotypes portraying science as a masculine field may deter some talented girls from pursuing science-related careers (Eccles, 1985). Unfortunately, this discourages girls from taking advanced science courses and precludes them from later pursuing science-related careers, many of which are high-status and high-paid occupations. Numerous researchers have argued that some gender differences in social, personality, and academic variables may actually be a function of gender orientation, the stereotypic beliefs about gender that students hold, rather than of gender (Eisenberg et al., 1996; Hackett, 1985; Harter, Waters, & Whitesell, 1997; Matsui, 1994). For example, gender differences in variables such as moral voice or empathy tend to disappear when gender stereotypical beliefs are accounted for (Harter et al., 1997; Karniol, Gabay, Oehion, & Harari, 1998). Eccles' (1987) model of educational and occupational choice posits that cultural milieu factors such as students' gender role stereotypes are partly
responsible for differences in course and career selection and in confidence beliefs and perceived value of tasks and activities.

To determine the degree to which gender differences in writing motivation and achievement were a function of gender stereotypic beliefs rather than of gender, Pajares and Valiante (in press) asked students to report how strongly they identified with characteristics stereotypically associated with males or females in American society. Results revealed that holding a feminine orientation was associated with writing self-efficacy and rendered nonsignificant gender differences in writing self-efficacy beliefs and even in writing achievement. This suggests that gender differences in academic motivation and achievement may indeed be accounted for by differences in the beliefs that students hold about their gender rather than by their gender differences per se.

Motivation and Science Performance in African American Students

It goes without saying that the construct of "motivation" cannot be conceived merely as a psychological construct at the mercy of personal variables. Embedded in a fuller and richer conceptualization of the term is the understanding that individuals are motivated as a result of psychological, interpersonal, and sociostructural processes. For example, students are motivated by the beliefs they come to hold about themselves and about their environments (e.g., self-efficacy, self-concept). They are also powerfully motivated as a result of the interpersonal relationships they establish with their teachers, parents, and peers. For example, teachers' expectations play a powerful role in the motivation of the students in their charge (Delpit, 1995). Additionally, sociostructural influences in students' environments can build or diminish motivation that can in turn ensure success or disappointment in the tasks and activities that students are asked to undertake (Walker, 1996). For example, students who experience prejudicially structured
educational environments will require exceptional powers of resilience to surmount the obstacles that such environments place in their path (Bandura, 1997).

The traditional literature on academic motivation has focused nearly exclusively on the psychological processes. Moreover, historically there has been less research on the motivational psychology of African American students than of White students. Graham (1994, 1995) criticized the existing motivation research on African Americans because it focused too narrowly on socioeconomic factors, consistently compared African American students with White students, and was based on a deficit model. She encouraged more research based on theoretical principles and suggested that insights resulting from studies of motivation in African American students need not be applied only to African American students but can be used to inform the psychology of human behavior.

Research on self-efficacy in African American students is even more scarce (Graham, 1994). In her review of the literature published prior to 1990 on the motivation of African American students, Graham found only 18 studies on ability self-concept (none used the term self-efficacy), with 7 of these published in the 1980s, 8 in the 1970s, and 3 in the 1960s or before. Graham's summary of this literature revealed that African American students maintain optimism and positive self-regard in the face of social and economic disadvantage. She also found evidence that the academic self-beliefs of African Americans are strong, even in the face of low achievement. Moreover, the academic self-beliefs of African American students are as strong, and sometimes stronger, than those of their White peers. All the studies on academic self-belief reviewed by Graham were race-comparative, which is to say that the confidence and performance of African American students were compared to those of White students. Graham's call for research focusing
on in-group differences in the relationships among motivation variables in African American students has so far generated little new research on academic self-efficacy.

Hudley (1997) investigated motivation (intrinsic/extrinsic) and perceptions of competence in a program for middle school African American boys, finding average levels of intrinsic motivation and perceived competence, although no significant relationship between these two variables. This study was problematic in several aspects, including a small sample size composed of 12 African American boys, 3 Hispanic boys, and 3 African American girls. The "average" perceptions of competence of these students is of note in relation to their "at-risk" status in school, supporting Graham's (1994) observation that African American students maintain high self-beliefs in the face of academic challenges.

Mastery experiences, such as school performance, are believed to be the strongest source of information for the formation of self-efficacy beliefs (Bandura, 1997). This may not be the case with African American children, however. In the face of low academic performance and social and economic disadvantage, African American students' attempts to maintain positive self-regard may lead them to give more credence to social persuasion than to the interpretation of mastery experiences. In addition, parents of African American children, compared to the parents of White children, provide higher estimates of their children's cognitive abilities and higher predictions of their children's school achievement, irrespective of actual performance (Alexander & Entwisle, 1988; Stevenson, Chen, & Uttal, 1990). Given parents' influence on children's self-beliefs (Andre et al., 1999; Frome & Eccles, 1998), these social persuasions may be a stronger source of self-efficacy information for African American children than the interpretation of mastery experiences. It is also possible that African American students may use a
different "metric" than do White students when providing confidence judgments, similar to the response patterns of boys when compared to those of girls. That is to say, they may be more "self-congratulatory" when responding to self-belief-type questions on research instruments (see Pajares et al., 1999; Wigfield et al., 1996). If this is the case, as noted earlier in relation to gender differences, actual differences in confidence may be masked or accentuated by such a response bias.

Edelin and Paris (1995) investigated the degree of correspondence, or calibration, between African American students' self-efficacy and their subsequent performance in mathematics and in school. They reported that the majority of the elementary and middle school students in their sample had accurate perceptions of ability. However, among the students with poor calibration, boys were more likely to be overconfident and girls underconfident.

Britner and Pajares (2001) found that science self-efficacy among African American students predicted achievement ($\beta = .527$) in science class. In comparison to the White students in the study, African American students had lower self-efficacy and lower achievement, but the mean differences in self-efficacy reported by the two groups (0.3) did not correspond to the difference in science grades (1.2), again reflecting Graham's (1994) observation that African American students maintain strong self-beliefs, regardless of academic achievement. Given the paucity of information on the academic self-efficacy of African American students, there is a need for further research in this area.

The attitudes toward science held by African American students have an effect on their motivation, participation, and achievement in science (Graham, 1994; Yong, 1992). Also of interest are possible gender differences in attitudes toward science among
African American students, as there is little information on gender differences among minority groups that are underrepresented in science (Catsambis, 1995), and what is available is unclear.

Catsambis (1995) reanalyzed data from the National Educational Longitudinal Study (NELS) of 1988, looking at data from Grade 8 students in science. African American students responded more favorably on the science attitude measure than did White students, with the exception of aspiring to science careers. Although there were no significant gender differences on the science achievement test scores among African American students, boys reported significantly higher levels of math and science extracurricular activities, were more likely to aspire to science careers, reported higher levels of looking forward to science class, and were more likely to believe that science would be useful to them in the future. It is worth noting that despite girls' higher achievement, and African American students' more positive science attitudes, both girls and African American students reported significantly lower levels of aspiration to engage in future science-related careers.

In an effort to increase mathematics achievement and attitudes toward science, 38 urban, minority, high school students were invited to participate in a Saturday program emphasizing math and science (Ellis, 1993). At the conclusion of the program their attitudes toward science were significantly more positive. Interpreting the significance of this study is problematic, due to the small sample size and because details about the instrument used to measure science attitudes were not provided.

Weinburgh (2001) investigated the effects of a kit-based science program on the attitudes (anxiety, self-confidence, and desire to engage in science) and achievement of Grade 5, urban, minority students. Participants in the program showed increased
achievement and higher attitudes. There were no significant gender differences in program effect, although males had more positive attitudes towards science. One troubling finding was that students with longer participation in the program (up to 3 years) reported decreased valuing of science.

In a study of gifted African American middle school students, significant differences were found between male and female students in their attitudes toward mathematics, but not in their attitudes toward science (Yong, 1992). This is interesting in light of the common linking of mathematics and science and adds support to the findings of Britner and Pajares (2001) that beliefs about science in middle school students are more similar to those in language arts than to those in mathematics.

Synthesis

There is a rich data base in the areas of mathematics and language arts supporting Bandura's (1986) assertion that students' self-beliefs are often a better predictor of achievement than are their actual skills and abilities. Little self-efficacy research is available, however, in the domain of science, especially at the middle school level where self-beliefs related to science can have critical effects on students' future accomplishments. Research in science self-beliefs has also been hampered by inconsistent methodology. Further research is needed comparing the predictive utility of specific and general science self-beliefs when these constructs are operationalized and measured in accordance with the guidelines established by Bandura (1997). Despite Graham's (1994) call for more race-homogeneous research on African American students, there is scant information available on the relationship between science self-beliefs and science achievement in African American students.
In addition to these research-oriented issues, there is the human aspect of science education, the loss of potential when talented female and minority students fail to take advanced science courses and pursue science-related careers. Available evidence indicates that science aspirations are influenced as much by attitudes as by achievement. Efforts to encourage girls to continue in science should be focused on self-beliefs in relation to science as well as on their performance in science classes. The high levels of interest and confidence of African American students provide a foundation upon which educators can build their efforts to increase the participation and achievement of African American students in science. Regardless of gender or ethnicity, the middle school years are critical in terms of students' future science endeavors, and therefore an optimal time for effective intervention based on sound research.
CHAPTER 3
METHODOLOGY

The primary objective of this study was to determine whether self-efficacy assessed at two levels of specificity would each make an independent contribution to the prediction of science achievement (measured at two corresponding levels of specificity) when other variables that have been found to predict achievement indexes in mathematics and language arts are controlled. A second objective was to investigate whether motivation and achievement in science differ as a function of gender and/or gender orientation among African American middle school students. In this chapter I first restate the research hypotheses. Second, I describe the study's participants and their school. Third, I explain the procedures involved in data collection, followed by a description of the scales used in the instrument. Last, I outline the statistical analyses conducted.

Research Hypotheses

The research hypotheses for this study are informed by the theoretical tenants of social cognitive theory (Bandura, 1986) and were designed to build upon results of earlier investigations dealing with self-efficacy in academic settings. Research hypotheses were as follows:

1. Science lab self-efficacy will make an independent contribution to the prediction of science laboratory performance of African American middle school students when previous achievement, science self-concept, science anxiety, self-efficacy for self-regulation, and value of science are included in the statistical model.
2. Science grade self-efficacy will make an independent contribution to the prediction of the science grade of African American middle school students when previous achievement, science self-concept, science anxiety, self-efficacy for self-regulation, and value of science are included in the statistical model.

3. Mean scores in the science motivation and achievement of African American students will differ by gender.

4. Gender differences in science self-beliefs and achievement will be rendered nonsignificant when gender orientation beliefs are controlled.

Participants and Setting

Participants were 268 African American Grade 7 students (161 girls, 107 boys) from a middle school in a large urban area in the South. Only regular educations classes were included in the sample. This middle school had an enrollment of 1,553 students, of which 96% were identified as Black, not Hispanic in Georgia Department of Education statistics (Georgia Department of Education, 2001). Only 34% of the students were eligible for the free and reduced lunch program, well below the average for this school system (53%). The average Composite Score on the Iowa Test of Basic Skills for Grade 8 students at this school (data not available for Grade 7 students) was the 50th percentile. In science, the average score was at the 46th percentile. Results of the Grade 6 Criterion-Referenced Competency Tests from the previous year (students now in Grade 7, from whom participants in this study were selected) showed that fewer students from this school than from the system or the state failed to meet the criterion standards in reading and language arts, and a greater percentage from this school than from the system or the state met the criterion standards in reading, language arts, and mathematics.

Procedures
Written permission to conduct this investigation was obtained from the Executive Director for Secondary Administrative Services and from the Department of Research and Evaluation of the school system. Written permission was also obtained from the parents of participating students. These documents are available in Appendix A. I obtained approval from the Emory University Division of Educational Studies Human Subjects Committee prior to beginning the research.

Survey administrators were African American graduate students. This methodological decision was made to lessen race effects in the administration of the instrument. All administrators received instruction and practice in administering the instrument prior to the actual implementation in order to standardize procedures. Procedures are consistent with those used by previous self-efficacy researchers (see, for example, Pajares et al., 2000; Pajares & Valiante, 1997, 1999; Shell et al., 1995).

The instrument was group administered in the participants' science classes during Spring semester of the academic year. Students were told that the purpose of the study was to obtain their opinions about science class and about themselves as science students. They were informed that the results of the survey were confidential and would not affect their science grade. At the beginning of each of the first three subscales, the Likert-type scale was explained and students were guided through the first items to be sure that they knew how to respond using this type of scale. They were encouraged to ask questions as needed. Items were read aloud to the students, although they had copies of the questionnaire. This was done to lessen effects of different levels of reading skill among the students. Administrators were instructed to answer questions about the meanings of words or phrases that were unfamiliar to the students and, if necessary, to paraphrase
items without changing their meaning. No problems in survey administration were reported.

Instrumentation

Although researchers have been successful in demonstrating that various affective constructs are predictive of academic outcomes, it has been difficult to compare findings across theoretical lines. In part, this is due to the differing ways in which self-beliefs are operationalized and used in studies as a result of varying conceptualizations by different theoretical camps (see Bong, 1996). That problem was addressed in this study by operationalizing and using the various constructs in a manner consistent with each construct's theoretical home. The instrument is included in Appendix B. The items corresponding to each of the scales used in the study are listed in Appendix C.

Laboratory skills self-efficacy was assessed with the Lab Skills Self-Efficacy Scale, which consists of 12 items asking students how sure they are that they can perform specific science process skills commonly used in laboratory activities at the middle school level (Chiapetta & Koballa, 2002; National Research Council, 1996). Face validity was established by review of the instrument by middle school science teachers, science education faculty at the university level, and experts in self-efficacy research. In addition, teachers of the participants in the present study were shown the scale and asked to identify which of the items represented skills that they assessed in classroom laboratory activities. Every item was selected by the teachers as representative of those skills. Students estimated their confidence that they could perform each skill on a scale from 0 (no chance) to 100 (completely certain). This response format was adapted from the Writing Skills Self-Efficacy scale, developed to investigate students' writing skills self-efficacy (Pajares et al., 2001). The 0-100 scale was psychometrically stronger and
allowed greater prediction of subsequent achievement than the traditional Likert-type scale (Valiante & Pajares, 1999).

Because the Lab Skills Self-Efficacy Scale was created for the present study, I conducted exploratory factor analysis using the maximum likelihood method of extraction (Jöreskog & Lawley, 1968), which is believed to produce the best parameter estimates (Pedhazur, 1997). Criteria to determine the number of common factors to retain and analyze included Cattell's (1966) scree test; eigenvalues greater than 1.0; the percentage of common variance explained by each factor using the weighted, reduced correlation matrix; and the interpretability of the rotated factors. Because factors that emerged from the analyses might be intercorrelated, I chose the oblimin method of oblique rotation. All analyses were conducted using the SAS system’s FACTOR procedure (SAS Institute, Inc., 1999).

Results revealed that the scale was composed of two factors. Rotated factor pattern coefficients of .35 or higher were considered strong enough to demonstrate that the item indicated the common factor. Rotated factor pattern coefficients from the pattern matrix demonstrate the relationship between an item and a factor when holding all other items constant. Items 2, 7, 9, 10, 11, and 12 comprised Factor 1, which accounted for 82% of the variance proportion; items 1, 3, 4, 5, 6, and 8 comprised Factor 2, which accounted for 18% of the variance proportion.

Examination of the items revealed that the two factors could be categorized according to Bloom's taxonomy of learning objectives in the cognitive domain (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1957). Factor 1 tapped skills reflecting application (items 7 and 12), analysis (items 2 and 11), synthesis (item 9), and evaluation (item 12). Factor loadings ranged from .38 to .66. Factor 2 tapped the lower levels of knowledge
(items 1 and 6) and comprehension (items 3, 4, 5, and 8). Loadings ranged from .39 to .90. The interfactor correlation was .51. These findings are consistent with those of Pajares and his colleagues as regards the often-used Writing Skills Self-Efficacy Scale (e.g., Pajares et al., 1999; Pajares & Valiante, 1997, 1999, 2001). Cronbach's alpha coefficient for the Lab Skills Self-Efficacy scale used in the present study was .84. Item-total scale correlations ranged from .39 to .61.

Students' science grade self-efficacy was assessed with five items that asked students to provide a rating of their confidence that they could earn either an A, B, C, or D in their science class (see Bandura, 1997, for assessment procedures consistent with tenets of self-efficacy theory). Cronbach's alpha coefficient was .90.

Science self-concept is students' perceptions about their science ability and their feelings of self-worth associated with this ability. It was assessed with the 6-item science scale from Marsh's (1990) Academic Self Description Questionnaire (ASDQ-1). Directions asked students to indicate the degree to which statements applied to them on a Likert-type scale ranging from 1 (definitely false) to 6 (definitely true). Marsh obtained alpha coefficients from .88 to .94 on the 13 subject scales in the ASDQ-1, including the science scale. Factor analysis confirmed that the ASDQ scales, including the science scale, correspond unambiguously to unique factors. Britner and Pajares (2001) obtained a Cronbach's alpha coefficient of .82 using a similar science scale with middle school students. In the present study, I obtained a reliability coefficient of .80.

Science anxiety is feelings of tension and stress that interfere with the construction of science knowledge; the development of science skills and abilities; and the use of science knowledge, skills, and abilities in life and in academic situations (Mallow, 1981; Richardson & Suinn, 1972). The science anxiety scale asked students to
consider statements about comfort or anxiety with science and to indicate the degree to which these statements reflected their feelings about science. Responses range from 1 (definitely false) to 6 (definitely true) on this 11-item scale adapted from the Mathematics Anxiety Scale (Betz, 1978). Pajares and Urdan (1996) conducted factor analyses on the adapted Mathematics Anxiety Scale and found that mathematics anxiety explained 49% of the total variance with their middle school sample. Alpha coefficients range from .87 to .90 (Pajares & Kranzler, 1995; Pajares & Urdan, 1996). Britner and Pajares (2001) obtained a Cronbach's alpha coefficient of .63 using this scale adapted for middle school science. I obtained a reliability coefficient of .84.

Self-efficacy for self-regulated learning was assessed using a 7-item subscale adapted from Bandura's Children's Multidimensional Self-Efficacy Scales that assesses students' judgments of their capability to use various self-regulated learning strategies (Zimmerman & Bandura, 1994). Students responded using a 6-point Likert-type scale. A validation study by Zimmerman and Martinez-Pons (1988) revealed that a single factor underlay the items. Researchers have reported Cronbach's alpha coefficients ranging from .80 to .87 (Pajares, 1996a; Pajares et al., 1999; Zimmerman, Bandura, & Martinez-Pons, 1992). I obtained a reliability coefficient of .74.

Value of science is composed of self-beliefs assessing perceived importance, interest, and enjoyment of science. The scale that was used in the present study consists of nine items adapted from the Student Attitude Questionnaire (Eccles, 1983). Students rated how important it was to them to be good at and to get good grades in science. In addition, students were asked whether science was interesting for them and whether they enjoyed science. Responses range from 1 (definitely false) to 6 (definitely true). When this variable has been used in studies of mathematics or writing, alpha coefficients have
ranged from .69 to .92 (Pajares & Graham, 1999; Pajares & Valiante, 1997, 1999; Valiante & Pajares, 1999). The alpha coefficient in the present study was .87.

*Gender orientation* was assessed by asking students to report how strongly they identified with characteristics stereotypically associated with males or females in American society (Ballard-Reisch & Elton, 1992; Harter et al., 1997). Early on, researchers assumed that gender orientation was a unidimensional construct that could be adequately measured using a single score such that a low masculine score indicated high femininity (see Constantinople, 1973). More recently, researchers agree that gender orientation is not unidimensional. Rather, they contend that masculinity and femininity are orthogonal variables that represent two distinct dimensions of individuals' self-conceptions. An individual can possess both high masculinity and high femininity, low masculinity and low femininity, or score high in one orientation and low in the other (Ballard-Reisch & Elton, 1992; Boldizar, 1991; Hall & Halbertstadt, 1980; Harter et al., 1997; Spence, 1991).

For the present study, gender orientation was assessed with items used in various studies by Harter, Pajares, and their colleagues (see Harter et al., 1997; Pajares & Valiante, in press) and adapted primarily from the short form of the Children's Sex Role Inventory (Boldizar, 1991). Pajares and Valiante (in press) conducted exploratory factor analysis with students from Grades 6 to 8 to ascertain the psychometric properties of this scale. Of the 32 items on the original scale, 14 loaded on two factors that could be characterized as representing a feminine or masculine orientation. Factor loadings for the 7 items ranged from .43 to .66. The interfactor correlation was -.09. Factor 1 explained 70% of the common variance; Factor 2 accounted for 30%. Pajares and Valiante obtained Cronbach's alpha reliability of .76 for the final masculinity scale and .88 for the
femininity scale. Alpha coefficients for the present study were .69 for the masculinity scale and .83 for the femininity scale.

Achievement measures were collected corresponding both to the lab skills self-efficacy scale and the science grade self-efficacy scale. The relationship between measures of self-beliefs and performance is most valid and reliable when the performance measure directly corresponds to the self-belief measure and is measured in close temporal proximity to the administration of the instrument (Bandura, 1997). Thus, the achievement measure corresponding to lab skills self-efficacy was the student's grade on the laboratory activity subsequent to the administration of the research instrument. The achievement measure corresponding to the science grade self-efficacy measure was the student's final grade in science class obtained from the student's teacher at the end of the semester.

Data Analysis

Hypotheses 1 and 2 were tested with continuous multiple regression analyses to determine the influence of science lab skills self-efficacy, science grade self-efficacy, science self-concept, science anxiety, self-efficacy for self-regulation, value of science, and gender on science achievement. Separate regression analyses were conducted for boys and for girls. For Hypothesis 1, the dependent variable was the students' science lab grades. Independent variables were previous lab grades, science lab skills self-efficacy, science self-concept, science anxiety, self-efficacy for self-regulation, and value of science. For Hypothesis 2, the dependent variable was the end-of-semester science grade. Independent variables were previous science grades, science self-efficacy, science self-concept, science anxiety, self-efficacy for self-regulation, and value of science. Beta values were supplemented with regression structure coefficients, which are not
suppressed or inflated by collinearity between independent variables (see Thompson & Borello, 1985). To determine whether science self-beliefs differed as a function of gender (Hypothesis 3), multiple regression analyses were conducted with gender as the independent variable in the regression model. Hierarchical multiple regression analyses were conducted for those variables in which gender differences were found to determine whether gender differences in science self-beliefs would be rendered nonsignificant when masculinity and femininity were controlled (Hypothesis 4). The first regression model included gender as the independent variable. In the second model, masculinity was added. In the third model, masculinity was removed and femininity added. In the fourth model, masculinity and femininity were added jointly. Linearity was checked in all regression analyses by examining residual plots and analyzing regression models with quadratic terms for each variable. To check for homoscedasticity I examined plots including the standardized residuals by the regression standardized predicted value (Osborne & Waters, 2001). All analyses were conducted using the SAS system, Version 8 (SAS Institute, Inc., 1999).
CHAPTER 4
RESULTS AND DISCUSSION

In this chapter, I first provide descriptive statistics for the variables under investigation. I then present and discuss results of the data analyses pertinent to each hypothesis.

Descriptive Statistics

Means, standard deviations, and correlations for the variables in the study are provided in Table 1. Results were also analyzed separately for boys and girls. Means, standard deviations, and correlations by gender are provided in Table 2. Girls obtained higher lab grades \((M = 3.3)\) than did boys \((M = 2.8)\), higher science GPA, both during the previous (Fall) semester \((M = 3.1\) for girls, \(M = 2.6\) for boys) and during the semester (Spring) in which the study was conducted \((M = 3.1\) for girls, \(M = 2.5\) for boys). Girls also reported stronger science grade self-efficacy \((M = 5.2\) for girls, \(M = 4.7\) for boys). However, similar levels of science self-concept were reported by boys \((M = 4.5)\) and girls \((M = 4.7)\). The correlation of science lab self-efficacy and subsequently earned lab grades was very low both for girls \((r = .14)\) and for boys \((r = .03)\), whereas the correlation between science grade self-efficacy and subsequent science GPA is very strong for both girls \((r = .63)\) and boys \((r = .63)\). The correlation of science self-concept and science grade self-efficacy was higher for girls \((r = .53)\) than for boys \((r = .39)\), as was the correlation of science self-concept and science GPA \((r = .53\) for girls, \(r = .39\) for boys).
Table 1. *Means, Standard Deviations, and Zero-Order Correlations for Variables in the Study.*

<table>
<thead>
<tr>
<th></th>
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<td></td>
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<td></td>
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</tr>
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<td>.63***</td>
<td>.31***</td>
<td>—</td>
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<td>.30***</td>
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<td>.28***</td>
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<td>.65***</td>
<td>.47***</td>
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<td>.57***</td>
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<td>-.19*</td>
<td>-.10</td>
<td>.08</td>
<td>-.10</td>
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<td>-.23***</td>
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<td>.15*</td>
<td>.25***</td>
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<td>.31***</td>
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<td>.27***</td>
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<td>-.22**</td>
<td>.11</td>
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</table>

Note: Means for all motivation variables reflect the 6 points of the Likert-type scale. GPA and lab scores ranged from 0(F) to 4(A). Science lab SE scores range from 0-100. Gender was coded 0 for girls and 1 for boys. *p < .05, **p < .001, ***p < .0001.
Table 2. Means, Standard Deviations, and Zero-Order Correlations for Variables in the Study by Gender.

<table>
<thead>
<tr>
<th>Boys</th>
<th>Mean</th>
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<tr>
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<td>.31**</td>
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<td>.34***</td>
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<td>.17*</td>
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<td>-.20*</td>
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<td>.34**</td>
<td>.43***</td>
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<td>.38***</td>
<td>.50***</td>
<td>.16</td>
<td>.15</td>
<td>.27*</td>
<td></td>
<td>4.9b</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Note: Means for all motivation variables reflect the 6 points of the Likert-type scale. GPA and lab scores ranged from 0(F) to 4(A). Science lab SE scores range from 0-100. Group means for a dependent variable (row) that are subscripted by different letters are statistically different (experimentwise \( \alpha < .05 \)) computed on an effect identified by ANOVA test of difference between means. *\( p < .05 \), **\( p < .001 \), ***\( p < .0001 \).
Hypothesis 1

Bandura has consistently recommended that the most useful and valid self-efficacy measurements are those that are carefully matched with appropriate achievement measures. To this end, the present study was designed to evaluate the predictive utility of a laboratory skills self-efficacy measure on grades received in classroom laboratory activities. The hypothesis was that science lab self-efficacy would make an independent contribution to the prediction of science laboratory performance when prior achievement in lab activities, science self-concept, science anxiety, self-efficacy for self-regulation, and value of science were included in the statistical model.

Results of simultaneous multiple regression analysis revealed that lab skills self-efficacy did not make an independent contribution to the prediction of the science lab grades either for boys or for girls (see Table 3). Previous achievement in lab activities exercised a positive influence on lab grades both for boys ($\beta = .724$) and for girls ($\beta = .619$). In addition, for girls, the degree to which they valued science made a negative contribution to lab grades ($\beta = -.222$). The independent variables accounted for 43% of the variance in the science grades of girls, $F(6, 106) = 13.45, p < .0001$, and 54% of the variance in the science grades of boys, $F(6, 73) = 14.20, p < .0001$. The strength of the structure coefficients provides further evidence that the lab skills self-efficacy measure did not make an independent contribution to the prediction of the science lab grades for this group of students.
Table 3. *Standardized Regression Coefficients and Structure Regression Coefficients Predicting Lab Grades by Gender.*

<table>
<thead>
<tr>
<th></th>
<th>Girls $\beta$</th>
<th>Girls $s$</th>
<th>Boys $\beta$</th>
<th>Boys $s$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior lab grade</td>
<td>.619*</td>
<td>.928</td>
<td>.724*</td>
<td>.995</td>
</tr>
<tr>
<td>Lab self-efficacy</td>
<td>.099</td>
<td>.213</td>
<td>-.054</td>
<td>.041</td>
</tr>
<tr>
<td>Science self-concept</td>
<td>.075</td>
<td>.152</td>
<td>.015</td>
<td>.273</td>
</tr>
<tr>
<td>Science anxiety</td>
<td>.002</td>
<td>-.304</td>
<td>-.036</td>
<td>-.204</td>
</tr>
<tr>
<td>Self-regulation</td>
<td>.106</td>
<td>.061</td>
<td>-.008</td>
<td>-.027</td>
</tr>
<tr>
<td>Value of science</td>
<td>-.222*</td>
<td>-.137</td>
<td>.028</td>
<td>.109</td>
</tr>
</tbody>
</table>

Note: *$p < .05$
Hypothesis 2

Previous research has identified an association between subject-specific self-efficacy and achievement, both in language arts and mathematics. In an earlier study by Britner and Pajares (2001), science self-efficacy significantly predicted science GPA in White students ($\beta = .714$), as did both science self-efficacy ($\beta = 527$) and science self-concept ($\beta = .246$) in African American students. In the present study, the hypothesis was that science self-efficacy would make an independent contribution to the prediction of the science grade when prior achievement in science class, science self-concept, science anxiety, self-efficacy for self-regulation, and value of science were included in the statistical model.

Results of the multiple regression analysis (see Table 4) revealed that science self-efficacy did predict science GPA both for boys ($\beta = .464$) and for girls ($\beta = .215$), as did previous achievement in science (for boys, $\beta = .439$; for girls, $\beta = .510$). For girls, science self-concept had a positive influence on science GPA ($\beta = .253$) and value had a negative influence ($\beta = -.243$). It bears noting that the low structure coefficient obtained for value ($S = .100$) suggests that this effect may be a statistical artifact and that its significant beta value should be interpreted with caution. The independent variables accounted for 63% of the variance in the science grades of girls, $F(6, 150) = 41.98, p < .0001$, and 54% of the variance in the science grades of boys, $F(6, 97) = 19.14, p < .0001$. Again, the structure coefficients provide further support for the results from the multiple regression analysis.
Table 4. Standardized Regression Coefficients and Structure Regression Coefficients Predicting Science GPA by Gender.

<table>
<thead>
<tr>
<th></th>
<th>Girls</th>
<th></th>
<th></th>
<th>Boys</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β</td>
<td>S</td>
<td></td>
<td>β</td>
<td>S</td>
<td></td>
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<tr>
<td>Prior science GPA</td>
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<td>.918</td>
<td></td>
<td>.439*</td>
<td>.879</td>
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<tr>
<td>Science self-efficacy</td>
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<td>.802</td>
<td></td>
<td>.464*</td>
<td>.862</td>
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<td>Science self-concept</td>
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<td>Science anxiety</td>
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<tr>
<td>Self-regulation</td>
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<td>.150</td>
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<td>-.041</td>
<td>.109</td>
<td></td>
</tr>
<tr>
<td>Value of science</td>
<td>-.243*</td>
<td>.100</td>
<td></td>
<td>-.105</td>
<td>.080</td>
<td></td>
</tr>
</tbody>
</table>

Note: *p < .05
Hypothesis 3

Researchers have frequently observed that the fields of mathematics, science, and technology are typically viewed by students as being a male domain. Consequently, boys tend to be more confident and competent in these areas. Britner and Pajares (2001), however, found that middle school girls had higher self-efficacy and achievement in science. Consequently, the research hypothesis was that the science self-beliefs and achievement of African American middle school students would differ as a function of gender.

Multiple regression analyses were conducted with lab skills self-efficacy, science grade self-efficacy, science self-concept, science anxiety, self-efficacy for self-regulation, value of science, and science GPA as dependent variables and gender as the independent variable (see Table 5, Model 1). There were no significant gender differences in lab skills self-efficacy, science self-concept, science anxiety, self-efficacy for self-regulation, or value of science. Significant negative gender differences were found in science grade self-efficacy ($\beta = -.194$) and science achievement ($\beta = -.235$). Gender accounted for 4% of the variance in science grade self-efficacy, $F(1, 266) = 10.39, p = .0014$, and 6% of the variance in science GPA, $F(1, 266) = 15.52, p < .0001$. 
Table 5. *Standardized Regression Coefficients from Hierarchical Multiple Regression Models for Variables in the Study.*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lab skills self-efficacy</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
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<tr>
<td>$R^2$</td>
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<td></td>
<td></td>
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<tr>
<td><strong>Science grade self-efficacy</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>-.194*</td>
<td>-.266***</td>
<td>-.145*</td>
<td>-.213**</td>
</tr>
<tr>
<td>Masculinity</td>
<td>.234**</td>
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<td>.196*</td>
<td></td>
</tr>
<tr>
<td>Femininity</td>
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<td></td>
<td>.187*</td>
<td></td>
</tr>
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<td>.09***</td>
<td>.09***</td>
<td>.12***</td>
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<td>.05***</td>
<td>.08***</td>
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<tr>
<td><strong>Science self-concept</strong></td>
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<td></td>
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<tr>
<td>Gender</td>
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<tr>
<td>$R^2$</td>
<td>0.00</td>
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<td></td>
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<tr>
<td><strong>Science anxiety</strong></td>
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<td>Gender</td>
<td>.080</td>
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<tr>
<td>$R^2$</td>
<td>0.00</td>
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<tr>
<td><strong>Self-regulation</strong></td>
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<tr>
<td>Gender</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>$R^2$</td>
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<td></td>
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<tr>
<td><strong>Value of science</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>-.056</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.00</td>
<td></td>
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<tr>
<td><strong>Science GPA</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
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<td>-.225**</td>
<td>-.215**</td>
<td>-.198*</td>
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<td>Masculinity</td>
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<td>-.050</td>
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<tr>
<td>Femininity</td>
<td>.090</td>
<td>.099</td>
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<td></td>
</tr>
<tr>
<td>$R^2$</td>
<td>.06***</td>
<td>.06**</td>
<td>.06**</td>
<td>.07**</td>
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<tr>
<td>Change in $R^2$</td>
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<td>.01</td>
<td></td>
</tr>
</tbody>
</table>

*p < .05, **p < .001, ***p < .0001.*
Hypothesis 4

Self-efficacy researchers have reported that gender differences may be accounted for by differences in the beliefs that students hold about gender rather than by gender differences per se. In writing, holding a feminine orientation was associated with writing self-efficacy and rendered nonsignificant gender differences in writing self-efficacy beliefs and even in writing achievement (Pajares & Valiante, 2001). Research Hypothesis 4 was that gender differences in science self-beliefs and science achievement would be rendered nonsignificant when gender orientation beliefs are controlled.

In the regression analysis of Hypothesis 3, significant gender differences were found only in science grade self-efficacy ($\beta = -.194$) and science GPA ($\beta = -.235$). In each case, differences favored girls (who were coded 0). For these two variables, I added three models to the hierarchical regression analyses (see Table 5.) In Model 2, masculinity was added to gender as an independent variable predicting science grade self-efficacy and science GPA. In Model 3, femininity was substituted for masculinity. In Model 4, masculinity and femininity were both included.

Neither masculinity nor femininity exercised a significant influence on the prediction of science GPA. In all three models, gender was the only significant predictor of science GPA.

Gender orientation was associated with science grade self-efficacy. In Models 2 and 3, both masculinity ($\beta = .234$) and femininity ($\beta = .224$) contributed to the prediction of science grade self-efficacy and each added to the strength of the model (change in $R^2 = .05$). In Model 4, both masculinity ($\beta = .196$) and femininity ($\beta = .187$) were significant, with the combination increasing the strength of the model by an additional .03. In all three models, however, the influence of gender remained significant.
Given that both masculinity and femininity were positively associated with science grade self-efficacy, it seemed likely that it was in fact androgyny that was at work; i.e., that it was the combination of masculine and feminine self-beliefs that was associated with science self-efficacy. To test this hypothesis, I created a variable composed of the interaction between masculinity and femininity and conducted a multiple regression in which gender and the interaction term predicted science grade self-efficacy. In this model, gender was again negatively associated with science grade self-efficacy ($\beta = -.208$) and the interaction term was positively associated with science grade self-efficacy ($\beta = .281$). The positive beta coefficient demonstrated that students who possessed an androgynous orientation (high masculinity and high femininity) had higher self-efficacy than did students who possessed a diffuse orientation (low masculinity and low femininity). This model accounted for 12% of the variance in science grade self-efficacy, $F(2, 265) = 17.44, p < .0001.$
CHAPTER 5
SUMMARY AND CONCLUSIONS

Although there is a rich data base on self-efficacy in other academic areas, less information is available about the relationships among self-efficacy, motivational variables, and achievement in the domain of science. I have focused on the effects of these relationships in middle school students because students' self-efficacy beliefs tend to decrease during this time. In addition, they experience school transitions that often contribute to lower self-beliefs at a time when these self-beliefs are becoming less "plastic" (James, 1958) and more difficult to alter. This drop in confidence is especially critical in the areas of mathematics and science, as a failure to take these courses due to low self-efficacy will foreclose the pursuit of careers in these areas (Hackett, 1985; Oakes, 1990; Zeldin & Pajares, 2000). This is of particular concern with girls and African American students, who have participated in science courses at lower rates than have boys and White students and are underrepresented in science-related careers (National Center for Educational Statistics, 2000, 2001). Graham (1994) has recommended that more race-homogeneous studies be conducted in which within-group variation in academic motivation is studied. Accordingly, I have focused on the relationship between science self-efficacy and achievement in African American middle school students.

Recall that academic self-beliefs have been found to be unreliable predictors of achievement in African American students, who maintain positive self-beliefs despite sometimes problematic achievement (Graham, 1994). Bandura (1986) maintained that
self-efficacy is most reliable as a predictor of achievement when it measures specific skills and is closely matched with a performance measure. Consequently, the first objective of this study was to determine whether self-efficacy beliefs assessed at two levels of specificity would each make an independent contribution to the prediction of science achievement measured at two corresponding levels of specificity. I developed the Lab Skills Self-Efficacy Scale to provide a measure of students' confidence in their ability to perform skills required in laboratory activities at the middle school level. Students' scores on this scale were compared with a subsequent science lab grade provided by their science teachers. Results revealed that lab skills self-efficacy did not make an independent contribution to the prediction of lab grades for the students in this sample.

This disappointing result was likely due to teachers' instructional practices and evaluation criteria that became apparent during data collection and analysis. In one classroom, students indicated to the individual administering the surveys that they were unsure of how to respond to the lab skills self-efficacy measure because they had not completed any hands-on laboratory activities in science class. When I returned to the school to get students' grades, this teacher provided lab grades as well as final semester grades and completed the checklist of lab skills needed for lab activities in his class. When questioned about how often he did labs, he indicated that he mostly did them as demonstrations. Problems with lab grades in other classes came to light when I examined the data: in one class, all students received a grade of 100%, thus precluding any valid correlation of lab grades with lab skills self-efficacy ratings. This teacher indicated that she gave students what amounted to a participation grade to encourage them to actively participate in the lab activities. In other classes, lab grades were very high, with the
majority of the students receiving A or B on their lab activity, creating a problematic ceiling effect in this variable that foreclosed the possibility of obtaining reliable or valid findings.

In addition to the forms on which I asked teachers to record their students' grades, I provided them with the list of skills contained in the Lab Skills Self-Efficacy Scale and asked them to indicate which of the skills described were used in their evaluation of lab assignments. Each teacher checked most or all of the skills on the list. The lack of association between students' lab skills self-efficacy and their lab grades, however, raises strong doubt about the degree to which the lab skills indicated were used in assessing students' lab performance. As a consequence of these confounding factors, I was unable to evaluate the predictive utility of science self-efficacy measured at the task-specific level or to compare its effectiveness with that of science self-efficacy measured at the domain level.

The instructional and assessment practices I encountered as I collected data are disturbing. There was evidence that some students were receiving appropriate science instruction, and care must be exercised in making judgments based on limited familiarity with the instructional program. There was, however, clear evidence of inconsistencies in the science instruction provided to these students. Research has demonstrated that students learn science concepts most effectively when science instruction includes opportunities for students to engage in inquiry learning in which they construct meaning through investigation of natural phenomena (National Research Council, 1996). Science educators need to continue working to implement the National Science Education Standards in all classrooms and to educate school system administrators about the importance of science education reform. In addition, students need appropriate feedback
on their performance as they develop skills and conceptual understanding in science; this feedback is also crucial to the development of academic self-beliefs that mediate the expression of students' abilities in academic settings.

Schools administrators are conscious of their responsibility to ensure their students' well-being and to protect their privacy. In arranging for data collection, I described the nature of my research to the school administrator who selected the school in which I would be permitted to collect data. I was thus dependent on her judgment that this group of science teachers was a suitable match for my research purposes. Unfortunately, this proved not to be the case as regards instruction and assessment in laboratory activities, and I was unable to compare the predictive utility of task-specific self-efficacy and domain-specific self-efficacy. I hope that as I develop relationships with classroom teachers in the future I will be able to replicate this part of my dissertation in more effective instructional settings. The alpha coefficient obtained for the Lab Skills Self-Efficacy Scale and the results of the factor analysis indicate that this scale would be a useful instrument for future investigations in which lab grades are based on appropriate evaluation of the indicated lab skills. This would provide further support for Bandura's (1986) assertion that self-efficacy is most useful when assessed in relation to specific tasks.

The second objective of this study was to determine whether self-efficacy assessed at the domain-specific level of confidence to achieve a given grade in science would predict the science grades of African American middle school students. Consistent with well-established results, the confidence that students reported in their capability to earn specified grades in science class at the end of the academic semester predicted the grades obtained both by girls and by boys, even after controlling for the expected
influence of previously obtained grades, thus supporting the tenets of social cognitive theory (Bandura, 1986). Consequently, teachers and schools should be attuned to the self-efficacy beliefs of African American students in the area of science.

Britner and Pajares (2001) found that, although science self-efficacy was the only variable to predict the science achievement of White students, both science self-efficacy and science self-concept predicted the science achievement of African American students. For the African American students in the present study, however, this pattern held only for the girls, indicating that, at equal levels of self-efficacy and achievement, girls with higher science self-concept earned higher grades than did girls with lower science self-concept. It may well be that girls perform better in areas in which they invest their sense of self, and therefore that the feelings of self-worth associated with science performance result in higher achievement in science for middle school African American girls.

Value also played a role in the science achievement of girls. The girls' relatively high mean score for the value of science (4.4 on a 6-point scale) showed that they valued science. Nonetheless, at equal levels of previous achievement, self-efficacy, and self-concept, the degree to which these girls valued science was negatively associated with the grades they obtained. One would expect that valuing an academic area should be positively associated with achieving academic success in that area. There are several possible explanations for this finding. As noted in the previous chapter, the low structure coefficient suggests that the multicollinearity among value and other independent variables makes this result a statistical artifact. Nonetheless, other researchers have reported similar findings (see Britner & Pajares, 2001; Pajares, 2001).
According to expectancy-value theory (Atkinson, 1957), however, as self-efficacy for an activity or task increases, students may ascribe less value to it. Thus, in the present study, it may be that girls with higher science achievement took science for granted and placed less value on it, whereas those girls with comparatively lower science achievement valued it more because it was more difficult for them to succeed.

This does not explain, however, why value was not negatively associated with the grades of boys. The structure coefficients may be informative in this regard. Recall that structure coefficients were low, suggesting that the standardized regression coefficients should be interpreted with caution. Further research is recommended on two aspects of this question. First, investigations with larger samples and with other populations are needed to determine the actual relationship between perceived value of a school subject and academic success after controlling for other motivational influences. Second, although the regression models used in the present study predicted substantial amounts of the variance in science performance (63% for girls and 54% for boys), other variables such as goal orientation, prior science knowledge, and outside experience with science-related activities should be included in future studies.

What findings of the present study do make clear, however, is that the success in science of African American middle school girls depends on a more complex set of factors than does the science achievement of African American middle school boys. These include affective factors such as the value that girls place on science and their self-concept beliefs, which include a sense of self-worth associated with performance in science, in addition to the more cognitive science self-efficacy and prior achievement factors that predict achievement both for boys and for girls.
A qualitative investigation of the relationships among motivation constructs and achievement in science would contribute insights not readily obtainable through quantitative research. Qualitative approaches would free researchers from the constraints imposed by forced-choice survey measures and allow interpretation of the lived experiences of the students as expressed through their own voices. A study that included interviews both with students and teachers as well as classroom observations would also include a consideration of the social and interpersonal context of the classroom and the school.

The third objective of this investigation was to determine whether the science motivation and achievement of African American middle school students would differ as a function of gender. Girls reported stronger science self-efficacy and earned better grades in science class than did boys. These findings are consistent with those of Britner and Pajares (2001), who reported that gender differences in science self-efficacy and achievement in middle school students are similar to gender differences found in language arts rather than to those found in mathematics, as would be expected given the common linkage of mathematics and science.

Britner and Pajares (2001) observed that middle school science is often taught with methods more characteristic of language arts than of investigative science, which would perhaps account for the unexpectedly higher self-efficacy and achievement of girls. It was in part to test this hypothesis that I developed the lab skills self-efficacy measure and collected lab grades: If girls are more confident and successful in science because of teaching practices related to language arts, then a different pattern might be found in a study of science lab activities and lab skills, activities less dependent on language arts skills. And, in fact, no gender differences were found in lab skills self-
efficacy. Nonetheless, the problematic nature of the laboratory component for students in the sample was such that additional inquiry and replication are required. This replication should be conducted in a school context in which all students engage in lab activities that are soundly evaluated by their science teachers.

No gender differences were found in science self-concept, science anxiety, self-efficacy for self-regulation, or value of science. The failure to find gender differences in these motivation constructs in the domain of science is noteworthy, especially given the higher achievement of girls. For example, if girls have higher achievement than do boys and place equal value on science, it would seem that they should report higher science self-concept and perhaps lower anxiety, which was not the case. As some researchers have suggested, however, girls may be more modest in their responses to questions about ability than are boys (Pajares, 1997; Wigfield et al., 1996). Noddings (1996) argued that girls use "a different metric" than do boys, and that girls perceive that their statements represent more of a promise, whereas boys tend to be more self-congratulatory. Results from the present study would indicate that girls do have an accurate perception of their abilities in science, as reflected in their responses to the more specific self-efficacy items, but that more general measures, such as self-concept and self-efficacy for self-regulation, must be interpreted in light of the different response patterns of boys and girls.

The final objective of the study was to determine whether obtained gender differences could be accounted for by gender orientation beliefs. Recall that this was the case when investigators studied these differences in the domain of language arts (Pajares & Valiante, 2001). In the present study, students' gender orientation beliefs did not account for the gender differences in science grade self-efficacy or in grades obtained. Neither masculinity nor femininity were associated with science grades, but both were
positively associated with science grade self-efficacy. As described in Chapter 4, androgyny, defined as possessing high masculinity and femininity, is often associated with motivation indexes. In the present study, multiple regression analysis confirmed this association. Boys and girls with higher levels of androgyny reported higher science self-efficacy than did those with lower levels of androgyny. These results suggest that those students who can draw on the relational approach associated with a feminine orientation as well as on the instrumentality associated with a masculine orientation have more confidence in their science capabilities. Students would be well served by teachers who are aware of this pattern and who support the development of student self-beliefs that incorporate the strengths of both gender orientations.

A classroom is a microcosm of the broader cultural milieu, reflecting the diversity of American society as well as social, cultural, economic, and political patterns of behavior that may serve to enable or disable young people. Science educators concerned with supporting the optimal development of all students require information on relationships among factors that enable students to reach their full potential. Results of this investigation provide information for educators on the relationship of motivation constructs to science achievement in middle school African American students and support Bandura's (1986, 1997) contention that self-beliefs are a critical component in academic achievement. Educators should support the development of students' self-efficacy beliefs as well as the development of science knowledge, as positive self-efficacy beliefs enable students to fully express their competencies, abilities, and skills.
REFERENCES


APPENDIX A

Permission to Conduct Research
APPENDIX B

Instrument Used in the Study
APPENDIX C

Items Corresponding to Scales Used in the Study
**Science Lab Self-Efficacy Items**

1. Correctly follow directions to complete a laboratory activity.
2. Make appropriate predictions (hypotheses) about what will happen during a laboratory activity.
3. Use laboratory equipment correctly.
4. Make accurate measurements during a laboratory activity.
5. Make appropriate observations during a laboratory activity.
6. Collect accurate data during a laboratory activity.
7. Clearly record results from a laboratory activity.
8. Correctly complete necessary mathematical calculations in a laboratory activity.
9. Communicate results in the form of a data table or graph.
10. Draw correct conclusions from laboratory results.
11. Identify sources of error that might affect the results of a laboratory activity.
12. Describe how the laboratory activity is related to everyday life.

**Science Grade Self-Efficacy Items**

1. Using the scale above, how confident are you that you will pass science class at the end of this semester?
2. How confident are you that you will pass science at the end of this semester with a grade better than a D?
3. How confident are you that you will get a grade better than a C?
4. How confident are you that you will get a grade better than a B?
5. How confident are you that you will get an A?

**Science Self-Concept Items**

1. Compared to others my age I am good at science.
2. I get good grades in science.
3. Science is easy for me.
4. I am not good at science work.
5. Learning how to be better in science is easy for me.
6. I have always done well on science assignments.
Science Anxiety Items

1. Taking science tests does not scare me.
2. Science makes me feel uneasy and confused.
3. I have usually been at ease in science classes.
4. I almost never get uptight while taking science tests.
5. I get really uptight during science tests.
6. I get a sinking feeling when I think of trying hard science assignments.
7. My mind goes blank and I am unable to think clearly when doing science.
8. Science makes me feel uncomfortable and nervous.
9. I have usually been at ease during science tests.
10. I am afraid of doing science assignments when I know they will be graded.
11. Just thinking about science makes me feel nervous.

Self-Efficacy for Self-Regulation

1. How well can you finish your homework on time?
2. How well can you study when there are other interesting things to do?
3. How well can you concentrate on your school work?
4. How well can you remember information presented in class and in your school books?
5. How well can you arrange a place to study at home where you won't get distracted?
6. How well can you motivate yourself to do schoolwork?
7. How well can you participate in class discussions?

Value of Science Items

1. It is important to me to get good grades in science.
2. Being good in science is important to me.
3. I enjoy doing science work.
4. Science is interesting for me.
5. Science is boring.
6. Science is a lot of fun.
7. I like to do science work.
8. I look forward to science lab.
9. I like completing laboratory assignments.

Gender Orientation Items
Masculinity
1. I am willing to take risks.
2. I am an active, adventurous person.
3. I like to figure out how mechanical things work.
4. I like activities where it is one person or group against another.
5. I like building and fixing things.
6. I like to compete with others.
7. I like to show that I can do things better than others my age.
8. I am good at taking charge of things.
10. If I have a problem, I like to work it out alone.

Femininity
1. I am a gentle person.
2. I am good at understanding other people's problems.
3. When someone's feelings get hurt, I try to make them feel better.
4. I can usually tell when someone needs help.
5. I am a kind and caring person.
6. I am a warm person and express these feelings to those I feel close to.
7. I care about other people's feelings.
8. I like to work with children a lot.
9. I prefer to let others take charge.
10. I care about what happens to others.