2-2016

Expecting Success: Factors Influencing Ninth Graders' Science Self-Efficacy

Elizabeth Donahue
Graduate Center, City University of New York

EXPECTING SUCCESS:

FACTORS INFLUENCING NINTH GRADERS' SCIENCE SELF-EFFICACY

by

ELIZABETH DONAHUE

A dissertation submitted to the Graduate Faculty in Urban Education in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York.

2016

EXPECTING SUCCESS:

FACTORS INFLUENCING NINTH GRADERS' SCIENCE SELF-EFFICACY

by

ELIZABETH DONAHUE

This manuscript has been read and accepted for the
Graduate Faculty in Urban Education to satisfy the dissertation
requirement for the degree of Doctor of Philosophy.

_Juan Battle_______________________________

_______________ _______________________________

Date Chair of Examining Committee

_Anthony Picciano_________________________

_______________ _______________________________

Date Executive Officer

__Gillian Bayne___________________

__Nicholas Michelli________________

Supervisory Committee

THE CITY UNIVERSITY OF NEW YORK

Abstract

Expecting Success: Factors Influencing Ninth Graders' Science Self-Efficacy

by

Elizabeth Donahue

Advisor: Juan Battle

What factors influence ninth grade students' expectations for success in science? Using social cognitive theory and bioecological systems theory as theoretical frameworks, this dissertation employs data from the High School Longitudinal Study of 2009 (HSLS:09) to examine the relative impact of teacher practices and their perceived attitudes on students' science self-efficacy. Further, as they relate to this broader issue, the relative impact of student subjective task value and teacher characteristics is also investigated.

It has been well documented that U.S. students are not achieving at satisfactory levels in science. Education policy has focused on improving science teacher quality as one way to address this problem. Teacher effectiveness has been primarily measured by student achievement on standardized tests. However, not enough attention has been given to the social cognitive factors that can lead to increased achievement and persistence in science as well as how teachers may influence these factors. This study interrogates the relationship between student and teacher variables and the social cognitive construct of self-efficacy, which has proven to have a significant impact on student achievement and persistence in science. Findings add to the current literature surrounding ways that educators may increase student performance in science by employing policies and practices that benefit the development of student science self-efficacy.

Acknowledgments

Firstly, I would like to express my sincere gratitude to my advisor, Dr. Juan Battle. I could not have asked for a better guide along the journey that was this dissertation. With true dedication, insightful questioning, and remarkable organization Juan pushes all of his students to be better thinkers. I have learned so much from him about how to be a researcher, and for this I am beyond thankful.

I also want to thank my two committee members. Dr. Nicholas Michelli's philosophy of education has inspired me since the very beginning of my time in the Urban Education program, and his unwavering support has been a positive influence on my own self-efficacy as a researcher. Dr. Gillian Bayne gave me the push I needed to start my research, inspired me to read and write even more than I already thought possible, and challenged me to think about science education research from multiple perspectives.

I am grateful for the support of the faculty and students of the Urban Education program at the CUNY Graduate Center, and especially Christine Saieh for her steadfast assurance and encouragement.

The students that I had the opportunity to work with as a teacher in Brooklyn, New York have been a great source of inspiration for me. I probably learned just as much from them as they learned from me in my ten years of teaching, and they are a constant presence in my thinking about how to make education better for all students.

Lastly, I want to thank my family. My parents have encouraged me in so many ways throughout my life, and provided me with the time and emotional support that I needed to complete this dissertation. As lifelong educators, they served as the best possible role models that

I could hope for as a teacher, and shaped the way that I think about education. My husband, who believed in me before I even verbalized the thought of applying to doctoral programs, has been my champion throughout this process. He has been a sounding board for my research ideas and an academic colleague with whom I can discuss issues in education. Above all, his patience, encouragement, and dedication allowed me the time to work and the peace of mind that I needed to complete this dissertation. Finally, I want to thank my two little boys, who inspire me every day with their ways of thinking and communicating, their curiosity and creativity, and their pure joy in learning and interacting with others. I hope that they always believe in themselves and each other, and through this confidence that they will work to make our world a little better.

Table of Contents

List of Tables

Chapter 1: Introduction and Background

We must have perseverance and above all confidence in ourselves. We must believe that we are gifted for something and that this thing must be attained.
-- Marie Curie

1.1 Introduction

At the 2015 White House Science Fair, President Obama described the importance of science as a driving force for our nation's competitiveness in the global economy. He spoke to an audience of students, some as young as six years old, describing science as a "critical way to understand and explore and engage with the world" (The White House, Office of the Press Secretary, 2015). The president went on to give updates on a number of federal programs aimed at advancing science, technology, engineering, and math (STEM) education, including initiatives to develop higher quality science teaching and to improve the diversity of students choosing to pursue science in their postsecondary education and career paths. In recent years STEM education has been the primary focus of a number of federal education mandates and has subsequently been on the receiving end of a great deal of federal funding.

Student science achievement, primarily measured by test scores, has been the principal means of evaluation of both student progress and educator and policy effectiveness. However, science achievement remains stagnant despite an onslaught of policies aimed at improving STEM education (National Center for Education Statistics, 2011). Additionally, Blacks, Hispanics, and females continue to be underrepresented in STEM at both the postsecondary and the professional level even though a stated goal of recent reforms has been to increase diversity in STEM careers and decrease gender and race based achievement gaps in STEM education (National Science Foundation, 2013). This indicates that policies focused almost exclusively on an outcome of improved test performance are not an effective solution to the STEM crisis, and that other factors must be considered in order to increase science achievement and create more equitable pathways into science majors and careers.

Recent research suggests that in order to improve the state of education, both in general and in science and other STEM fields, greater attention must be paid to the relationship between student achievement and noncognitive factors, or the sets of behaviors, skills, attitudes and strategies that are essential to academic performance (Farrington et al., 2012). One of these factors is the construct of student self-efficacy, or the expectations that students have for success on a particular task or in a particular subject area. A vast body of literature has established self-efficacy as a powerful predictor of academic achievement and persistence (Pajares, 1997; Britner & Pajares, 2006; Chemers et al., 2011; Fouad & Smith, 1996; Graham et al., 2013; Mau, 2003), yet there is a relative paucity of research that considers academic self-efficacy as an outcome variable and that explores the ways in which students and teachers contribute to the development of student self-efficacy. This dissertation aims to explore the ways in which numerous student, school, and teacher level variables impact student science self-efficacy in order to add to the literature surrounding ways to improve student achievement and persistence in science.

Statement of the Problem

At a time when science is becoming increasingly important for participation in the global economy, U.S. students are neither achieving at sufficient levels in science nor are they persisting in pursuing science career paths. Despite years of interventions aimed at improving science education, there has yet to be seen a significant increase in student achievement. This indicates that there are factors contributing to student success in science that still need to be understood and explored in terms of their influence on student interest, achievement, and persistence in science.

In the past decade, two major federal policies have aimed to advance American competitiveness through the improvement of STEM education. The America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act of 2007, or America COMPETES, was first signed into law in August of 2007 by then president George W. Bush with the stated goal of improving the nation's competitiveness (Owens, 2009). One of the main provisions of America COMPETES was to improve STEM education by increasing both the numbers and qualifications of science and mathematics teachers, and to strengthen STEM teaching and learning based on the recommendations of a panel of STEM experts. America COMPETES was reauthorized in May 2010 and most recently in May 2015.

In 2009, President Obama added another policy aimed at improving STEM education: the "Educate to Innovate" campaign (The White House, Office of the Press Secretary, 2009). Two of the main goals of this initiative are to improve the quality of science and math teaching and to increase the education and career opportunities for underrepresented groups in STEM, including women and minorities. To this end, the 2009 campaign pledged over $260 million, funding which was added to that of existing programs aimed at improving STEM education, including the America COMPETES budget ($3.4 billion in 2011) and the funds from the president's $4.35 billion Race to the Top program (United States Department of Education, 2009). It cannot be said that the United States lacks in spending or legislation concerning the improvement of science and STEM education, the question remains as to whether any significant progress has resulted from these initiatives.

One international assessment of student math and science knowledge, the Trends in International Mathematics and Science Study (TIMSS), showed no significant change in U.S. fourth or eighth grade science performance scores from 2007 to 2011 (National Center for

Education Statistics, 2011). Results on a more national level are more promising; the National Assessment of Educational Progress (NAEP), which includes assessment results from a representative sample of 122,000 eighth graders, revealed that from 2009 to 2011 student science test scores improved by an average of two points, a number that is statistically significant for students at the basic and proficient level but not at the advanced level. However, there was no significant change in the science gender gap and only a one point improvement in the gap between White students and their Black and Hispanic peers (National Center for Education Statistics, 2012). These results portray a lackluster degree of progress in science education, especially in light of the overabundance of resources that have been directed towards the cause of advancing student science achievement. Additionally, the NAEP results do not reflect any improvement in science achievement for girls and only the slightest amount for Blacks and Hispanics despite the initiatives aimed at improving science education for these particular groups of students.

If science education is truly to be improved, it is necessary to look beyond test scores and other traditional measures of achievement and instead explore the factors that have been shown to lead to academic success. Enhancing the understanding of the psychological antecedents to achievement and persistence in science can add a new perspective to the design of educational policies and practices aimed at improving student science performance. Social psychologists have increasingly focused on social cognitive factors as a predictor of academic achievement and persistence (Farrington et al., 2012). One such factor is the concept of self-efficacy, which was first introduced by Albert Bandura in 1977 and has since been established as a powerful psychological antecedent to achievement. Self-efficacy refers to a person’s expectations for success on a specific task or in a particular subject area, and has been shown to be a significant predictor of student achievement, persistence, and career aspirations in science and other STEM-related fields (Simpkins et al., 2006; Mau, 2003; Fouad & Smith, 1996). A substantial body of existing research indicates that improving students' science self-efficacy will lead to increased achievement and persistence in science (Bandura, 1997; Schunk, 1995; Siegle & McCoach, 2007; Graham et al., 2013); researchers, educators, and policymakers must therefore understand how to support the development of this construct. Thus far, there is a lack of research on the factors that impact student science self-efficacy; this study seeks to fill that void in order to provide better insight into the ways that noncognitive factors may be used to improve science education.

In addition to schooling, there are a number of factors from outside the classroom setting that can contribute to students' self-efficacy, such as students' families, their access to capital, and their peer networks (Schunk & Meece, 2006). However, this study will focus primarily on interactions that occur within the classroom in order to identify ways that individual classroom teachers may influence the development of self-efficacy in their science students despite all of these other contributing factors, and to provide both practical and policy implications for educators and education policymakers. This study aims to explore the ways in which science teachers may impact student science self-efficacy through their attitudes towards students and the teaching practices they choose. Student characteristics and teacher characteristics will also be examined in order to develop an understanding of the ways that student-teacher classroom interactions may affect the self-efficacy of students from various groups, especially those that have been historically underrepresented in science.

Rationale

A profusion of recent research has focused on science and STEM education, and for good reason. The number of science, technology, engineering, and math-related jobs needed to be filled in the United States is rapidly increasing; it is projected that the number of these occupations in the U.S. will grow at almost two times the rate of non-STEM occupations from 2008 – 2018 (Langdon et al., 2011). STEM jobs come with a number of advantages – workers generally earn higher wages and face lower levels of unemployment than non-STEM workers. Additionally, STEM degree holders are usually paid more than non-STEM degree holders, even if they are not working in a STEM occupation. The advantages of pursuing a science or other STEM-related degree and career are clear; however, the current state of STEM education does not position students well enough to attain these benefits, and does a particularly poor job at preparing and encouraging students who would gain the most from obtaining a STEM degree: girls, students from racial and ethnic minority groups, and students who are economically disadvantaged.

According to the Program for International Student Assessment (PISA), the United States ranks twenty-third in a list of sixty-five of the world's most-developed countries in terms of science achievement (Organisation for Economic Cooperation and Development, 2014). TIMSS, another international assessment, shows that the 2011 science performance test scores of United States fourth graders rank 7th out of a group of 57 international education systems and those of U.S. eighth graders rank 13th out of 56. Together these statistics have created anxiety about a national "STEM crisis"; America is feared to have has lost its lead in science education and its global competitiveness will suffer.

This study focuses on American students only, while the abovementioned assessments are used multinationally. Some researchers have voiced concerns regarding the interpretation of results from international assessments such as PISA and TIMSS, especially in regards to the fairness of student selection and testing in different countries and the usefulness of international data for educators within our own country (Bybee, 2007). Certainly, the cultural and demographic characteristics of each participating country do indeed differ, which should be noted in any analysis or interpretation of test results. However, student selection for the abovementioned international assessments cannot be deemed unfair: students tested are randomly selected from schools which in turn have been randomly selected, resulting in representative samples for each participating country. To reiterate, the current study focuses only on a nationally representative sample of students, the data from PISA and TIMSS is used only as an illustration of the ways in which the Unites States as a country differs from other nations in terms of science achievement.

Despite the growing need for STEM professionals, students are not performing as well as they should be in science, and are not persisting in the educational pathways that would lead to STEM careers. In order to increase interest and competency in STEM careers, $2.9 billion has been allocated in the 2015 budget for federal programs aimed at improving STEM education (Office of Science and Technology Policy, 2013). A particular point of concern is making science education more equitable in order to increase the interest in and involvement of students from groups that have been historically underrepresented in STEM – mainly girls, racial and ethnic minorities, and the economically disadvantaged. Thus far, research on equity in science education has focused on three major categories – access, retention, and achievement (Hewson et al., 2001). This study will expand the discourse surrounding equity in science education by looking past traditional measures of achievement and instead examining the impact of student and teacher variables on science self-efficacy, a proven predictor of achievement, persistence, and resilience in science. The inclusion of the student level variables of race, gender, and socioeconomic status will assist in determining how to increase expectations for success in science for all students.

A main component of the federal STEM initiative is the recruitment, preparation, and support of excellent science and math teachers. Despite other important factors that can influence student performance, teachers have been shown to have a significant effect on student achievement as measured by test score gains (Nye, Konstantopoulos & Hedges, 2004) and teachers are often considered to be the single most important school-based factor in terms of impacting student success (Goe et al., 2008). However, prior research has shown that rigorous teacher training does not always translate to success in the classroom (Hill & Dalton, 2013). When a teacher enters a classroom, other variables arise in daily interactions between teacher and students that may shape students' expectations for success in science. This study will examine the ways that teachers may impact students' science self-efficacy by examining teacher characteristics, teaching practices, and student perceptions of teacher attitudes. The focus on self-efficacy, rather than achievement, will add to the understanding of the psychological antecedents that lead students to feel successful, achieve, and persist in science.

Contribution to the Field

The improvement of science education has received much attention in recent education research and policy due to the push to better prepare the nation's students for STEM majors and careers. Most of the existing literature on science education focuses on student achievement and persistence in science as measured by standardized test scores, course grades, and postsecondary course enrollment; the need remains for a deeper understanding of the factors that contribute to student achievement in order to improve these outcomes. Prior studies have explored student self-efficacy as a psychological antecedent to achievement, examining the ways in which self-efficacy influences achievement in science and other academic domains. However, there is a lack of research surrounding the factors that contribute to student science self-efficacy. While a small body of literature has examined the impact of student level variables on self-efficacy, not much has included the effects of teachers on student science self-efficacy. Even fewer studies have considered self-efficacy in the particular domain of science; a great deal of the research on self-efficacy and STEM education has focused primarily on mathematics. This study seeks to add to the existing literature on student self-efficacy by concentrating specifically on science self-efficacy and by considering the effects of teacher level variables in addition to those of student level variables.

Much of the research on student self-efficacy uses either qualitative (Zeldin & Pajares, 2000; Zeldin et al., 2008) or small scale quantitative studies (Britner & Pajares, 2006; Britner, 2008; Siegle & McCoach, 2007; Battistich et al., 1995; Fouad & Smith, 1996); there is a relative dearth of nationally representative samples in the literature concerning student self-efficacy. This study aims to fill this void by employing data from a nationally representative sample of high school students to examine the impact of various student, school, and teacher level variables on student science self-efficacy.

1. 2 Background

This study aims to explore the ways in which student and teacher variables influence the development of student self-efficacy in science. A large body of literature in the fields of both education and psychology surrounds the construct of self-efficacy and its development in science and other academic fields, as well as its powerful influence on academic achievement, persistence, and resilience. The theoretical framework for this dissertation will draw upon the ideas of four theories – bioecological systems theory, social cognitive theory, motivation theory, and achievement goal theory – in order to position the current study within the existing literature on self-efficacy.

Theoretical Framework

This dissertation is guided by a theoretical framework comprised of four interrelated theories. The first of these is bioecological systems theory (Bronfenbrenner, 2005), which emphasizes the importance of both person and context in human development, and which will be used to situate this study in the science classroom and the pattern of interactions that occur between teacher and students, while at the same time considering the individual characteristics of the person, or student, at the focus of this study.

Bronfenbrenner describes the bidirectional nature of interactions between a person and their environment that work to shape human development. Both environmental context and personal characteristics must be considered in order to truly understand development. Bronfenbrenner (1997) also discusses the importance of proximal processes, or the patterns of interactions in an individuals' immediate environment, in shaping development. These interactions occur on a regular basis, such as in the daily exchanges between a teacher and student that arise from teacher attitudes, the classroom practices that a teacher chooses to emphasize, or the social roles that a student takes on based on classroom structures and activities. This study aims to explore the ways in which the interactions, or proximal processes, between teachers and students in the science classroom influence the development of students' expectations for success in science, or their science self-efficacy.

Bioecological systems theory will first be used to position this study in the context of classroom interactions as well as to establish the student as the focus of analysis. Social cognitive theory will then be added to the theoretical framework in order to develop the variables to be considered in this study of student science self-efficacy. The construct of self-efficacy originated in social cognitive theory in the work of Albert Bandura. Throughout his research in developmental psychology, Bandura emphasized the social nature of learning, maintaining that self-efficacy is influenced by various personal, contextual, and social variables (1997). In discussing human behavior, Bandura (2011) describes a reciprocal triadic relationship between personal, behavioral, and environmental factors; behavior is not solely attributable to either internal dispositions or external elements but is rather both a result of and influence on the person and the environment. This bears a striking similarity to Bronfenbrenner's concept of the bidirectional relationship between the environment and individual development and the importance of both person, process, and context in development.

Social cognitive theory emphasizes that learning occurs in a social context, and often through observation. Additionally, one's own thoughts and beliefs influence both learning and the interpretation of contextual events. Self-efficacy, for instance, can influence the academic decisions students make and their perceptions of classroom interactions that may either encourage or inhibit participation in the learning process. One valuable principle of both social cognitive theory and bioecological systems theory is the assertion that the individual and the environment influence both development and each other; this viewpoint acknowledges the importance of external factors while still allowing for a sense of agency within the individual.

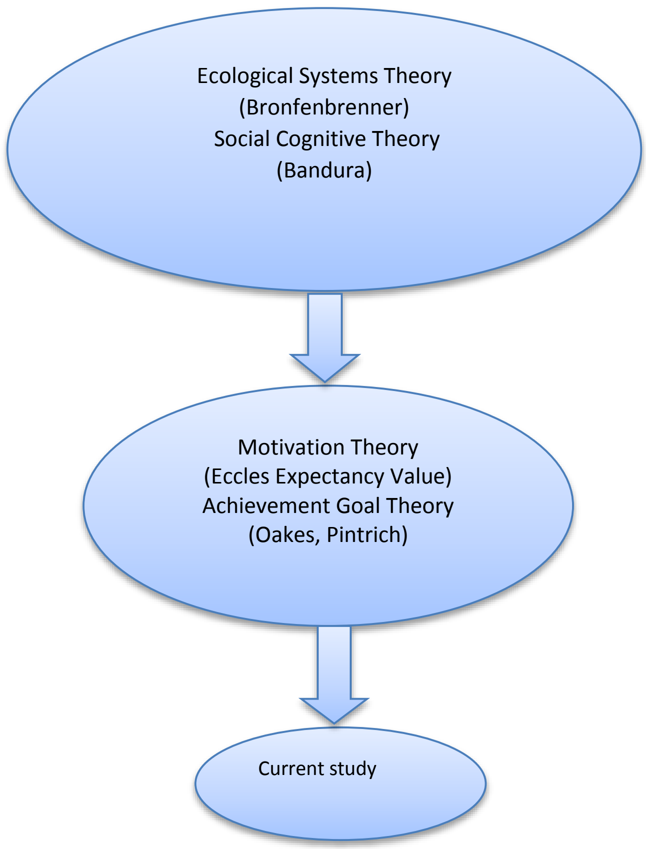
Self-efficacy has been widely established as a psychological antecedent to achievement and persistence (Pajares, 1997; Britner & Pajares, 2006; Chemers et al., 2011; Fouad & Smith, 1996; Graham et al., 2013; Mau, 2003) and thus should be considered as a potential means of improving student outcomes in science and other STEM related fields. For these reasons, this dissertation will explore the relationships between student science self-efficacy and a number of student, school, and teacher level variables. Drawing upon the ideas of social cognitive theory, science self-efficacy will be examined in relation to the personal factors within the student and the behavioral and environmental factors found within the context of the science classroom. Student level variables will include race, gender, and socioeconomic status in order to explore the ways that self-efficacy may be influenced by the demographic factors that characterize underrepresented groups in science. In addition, student self-beliefs and attitudes based on the expectancy-value framework of motivation theory discussed later in this section will be included as variables representing students' personal thoughts and beliefs about science. Teacher level variables will include the personal characteristics that the science teacher brings with them into the classroom, based on both demographics and qualifications, and the environmental factors such as teaching practices and teacher attitudes that need to be further explored in relation to student self-efficacy.

Bandura theorized four main sources of self-efficacy: mastery experiences, verbal persuasion, peer comparison, and physiological factors (Bandura 1977; Pajares, 1997). Mastery experiences occur when a student feels as if he or she has achieved a successful outcome. Verbal persuasion occurs through authentic encouragement that may be conveyed through the actions and attitudes of a teacher. Peer comparison occurs when a student compares him or herself to other individuals, often other students or peers but also others such as teachers. Physiological factors include the presence or absence of stress and anxiety; anxiety due to self-doubt will have a negative impact on self-efficacy. Independent variables representing these four possible sources of self-efficacy will be included in the design of this study.

Following the selection of variables based on the tenets of social cognitive theory, two additional theories can be used to give insight to the major domains of this study; student and teacher level variables. The expectancy value model of motivation theory developed by Jacquelynne Eccles and her colleagues asserts that achievement-related decisions depend upon a person's expectations for success and the values they assign to various options or behaviors (Eccles & Wigfield, 2002). Self-efficacy is defined as expectations for success; the remaining portion of the expectancy-value framework includes four components often referred to as subjective task value, or STV. These values include attainment value (the consistency of the task with the person's identity), utility value (the importance of the task in relation to future goals), intrinsic value (the level of interest in or enjoyment of the task), and cost perception (the perceived negative consequences of task-related decisions). There is a complex relationship between self-efficacy and the remaining four components of the expectancy-value model that works to influence students' achievement related choices; this study will examine the influence of the four STV components on student science self-efficacy in order to identify motivational factors that may be used to improve students' expectations for success in science.

Achievement goal theory, similar to motivation theory, considers the impact of the reasons a person has for completing a task on the performance of said task. These reasons, or goals, are often separated into two categories: performance oriented and mastery oriented (Pintrich 2000; Oakes, 1990). Mastery oriented goals refer to the desire to understand or master the task, for example, a student involved in a science inquiry activity may make decisions based on the goal of working to find a solution to a problem. Performance goals tend to focus on outperforming others, such as scoring the highest on a science exam. Although achievement goals can be formed internally, they can also be influenced by the ways that classroom activities are structured. Teachers may design practices that emphasize mastery or performance oriented goals, these practices can influence student performance on designated tasks. Achievement goals have the potential to influence the theorized sources of self-efficacy. For instance, mastery oriented goals can result in mastery experience when students experience success in accomplishing a task. Performance goals can encourage peer comparison and may also create anxiety for students who are trying to outperform others (or are feeling outperformed by their peers). This study will explore the influence of teaching practices on student self-efficacy in science in order to determine if practices aligned with varying achievement goals result in different levels of student self-efficacy.

Figure 1.1: Logic Model, Theoretical Logic



Literature Review

Science can often be an intimidating subject for students, yet student self-confidence in science courses is essential to their academic success. Self-efficacy, or one's expectations for success on a particular task, has been widely established as a psychological antecedent to academic achievement and persistence, as described above. However, the education community has yet to capitalize on this known precursor to success; thus far the research on self-efficacy has focused almost solely on individual characteristics as determinants of self-efficacy. A small but growing body of research on the role of noncognitive factors in student performance has examined the effects of small scale intervention strategies aimed at improving student self-efficacy (Farrington et al., 2012; Siegle & McCoach, 2007; Grant & Dweck, 2003), but the strength and direction of the relationship between teacher level variables and student self-efficacy has yet to be determined. While this dissertation will consider the impact of student characteristics on student science self-efficacy, it will expand the periphery of self-efficacy research by exploring teacher level variables as possible predictors of student expectations for success in science.

A great deal of research has examined the ways in which student demographics influence self-efficacy. Student race has been explored as a predictor of self-efficacy; findings indicate that in general, white students have higher levels of self-efficacy than their Black and Hispanic peers (O'Brien et al, 2010; Usher & Pajares, 2006; Gecas, 1989) Throughout the literature, socioeconomic status has also been proven to have an impact on self-efficacy both in general and at the academic level; this relationship has been firmly established as positive in nature (Han et al., 2015; Boardman & Robert, 2000; Battistich et al., 1995; Gecas, 1989).

In regards to student gender, males have generally been shown to have a greater sense of self-efficacy, both in general (Gecas, 1989), and in science. Even when controlling for performance, girls tend to be less confident in their abilities in science than their male peers (Sikora & Pokropek, 2012). However, one study did find that girls at the middle school level reported higher levels of science self-efficacy than did boys, this was theorized to be potentially due to the tendency of middle school science instruction to be more language based than in the higher grades (Britner & Pajares, 2006). It is important that the relationship between student gender and science self-efficacy be fully explored as girls continue to be underrepresented in scientific college majors and careers. This study will attempt to add clarity to the understanding of the impact of student gender on student science self-efficacy by using a nationally representative sample of students; in addition to analysis of the entire sample of students, data will analyzed for female and male students separately to determine any gender based differences in the factors that influence the development of student science self-efficacy.

Self-efficacy is often studied in combination with the other components of the expectancy-value model of motivation theory – identity, utility value, interest, and cost perception. While these constructs have been shown to be highly related, it is important that they be considered as separate elements in order to understand the ways that various motivational factors act upon one another (Pintrich, 2000). As social cognitive theory emphasizes the reciprocal nature of interactions between personal, behavioral, and environmental factors, it is important to consider the ways in which various motivational factors influence one another. It is hypothesized that self-efficacy both affects and is affected by students' subjective task value, this study will explore the dynamics of the latter portion of this interaction.

Despite the profusion of research on the development of self-efficacy and its influence on academic achievement and persistence, there is a dearth of research on the role of teachers in developing students' self-efficacy. Most of the existing literature on teacher effects focuses on achievement outcomes such as standardized test scores as a measure of instructional quality. Some researchers argue that this measure of teacher effectiveness is limited and that greater attention needs to be paid to outcomes such as students' affective and personal development (Goe et al., 2008). This dissertation will address this concern by looking beyond the typical "achievement only" view of teacher effectiveness in an exploration of the role that teachers may play in the development of student science self-efficacy.

Due to the limited amount of research on the relationship between student self-efficacy and teacher level variables, this dissertation will consider literature on teacher impact on student achievement and general performance in order to identify factors that may also contribute to student self-efficacy. A vast quantity of research has been devoted to the ways in which teachers impact student achievement; this literature can be divided into three main areas of concern: teacher characteristics, teaching practices, and teacher expectations and attitudes.

Teacher characteristics such as background, certification status and pathway, time teaching, and content area coursework, are often determinants of the dynamics of classroom interactions between students and teachers. These factors are ubiquitous in the political discourse on teacher quality and qualifications, and a robust body of literature has explored their impact on student achievement and persistence, with a variety of results. However, the impact of teacher characteristics on student self-efficacy has not received much attention, even more so in the particular domain of science education. This study seeks to explore the teacher characteristic variables that have often been linked to student achievement (Darling-Hammond & Youngs, 2002; Darling-Hammond et al., 2005; Goldhaber & Brewer, 2000; Eckert, 2012) in the context of their impact on student expectations for success in science.

Teachers' choices of instructional practices also have the potential to influence student teacher interactions and to create potential sources of self-efficacy, such as mastery experiences and peer comparison (Siegle & McCoach, 2007). For this reason, teaching practices such as the use of group work and the level of emphasis placed on various instructional objectives will be explored as they relate to the development of student science self-efficacy. Previous research has shown that teachers may utilize different instructional practices and emphasize different learning outcomes based on the demographics of their students (Oakes, 1990; Kumar & Hamer, 2013), if so, then the impact of varying teaching practices must be fully understood so that all students have the opportunity to develop confidence in their science abilities.

Teacher attitudes are also theorized to impact student self-efficacy; perceived caring and encouraging attitudes can improve students' expectations for success while perceived negative attitudes have the opposite effect (Pajares, 1997). However, the literature on teacher attitudes again has focused primarily on student achievement or persistence as an outcome. Previous studies have demonstrated that teacher attitudes and expectations vary depending on student background (Anyon, 1981; Tenenbaum & Ruck, 2007; Stronge et al., 2011; Kumar & Hamer, 2013), making the understanding of the relationship between perceived teacher attitudes and student science self-efficacy essential for improving the science confidence of diverse groups of students.

While the literature has demonstrated significant effects of teacher level variables on student achievement, the nature of the relationship between teachers and student self-efficacy remains to be understood. Teacher level factors that have been shown to improve student achievement will be included as variables in this study to determine if the nature of this relationship is also true for student science self-efficacy.

1.3 Methodology

This dissertation aims to explore the ways that student, school, and teacher level variables contribute to the development of student self-efficacy in science. For this purpose, data will be drawn from a national survey of high school students, their teachers, school administrators, school counselors, and parents. Ordinary least squares regression will be used to analyze the relationships between selected student, school, and teacher level variables and the dependent variable of student science self-efficacy.

Procedures

Data employed in the present study is drawn from the first wave of the High School Longitudinal Study of 2009 (HSLS:09) conducted by the National Center for Education Statistics (NCES). HSLS:09 (Ingels et al, 2011) is the fifth in a series of longitudinal studies that follows students through their secondary and postsecondary experiences and beyond. One distinguishing characteristic of this survey is its specific focus on STEM education, a feature that is greatly beneficial for the study of science education. The current study is cross sectional in nature as it will use only base year data in order to examine the impact of specific student and teacher variables on students' science self-efficacy in the context of a particular science course; however, the longitudinal design of the HSLS:09 survey allows for possible avenues of future research based on the results of this dissertation.

In the fall of 2009, over 21,000 ninth grade students from 944 schools completed electronic questionnaires which elicited information about their background/demographic characteristics, previous school experiences, current school experiences – with a specific focus on math and science, home experiences, and plans for postsecondary education and life after high school. Students also completed an online algebra assessment.

HSLS:09 school and student samples are nationally representative, with students considered to be the primary unit of analysis. In a two stage sampling process, 1,889 schools were first identified as eligible through random sampling, with a total of 944 schools eventually participating. Students were then randomly sampled from participating schools, with over 21,000 students completing the HSLS:09 questionnaire. Contextual information was also provided in the survey of parents, science and math teachers, school counselors, and school administrators, all of whom completed questionnaires due to their connection with the student. The use of a nationally representative sample of students will allow for results of this study to be generalized for the entire population of U.S. ninth grade students in 2009. Additionally, this dataset fills a void in self-efficacy research, which lacks studies focused on nationally representative samples of students.

Student science self-efficacy, which was included as a composite variable in the HSLS:09 survey, serves as the dependent variable in this study. Student responses to four questionnaire items were used to compose the self-efficacy variable; students were asked to rate how confident they felt that they could do an excellent job on tests in their science course, how certain they were that they could understand the most difficult material presented in the textbook used in their science course, how certain they were that they could master the skills being taught in their science course, and how confident they were that they could do an excellent job on assignments in their science course.

Numerous independent variables were selected based on the literature surrounding both self-efficacy and student achievement in science. Four domains of independent variables will be used in this study; student and school level variables, teacher characteristic variables, teaching practices variables, and teacher attitude variables.

Analysis of data in this dissertation will be conducted in three separate stages. Univariate analysis will first be used to provide descriptive statistics in order to characterize the study variables. Bivariate analysis will then be used to establish the relationships between the dependent variable of student science self-efficacy and each independent variable. Finally, Ordinary Least Squares (OLS) regression analysis will be used to determine the impact of student, school, and teacher level independent variables in predicting student science self-efficacy. A total of twelve regression models will be used. Model I will include student level variables such as demographics (student gender, race, and socioeconomic status) and science related attitudes (identity, utility value, interest, and cost perception) as well as school characteristic variables such as control and urbanicity. Model II will consist of teacher characteristic variables, including teacher race and gender, certification status, science coursework, and other purported measures of teacher quality. Model III will add teaching practice variables including the use of group work and the amount of emphasis placed on various instructional practices. Finally, Model IV will add the domain of perceived teacher attitudes. These four models will then be examined for female students only (Models V through VIII) and male students only (Models IX through XII) in order to uncover any gender based variances in the impact of the selected independent variables on student science self-efficacy.

This dissertation consists of six chapters. Chapter two will outline the literature that exists around self-efficacy and its role as a predictor of success in science. Chapter two will also describe the existing research surrounding student perceptions of teacher attitudes, teacher characteristics and effectiveness, and teaching practices. The use of the various theories in this study (bioecological systems, social cognitive, motivation, achievement goal) will be explained and linked to the dependent variable of self-efficacy. Chapter three will then outline the methodology involved in this dissertation, including a discussion of the HSLS:09 survey instrument, the dependent and independent variables, and the design of the four regression models. Following this discussion of methodology, Chapter four will present the statistical findings generated by the described methodology, specifically the impact of student, school, and teacher level variables on students' science self-efficacy. Chapter five will provide an in-depth discussion of the relevant findings presented in Chapter four and will relate them to the literature and theories discussed earlier in Chapter two. Finally, Chapter six will discuss the ways in which the results of this study may inform educators and policymakers on ways to support science achievement and persistence through the development of self-efficacy, as well as the limitations of the study and ideas for future research.

Chapter Two: Literature Review

Chapter One presented a synopsis of the current challenges with improving student achievement and persistence in science and STEM related fields, as well as the issue of lack of diversity in science education and career pathways. The initiatives that are currently in place to improve STEM education and diversify the STEM workforce were reviewed, including the focus on improving science teacher quality. In order to understand the reasons that certain groups of students are more likely to achieve and persist in science courses and career pathways, there is a need for research that goes beyond superficial measures of student achievement such as test scores and looks more closely at the known psychological antecedents to achievement, or the noncognitive factors that foster achievement, persistence, and resilience in academic subject areas. One of these factors, the construct of self-efficacy, is the focus of this dissertation. Section 2.2 of this chapter will explain in detail the theoretical framework that will be used both to situate this study within the science classroom and to consider the variables within and between science teachers and students that may contribute to the development of student science self-efficacy. Following the discussion of theory, Section 2.3 will delve into the volume of literature that has been developed surrounding self-efficacy, student and teacher characteristics, teaching practices, and teacher attitudes.

2.1 Theoretical Framework

This section will explain the four main theories that will be used as a framework for this dissertation. Bioecological systems theory will first situate the study within the science classroom, while at the same time taking into account the numerous contributing factors from outside the classroom that may affect students' expectations for success in science. The tenets of social cognitive theory will inform the variables chosen for this study, including the dependent variable of self-efficacy which emerged from social cognitive theory. Motivation theory will give insight into the ways that students' personal expectations and values interact to inform their achievement related decisions. Finally, achievement goal theory will be used to consider the effects that various teaching practices and attitudes surrounding their goals and expectations for students may have on students' science self-efficacy.

Situating the Study: Bioecological Systems Theory

Science self-efficacy does not develop only in the classroom or in any other isolated area in which a student experiences science; rather it should be viewed as a characteristic that is formed over time as a function of the various parts of a student's life. The various factors that contribute to the development of students' science self-efficacy can be understood through the lens of Urie Bronfenbrenner's bioecological model of human development, or bioecological systems theory (Bronfenbrenner, 2005). Rooted in developmental psychology, Bronfenbrenner's theory emphasizes the importance of considering the role of environmental contexts when examining human development, while at the same time acknowledging the significance of the person in their own development and the bidirectional nature of influence between the environment and individual development. The "mature" version of Bronfenbrenner's theory includes the *process-person-context-time* model, or PPCT, (Tudge et al., 2009). Interactions between these four components determine the course of development; they will be used to situate this study of student self-efficacy within the context and processes of the science classroom while simultaneously considering factors that already exist within the person, or student.

Bronfenbrenner's *process* refers to *proximal processes* or the "enduring forms of interaction in the immediate environment" (1997, p. 38). These processes occur on a regular basis and are a major influence on development. This study will examine the effect of proximal processes from within the science classroom on the development of student science self-efficacy. For example, teaching practices can set up interactions that occur regularly through the science activities that students participate in, as well as the social roles that students may adopt and the interpersonal relations that occur between a student and a teacher or a student and his or her peers in the science classroom. Teachers who use teaching practices that employ constructivist classroom activities – such as having students work in groups and participate in discussions, encouraging students to ask questions, and emphasizing inquiry and problem solving – may create different experiences for students than teachers who choose to use more traditional teaching practices. The choice of teaching practices can have an impact on students' expectations for success as each method has varying potential to provide the sources of self-efficacy such as mastery experiences, verbal persuasion, and peer comparison. The perceived attitudes of teachers towards their students can also influence recurring interactions through interpersonal relations and social roles within the science classroom, and may either support or delay the development of science self-efficacy through verbal persuasion and other means.

In the *person* component of the PPCT model, Bronfenbrenner discusses three types of personal characteristics that individuals bring into social situations; he terms these categories demand, resource and force characteristics (Tudge et al., 2009). Demand characteristics, or personal stimulus characteristics, are characteristics such as age, gender, or physical appearance which act as an immediate stimulus on other individuals and influence social interactions by the expectations that are formed around them. This study will examine the influence of demand characteristics on student science self-efficacy in a bidirectional relationship between the demographic variables of teachers and students. Student level demographic variables such as race and gender may influence teachers' practices and attitudes through the expectations that teachers have for students from different backgrounds. Conversely, teacher race and gender may influence students' expectations for success in the course.

The second category of personal characteristics Bronfenbrenner describes are resource characteristics, these are broken down into mental/emotional resources such as prior experience or skills, and social/material resources such as parental support or access to food and housing (Tudge et al., 2009). The effect of resource characteristics on student science self-efficacy will be considered in this study by the inclusion of students' socioeconomic status as an independent variable. Bronfenbrenner's third personal characteristic type is force characteristics, those characteristics having to do with an individual's temperament, motivation, and persistence (Tudge et al., 2009). The expectancy-value framework of motivation discussed later in this chapter introduces five student characteristics that fall within Bronfenbrenner's force characteristics category and which will be used as variables in this study. The first is students' expectations for success in science, or their science self-efficacy, which is the outcome measure to be explored in this study. The remaining student characteristics, which as a group are termed students' subjective task value or STV, include science identity, science utility value, science interest, and cost perception are all force characteristics that have been theorized to interact with and influence the development of self-efficacy; these characteristics will serve as independent variables in this study.

In referring to *context*, Bronfenbrenner (1997) proposes that cognitive development is influenced by five socially organized environmental subsystems, and that we need to understand the entire system in which development occurs in order to help support developmental growth. The focus of this study lies within the first level, or microsystem, in looking at interactions within the classroom. However, the complete set of Bronfenbrenner’s ecological systems can be used as a framework to help understand how teachers can aid in the development of students’ science self-efficacy despite other contributing factors that students bring from outside of the classroom setting.

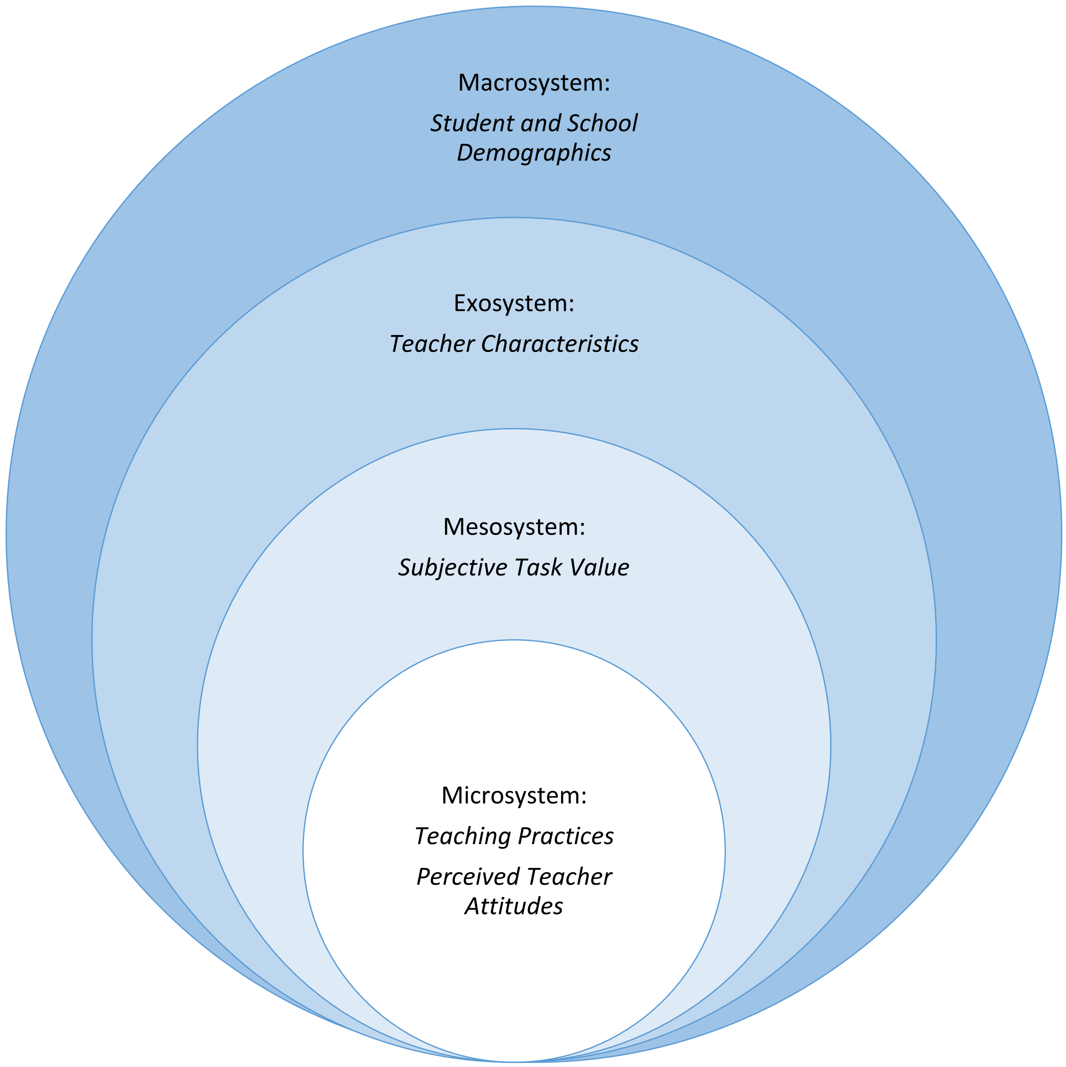
Bronfenbrenner’s first subsystem is the microsystem, which includes the immediate surroundings of an individual – in this case the student – and the “pattern of activities, social roles, and interpersonal relations experienced by the developing person in a given face-to-face setting” (1997, p.39) that influence increasingly complex interaction between the individual and the environment. Examples of microsystem settings include the family, the school, or a peer group. The science classroom is the microsystem in this study. The activities, social roles, and interpersonal relations that a student experiences in the context of the science classroom will be examined in order to determine the relationship between these factors and the development of students’ science self-efficacy. Teaching practices and teachers’ attitudes towards students can both influence the proximal processes of the science classroom. It should be noted that the interactions within the classroom microsystem are just that – bidirectional interactions, occurring *between* teachers and students, as opposed to a one-sided action of teacher upon student. Students, the subjects of this study, can maintain their own agency within Bronfenbrenner’s systems. In discussing the role of agency in social cognitive theory, Bandura states that personal agency functions within a system of sociostructural influences, students are not only the products but also the producers of their social systems (2001, p.1).

Bronfenbrenner’s second subsystem is the mesosystem – the area in which there are connections or relations between two of an individual’s microsystems. Students’ subjective task value, or STV, in science will be used in this study to represent the connections between a student’s various microsystems in regards to the values assigned to and expectancies for success in science. Subjective task value is made up of a student’s interest in science, the perceived usefulness of the material, the degree to which a student feels the course aligns with his or her identity, and the perceived “cost” of achievement in the course. It can be argued that these four factors – interest, utility, identity, and cost perception – are not only influenced by the experiences a student has within a science classroom, but rather by the ways in which a student encounters science in all of his or her microsystems. For example, familial attitudes towards science or the events that a family participates in may help to shape a student’s science identity. The perceived cost of higher achievement in science may be affected by interactions within a student’s peer network. The usefulness or utility value of science may be influenced by the family and neighborhood microsystems that can have an effect on a student’s plans for career and postsecondary education. The inclusion of subjective task value as a variable in this study will account for the factors in a student’s various microsystems that can affect the development of the student’s attitudes towards science.

The third subsystem is the exosystem. This is where there is a connection between two or more settings but the individual is not active in at least one area. In this study, students do not actively influence many of the characteristics that science teachers possess – such as coursework, certification, or training – but students can be directly affected by these characteristics. For example, the amount of science coursework that a science teacher has completed has been shown to have a positive impact on student achievement (Goldhaber & Brewer, 2000). Students have nothing to do with their teacher’s previous coursework but are directly affected by it. The interactions between the systems that contribute to science teacher characteristics and the microsystem of the science classroom will compose the exosystem through which the relationship between said characteristics and self-efficacy can be explored.

The fourth subsystem applicable to this study is the macrosystem. Bronfenbrenner describes the macrosystem as the “overarching pattern of micro-, meso- and exosystems of a given culture or subculture” (1997, p. 40) and notes that it includes factors such as cultural belief systems, bodies of knowledge, material resources, and pathways to opportunity. This subsystem is the most distal to a student’s everyday experiences but still has a great influence on development. In this study, student demographic variables such as race/ethnicity and socioeconomic status, and school demographics such as region, urbanicity, and control will make up the macrosystem that will be explored in terms of the development of students’ science self-efficacy.

Figure 2.1 Study variables situated within Bronfenbrenner's ecological systems



The final PPCT component is *time*; Bronfenbrenner and Morris (2006) argue that the study of development should consider what is occurring over three levels of time: micro (i.e. during discrete proximal processes), meso (i.e. recurring processes that across subsystems), and macro (i.e. the context of larger culture and society).

In a critique of the ways that Bronfenbrenner's theory has been applied, Tudge et al. (2009) advise that research using bioecological systems theory should include and test all elements of the PPCT model. Process, or proximal processes, should be incorporated by using an assessment such as a questionnaire of "the types of typical activities and interactions believed to be relevant for the study participants' developmental outcomes of interest" (Tudge et al., p. 202). In this study the developmental outcome of interest is that of student science self-efficacy. Proximal processes will be explored through classroom interactions that are both passive, such as those built upon demand characteristics of student and teacher demographic and active, such as teacher practices and attitudes. Tudge et al. advise that person or personal characteristics should be explored as well by including demand characteristics (such as student and teacher demographic variables), resource characteristics (such as student socioeconomic status or teacher qualification characteristics) and force characteristics (such as student subjective task values). Context should be included by examining the influence of more than one subsystem on the activities of interest. As explained above, the variables used in this study are judged to be representative of Bronfenbrenner's four subsystems; the purpose of this dissertation is to explore the impact of variables from each of these subsystems of the personal characteristic of self-efficacy. Finally, Tudge et al. recommend that a study should "take into account what is occurring, in the group being studied, at the current point of historical time" (p. 202). This is where the current study will connect to education policy. The inclusion of the teacher characteristics domain will explore the impact of variables that are either being used currently, or have been proposed to be used as measures of teacher quality. The use of a nationally representative sample will allow for the examination of the ways in which education policy decisions regarding teacher qualifications may impact student science self-efficacy.

Self-efficacy and Social Cognitive Theory

The essence of social cognitive theory is the idea that human knowledge is acquired through social interactions and experiences, particularly through the act of observing others. As opposed to other theories that attribute human behavior to either internal dispositions *or* external influences, social cognitive theory posits that both personal and environmental factors influence observed behavior in a *reciprocal triadic relationship* between personal, behavioral, and environmental factors (Bandura, 2011). For example, students' personal beliefs about their ability to succeed in science, the responses they receive from teachers after they perform a behavior in a science classroom, and the support and materials provided in the science classroom and school environment all act upon each other to influence students' knowledge acquisition (achievement) and behavioral choices (persistence) in science.

In the 1960's, Albert Bandura built on the work of other social cognitive theorists to introduce the concept of social learning. Through a series of experiments where children's behavioral decisions were monitored after observing an adult act aggressively towards a doll (the "bobo doll" experiments), Bandura demonstrated the value of modeling for learning new behaviors. The concept of learning occurring through social interactions, including modeling, rather than isolated within an individual, forms the basis for this dissertation. Rather than considering students or teachers alone, this study will explore the importance of the reciprocal relationships between students and teachers and the ways in which they may influence students' expectations for success in science, i.e. their science self-efficacy.

Originating in social cognitive theory, Bandura's concept of self-efficacy will serve as both a major theoretical framework and as the dependent variable in this study. Self-efficacy is defined as one's perceived capabilities for learning or performing actions at designated levels

(Bandura 1997). While cognitive in nature, self-efficacy is influenced by various personal, contextual, and social variables (Bandura 1997, Schunk & Meece 2006), making classroom interactions between teachers and students important factors to be examined in regards to their impact on students' self-efficacy. Self-efficacy has been shown to affect task choice, effort, persistence, and achievement (Bandura 1997, Schunk 1995) and to increase students' intrinsic interest in the material (Pajares, 1997).

Bandura pioneered the ideas of self-efficacy with his seminal work in the field of social cognitive theory. More recent studies have replicated Bandura's construct showing that the ideas surrounding self-efficacy, achievement, and persistence hold over time. In a critical review of research on the role of noncognitive factors in school performance, Farrington et al. (2012) include self-efficacy as part of a group of academic mindsets that have been shown to improve student motivation, persistence, and achievement.

Other studies have tested the ideas of self-efficacy in the particular domain of science. In the development of a STEM persistence framework, Graham et al. (2013) describe the "powerful influence of confidence" (i.e. self-efficacy) as a predictor of college students' persistence in science and other STEM related disciplines. Self-efficacy beliefs are domain specific (Schunk & Meece, 2006), therefore requiring the distinct focus on science self-efficacy in this study.

Motivation and Achievement Goal Theory

Motivation theory and achievement goal theory will both play a key role in developing the independent variables to be examined in this study. The motivation theory of interest in this study is the expectancy-value model first developed by Jacquelynne Eccles and her colleagues.

This theoretical framework states that a person's achievement-related decisions are based on two sets of beliefs: their expectations for success and the values assigned to the available options (Eccles & Wigfield, 2002). Self-efficacy makes up the expectations portion of the framework; the values portion, also described as subjective-task value (STV) consists of four parts: utility value (the importance of a task in relation to future goals), intrinsic value (interest in/enjoyment of the material), attainment value (consistency of the material with a person's identity), and cost perception (if the task takes away from other activities or has any other negative consequences) (Eccles, 2009). This study will use the expectations portion of the framework as the dependent variable and the values portion will be used in the exploration of students' STV in order to understand the relationship between students' values and expectations in science.

Unraveling the relationships between various student motivational factors will lead to a better understanding of student achievement in science and other academic fields. According to Lee and Brophy (1996), students who are motivated to learn are more likely to employ cognitive and metacognitive learning strategies that can lead to a deeper understanding of the learning goals, while students who lack motivation will either fail to complete tasks or will only complete them out of a sense of obligation, resulting in a more shallow understanding of course content. While the current study does not include student achievement as a variable, the interrogation of the relationship between self-efficacy and other student motivational factors will provide important insight into student motivation in high school science.

Achievement goal theory refers to the reasons a person – in this study a student – has for completing a task, and generally separates these goals into "performance oriented" or "mastery oriented" categories (Pintrich, 2000, Oakes 1990). Mastery oriented goals emphasize the effort and strategies that lead to task completion, such as the tactics that a cooperative group may come up with when trying to solve a science-related problem. Performance-oriented goals emphasize performing better than others, such as a student aiming to get the highest grade on a class exam. Achievement goals have been shown to be linked to a number of outcomes, including self-efficacy, and to overlap with many of the concepts discussed in motivation theory (Pintrich, 2000). Although much research focuses on goals as originating from within the individual, they may also be imposed or suggested by others who interact with the individual, as is the case with teachers and students.

Goals and motivation constructs such as self-efficacy and the four components of subjective task value have demonstrated consistent relationships; some in the research community have questioned whether it is useful to consider these concepts separately (Pintrich, 2000). As Pintrich explains, they can and should be used as independent variables in order to understand the motivational dynamics that operate on student achievement. Furthermore, there may be important differences in the ways in which individual students are motivated to achieve. For these reasons, this study will treat each of the four subjective task value components as separate factors that may influence student science self-efficacy.

This dissertation will utilize achievement goal theory in two ways. First, students' goal achievement mindset will be explored by examining the pattern of beliefs that students have about the specific target of science achievement, including their expectations for success (science self-efficacy), personal identification with the subject of science (science identity), perceived purpose or usefulness of science (science utility value), interest in the subject (science interest or intrinsic value), and beliefs about the potential negative consequences of achievement (science cost perception). This study will also interrogate the ways in which the instructional goals set for students by their science teachers through emphasis placed on various instructional practices may impact students' science self-efficacy.

2.2 Literature Review

Since Bandura's introduction of the concept of self-efficacy, a wealth of studies have been conducted in the fields of psychology and education in order to explore the factors that contribute to self-efficacy and the ways in which these factors may improve student achievement in general and in specific academic fields such as science. Most of this research has focused on either student-level variables or general behaviors theorized to be sources of self-efficacy; however, there is a dearth of literature exploring the direct impact of teachers on student self-efficacy in science. While an array of existing research has interrogated the ways in which teacher variables such as characteristics, practices, and attitudes influence student achievement and persistence in science and STEM related fields, the influence of teachers on student science self-efficacy has been relatively underexamined. The remainder of this chapter will describe in detail the major scholarship that will be used to inform the design of this dissertation, and will attempt to draw connections between the psychological research on self-efficacy and the educational research on factors influencing student achievement.

Student Science Self-Efficacy

The concept of self-efficacy, first introduced by Bandura in 1977, received a great deal of attention in the psycho-social research of the late twentieth century (Bandura, 1977, 1986 & 1997; Lent et al., 1986; Schunk, 1995; Zimmerman et al., 1992). This led to a profusion of research in education that firmly established self-efficacy as a predictor of students' effort, persistence, and resilience in various academic areas including the domain of science (Pajares, 1997; Britner & Pajares, 2006; Chemers et a., 2011; Fouad & Smith, 1996; Graham et al., 2013; Mau, 2003).

Recently, self-efficacy has been discussed as part of what some researchers are referring to as “noncognitive factors”; that is, the skills, behaviors, strategies, and attitudes that are essential to academic performance but may not directly be reflected in course grades or on cognitive tests (Farrington et al., 2012). Much of this research has focused on small scale intervention strategies aimed at improving self-efficacy or other academic mindsets (Farrington et al., 2012; Siegle & McCoach, 2007, Grant & Dweck, 2003); however, a need remains for the exploration of the broad range of student and teacher characteristics that may contribute to the development of student self-efficacy.

In order to identify the ways in which students and teachers may impact students’ science self-efficacy, we first need to understand the multiple pathways through which self-efficacy is developed. One source is mastery experience – outcomes deemed successful will boost students’ self-efficacy, while outcomes interpreted as failures will cause a decrease in students’ self-efficacy (Pajares, 1997). Perceived task difficulty influences mastery experience - if a task is considered too easy, success will not have a positive impact on self-efficacy. This demonstrates the balance that teachers must find in developing tasks that are at an appropriate level for students while also employing instructional practices that allow students to experience success. An implication of self-efficacy in learning environments is that educators “must facilitate optimism in students while ensuring that they have the skills to be successful” (Schunk & Meece, 2006, p.76).

Another source of self-efficacy is verbal persuasion. Although weaker than mastery experience in its effect on self-efficacy, verbal persuasion such as words of encouragement is a simple way for teachers to develop students' confidence in science. One caution is that the persuasion must be authentic – students will not benefit and may in fact be harmed if they perceive the persuasion as "empty praise" or "condescending encouragement" (Pajares, 1997). It has also been shown that it is easier to weaken self-efficacy through negative discourse than it is to strengthen it through positive discourse. This is a reminder to teachers to find ways to help students believe in their own capabilities while working to help them develop the skills they need to master the material, and a caution against using negative, discouraging, or deficit-centered language in the classroom. A concern raised by Eccles (2009) is that negative stereotypes surrounding race/ethnicity, gender, and social class can lead teachers to communicate low expectations to students in their daily interactions. This negative discourse may have a profound effect of student expectations for success and needs to be identified in the classroom. The inclusion of student perceptions of teacher attitudes as a variable in this study will help to examine the impact of perceived negative and positive discourse on students' science self-efficacy.

Peer comparison is another source of self-efficacy. Also referred to as a type of vicarious experience, the social comparisons that students make between themselves and other individuals, including peers, can have an impact on their self-efficacy beliefs (Pajares, 1997). Teachers can create situations within the classroom that can set up peer comparisons – either negative or positive – between students. One example is having students work in cooperative groups and how these groups are arranged. Another example is perceived teacher attitudes regarding how successful they think students can be, or how fairly they treat students. The relationship between self-efficacy and the instructional practices and teacher attitudes such as the ones just mentioned will be explored in this study due to their potential for providing peer comparisons and other sources of self-efficacy.

One final source of self-efficacy is an individual’s interpretation of physiological factors, such as stress or anxiety. If an individual believes they are anxious about completing a specific task because they doubt their ability, their self-efficacy will suffer. If anxiety is considered to be a more normal and commonplace occurrence, the individual’s self-efficacy will be less likely to suffer. This reaction can be mediated by the actions of teachers; for example, if students are led to believe that mistakes are part of the learning process, their anxiety may be reduced and they may be more likely to persist after making errors. Although student physiological states are not included due to the nature of the dataset used in this study, teacher attitudes that may reduce student anxiety and stress will be included as variables to consider in relation to the development of student science self-efficacy.

It is important to consider self-efficacy in high school students, as this time in adolescence is usually associated with a decline in self-competence beliefs (Jacobs et al., 2002). As students transition into high school, they are confronted with a new set of peers to compare themselves against, and are more strongly influenced by stereotypes regarding the capabilities of different groups, such as the idea that girls, non-Asian minorities, and students of low socioeconomic status are less capable at science (Meece & Scantlebury, 2006). Students in school transition periods such as the beginning of high school may also be vulnerable to a “recursive effect” in relation to their self-efficacy (Farrington et al, 2012). Students are likely to enter high school feeling unsure of themselves; if teacher attitudes or behaviors reinforce feelings of self-doubt, students will enter into a negative feedback loop that will further discourage their self-efficacy beliefs. However, if teachers are able to create authentic experiences that enable students to feel successful, there may be a decline in the self-doubt associated with the ninth grade transition. This indicates the essential need for an understanding of how teachers may foster the development of self-efficacy in ninth grade students.

Student and School Level Variables

In light of the underrepresentation of Black, Latino, female, and economically disadvantaged students in science, it is important to understand how student expectations and values interact and how they may differ based on race, gender, and social class in order to develop ways to support success in science for students from all groups. A number of studies have explored the relationship between students' race/ethnicity and their self-efficacy and have found that white students generally have a greater sense of self-efficacy that their Black and Latino counterparts. Gecas (1989) theorizes that this is due to the responsiveness of self-efficacy to social structural influences such as racial discrimination and the inequalities in power, control, and access to resources experienced by students. Self-efficacy is also significantly influenced by culture, perhaps even more so than race (Gecas, 1989). Student race and ethnicity will be included as student demographic variables in this study in order to determine the relationship between these demographic variables and science self-efficacy.

Researchers have also examined the relationship between students' social class and self-efficacy. In general, socioeconomic status has been found to have a significant positive impact on self-efficacy. In a survey of over five hundred high school students in Beijing, Han et al. (2015) found family socioeconomic status to be a significant predictor of student self-efficacy. In the United States, both individual and neighborhood socioeconomic status have been linked to self-efficacy. Boardman and Robert (2000) used a nationally representative panel survey of Americans aged twenty five and above (the Americans' Changing Lives Survey, or ACL) to examine the “neighborhood effect” of socioeconomic status on general self-efficacy. Findings indicated that when controlling for age, race, and gender, both individual and neighborhood level socioeconomic status are positive predictors of self-efficacy, and in some cases, the effects of neighborhood SES are even more powerful than that of individual SES. While this research demonstrates the impact of socioeconomic status on generalized self-efficacy, fewer studies have examined the effects of socioeconomic status on self-efficacy at the individual level for adolescents, especially for the domain of science. Some work has explored the influence of schools on students’ self-efficacy. Interestingly, Battistich et al. (1995) found that although poverty has a negative impact on self-efficacy, this effect can potentially be mediated if a school creates a “caring, supportive, and responsive community (p. 649). The relationship between students’ socioeconomic status and science self-efficacy will be examined in this study.

The relationship between students’ gender and science self-efficacy is important considering the striking underrepresentation of women in studying science and other STEM related fields at both the undergraduate level and graduate levels, as well as in pursuing science and STEM careers (National Science Foundation, 2011). Although previous studies have examined the impact of students’ gender on their self-efficacy, the research is not as robust as that surrounding the relationship between self-efficacy and the demographic variables of race and socioeconomic status. The need remains for a greater understanding of the factors that can support the development of science self-efficacy for female students.

In general, researchers have found that males tend to have a greater sense of self-efficacy than do females (Gecas, 1989). In the context of science, studies have found girls to be less confident in their knowledge of the material, despite controlling for performance. Sikora and Pokropek (2012) used the Program for International Student Assessment (PISA) 2006 surveys to analyze the science career plans of adolescents in over fifty countries and found that almost everywhere, boys were more confident in their science abilities, even when accounting for science performance. In contrast, some studies have found that in certain situations girls may have a greater sense of self-efficacy in science. As part of a study exploring the theorized sources of science self-efficacy in middle school students, Britner and Pajares (2006) found that girls actually reported higher science self-efficacy than did boys; the authors theorized that this may be due to the tendency for middle school science to be more language-based than high school science courses. Despite the discrepancies in whose self-efficacy is higher, there is an agreement across the board that there is a significant difference between male and female students in regards to science self-efficacy and the variables that influence it (mastery, persuasion, and vicarious experiences). This study will explore the variance in the factors affecting science self-efficacy by student gender in order to clarify how confidence in science performance may differ for males and females in high school, and also how students may be impacted differently by teacher characteristics, attitudes, and practices.

Self-efficacy is domain-specific, requiring the focus on science self-efficacy in this study. However, science itself is still a fairly broad domain. Science education researchers have argued that in order to gain a deeper understanding of student attitudes and motivation in science, data must be disaggregated by science discipline. Britner (2008) explored the impact of different science courses on student self-efficacy, by examining gender variation in each of the three main branches of science (life, physical, Earth/environmental). Using a sample of high school students ($n = 502$) enrolled in either a life science course, a physical science course, or an Earth/environmental science course, Britner observed gender differences in science course grades, science self-efficacy, and Bandura’s hypothesized sources of self-efficacy (mastery experience, social persuasion, vicarious experiences, and physiological states) based on the type of science course a student was enrolled in. As a brief summary of Britner's findings, girls had higher grades than boys in Earth/environmental and life science courses; there was no significant gender difference in grades in physical science courses. Girls reported higher levels of self-efficacy than boys if enrolled in Earth/environmental science; there was no significant gender difference in science self-efficacy in life or physical science. Girls also reported higher levels of anxiety in life and physical science courses. This study will include student science course enrollment as an independent variable in order to explore how science self-efficacy may differ for male and female 9th graders depending on the branch of science they are studying.

Self-efficacy is only one part of the expectancy-value framework used in this study. The other components of the framework, or the "values" portion, are thought to act in combination with self-efficacy to influence students' educational decisions. The four values that students may use to make academic decisions are often termed their subjective task value (STV), and include: utility value – how useful students think the material is in relation to their future goals; intrinsic value – students' enjoyment of the material; attainment value – based on the consistency of the subject matter with students' identities; and cost perception – the value that students assign to perceived "costs", such as time taken away from other activities or negative responses of peers (Andersen & Ward, 2014).

A plethora of previous work has used the expectancy value model as a framework for examining student achievement in science and STEM education (Simpkins, Davis-Kean, & Eccles, 2006; Mau, 2003; Fouad & Smith, 1996) and has shown self-efficacy, or the expectations side of the framework, to be a significant predictor of student engagement, persistence, and resilience in science coursework. However, these studies have not utilized a nationally representative sample of high school students, and have not done much to examine the differences in expectancies and values for students from diverse backgrounds. Additionally, self-efficacy is most often included as an input variable rather than an output variable. Although Andersen and Ward (2014) did use the HSLS survey – a nationally representative sample – to examine the relationships between the expectancy-value model variables and student science persistence plans, they only used a small subsample as they looked at high achieving students only, which leaves out 90% of the student population. Their findings indicate that self-efficacy and the STV variables have different levels of impact on persistence plans for Black, White, and Latino students. An understanding of how the expectancy value variables interact in the entire student population is still necessary, and the relationship between these variables must also be examined for the various groups that have been historically underrepresented in science. In addition, the relationship between the values themselves and self-efficacy has not been fully explored. This study will use self-efficacy, rather than achievement, as the outcome variable in order to explore the relationship between students' subjective task values in science and their expectations in science.

Teacher Characteristics

The link between student achievement and teacher characteristics is not a new concept in the field of education. In recent history, teacher characteristics such as training, coursework, and certification status have come under scrutiny due to the federal mandate that all students must have "highly qualified teachers" (Darling-Hammond & Youngs, 2002). Recent policy on teacher evaluation practices measures student achievement primarily in terms of standardized test scores; however, many would argue that this measure puts an extreme limitation on the definition of teacher effectiveness. In a research synthesis of 120 research and policy documents, Goe et al.

(2008) describe the constraints of an “achievement only” definition of teacher effectiveness, stating that improving outcomes such as students’ affective and personal development must also be a goal of good teaching. Following the analysis of ideas on teacher quality from research and policy documents, Goe et al. composed a five point definition of effective teachers, the second point of which states “Effective teachers contribute to positive academic, attitudinal, and social outcomes for students such as regular attendance, on-time promotion to the next grade, on-time graduation, *self-efficacy*, and cooperative behavior.” (p. 8, emphasis added). The authors go on to say that there is a relative dearth of research on teacher effectiveness in areas outside of academic achievement, and describe a need for measurement of teachers’ contributions to nonacademic outcomes (such as self-efficacy).

Teacher characteristics such as certification status, subject area coursework, and years teaching have been shown to impact student achievement (Darling-Hammond et al., 2005; Goldhaber & Brewer, 2000; Eckert, 2012) and have been major players in the policy discourse on teacher quality. Most of the existing literature surrounding these characteristics examines them in relation to student achievement. As noted, there is a lack of research on and the need for a greater understanding of the ways in which teachers contribute to students’ affective, nonacademic outcomes, such as self-efficacy. The remainder of this section will discuss the small body of research that exists regarding the ways that various teacher characteristics may affect the development of student self-efficacy. However, most of the literature discussed surrounds teacher characteristics impact on student achievement; connections will be made to self-efficacy research in order to hypothesize the ways in which these characteristics may impact the construct of student science self-efficacy.

Teacher certification is one major characteristic that has been the focus of research on teacher effectiveness, both in terms of certification status and pathway to certification. Darling-Hammond et al. (2005) used a sample of over four thousand fourth and fifth grade teachers in Texas to compare the impact of certified versus noncertified teachers on student standardized test scores. Noncertified teachers were found to have negative effects on student test scores across six standardized exams. Teachers who had entered the profession through an alternative certification pathway (Teach for America) were also found to have a negative impact on student achievement; however, this effect disappeared if alternatively certified teachers had gone on to acquire regular certification status.

Content area coursework is another variable of interest in determining predictors of teacher effectiveness, especially in the STEM disciplines of mathematics and science. In a review of data from the National Education Longitudinal Study of 1988 (NELS:88), a predecessor to the survey used in this study, Goldhaber and Brewer (2000) found that subject-specific training in math and science had a significant positive impact on student achievement in high school STEM courses. Likewise, Monk (1994) used another longitudinal study – the Longitudinal Survey of American Youth – to examine the impact of teacher math and science coursework on student achievement. Teacher subject area coursework was found to have a significant positive effect on student achievement in math and science, as measured by achievement test scores. While these studies indicate that teachers' science coursework has a positive impact on student achievement in science, it is still necessary to understand how this training may contribute to the development of students' science self-efficacy, a psychological antecedent of achievement, thus the need for its inclusion as a teacher characteristic variable in this study.

Time teaching has also been shown to have an extent of positive impact on student achievement. In a review of over 230,000 fourth through eighth grade student records from a large urban school district, Hanushek et al. (2005) found that teacher experience had a positive impact on student achievement on the Texas Assessment of Academic Skills (TAAS). However, this effect was only significant for the first few years of teaching, indicating that there may be some sort of plateau for the impact of teaching experience on student achievement. Likewise, Rivkin et al. (2005) used TAAS reading and mathematics scores for third through seventh graders to examine the effects of teacher experience on student achievement gains. Findings again indicated that experience matters in the first few years of teaching; teacher experience showed to have a significant effect on student achievement but only in the first three years of teaching. The current study will attempt to determine if these findings hold true for student self-efficacy in addition to achievement.

Two demographic variables will also be considered as teacher characteristics – science teacher gender and science teacher race. In regards to self-efficacy, Schunk (1999) discusses the importance of modeling in social cognitive theories of learning. Models demonstrate the functional value of behavior and motivate the learner, or observer, to act in ways that they believe will result in positive outcomes. According to Schunk, when a model experiences success, observers experience an increase in self-efficacy and task motivation because they perceive that they too can be successful. Alternately, when a model struggles with a challenge, observers may experience a decline in their own self-efficacy and motivation. Perceived similarity between the model and the observer is important for both motivation and self-efficacy; the more alike an observer is to a model, the greater the chances of completing the modeled task and of self-efficacy formation (Schunk, 1999). At least two sources of modeling can be found in the classroom – students can learn through observing the behavior of their teacher and that of their peers.

Dee (2005) describes "passive" teacher effects as those that can be triggered by teacher characteristics such as race, ethnicity, or gender. An example is what Dee calls the "role model" effect; he theorizes that the mere presence of teachers who are demographically similar to students will improve the academic motivation and expectations of the students with whom they share characteristics. Dee used a nationally representative dataset, the National Education Longitudinal Study of 1988 (NELS:88), to explore the influence of teacher-student demographic matches on teachers' subjective evaluations of student behavior and performance (i.e. whether the student was seen as frequently disruptive, consistently inattentive, or rarely completed homework. Dee found that demographic differences between teacher and student significantly increased the likelihood of the teacher having negative perceptions of the student. This was true for both racial and gender differences. Furthermore, students who were viewed negatively by teachers performed significantly lower on subject tests, were less likely to take Advanced Placement courses, and more likely to drop out than students who were not viewed negatively. Dee's work indicates that racial and gender differences between students and teachers have a significant effect on teacher perceptions of student performance which can have negative consequences in the academic careers of students who do not match the demographic characteristics of their teachers. The underrepresentation of female students in science is one of the issues that drives this dissertation; the impact of science teacher gender on student self-efficacy will be explored across the entire sample of students and then for male and female students separately to determine if a role model effect exists for the science self-efficacy of ninth grade students.

Teaching Practices

Previous research has also shown that teaching practices such as setting instructional goals play a key role in student engagement and achievement in science and other STEM related fields (Oakes 1990); however, teachers may set different instructional goals for their students based on stereotypes surrounding students' race/ethnicity, gender, and socioeconomic status. In a study of 784 preservice teachers, Kumar and Hamer (2013) found that 25% of the teachers had some kind of stereotypic beliefs about low income and minority students and expressed some level of discomfort with student diversity. While multicultural education coursework mediated some of these biases, they did not completely disappear and some returned by the end of the preservice program. Furthermore, more open minded teachers were found to be more likely to focus on mastery based al practices involving critical thinking, understanding, and reflection, while less open minded teachers were found to be more likely to focus on performance based instructional practices involving memorization and the learning of basic skills. Such a large percentage of teachers expressing prejudice towards potential students is alarming, and the fact that teaching practices are influenced by the teachers' biases demonstrates one subtle way that prejudices can play out in the classroom. In examining the impact of a range of teaching practices on students' science self-efficacy, this study will help teachers identify best practices for their students; splitting the data by gender may help to reveal differences in the ways that various teaching practices affect the self-efficacy of male and female students.

In a study exploring the link between teaching practices and student academic performance, Wenglinsky (2002) found that the effects of teaching practices, when combined with other teacher characteristics, were as significant as the effects of student background variables. Using the National Assessment of Educational Progress (NAEP) scores of 7,146 eighth grade students, Wenglinsky examined the impact of "active" teaching practices such as hands-on learning and the use of higher-order thinking skills, and found a significant relationship between these practices and student achievement when controlling for students' socioeconomic status. This demonstrates that teachers and the practices they choose to implement in their classrooms are important variables to be considered in relation to student achievement; however, it should not be ignored that there are external variables that are just as strong as the "teacher effect". One limitation of Wenglinsky's study is that it does not take into account teacher distribution patterns. Although all students were shown to benefit from "active" teachers, the question remains of how these teachers are distributed among the nation's schools.

This study does not deny the fact that a multitude of inequities exist both inside and outside of the classroom, and that these issues that must be addressed in order to improve the state of science education for all students, especially those from underrepresented groups. In addition, there is no desire to take away from the autonomy and agency of students by overemphasizing the focus on the influence of teachers and students. Bandura writes of the agentic perspective of social cognitive theory, asserting that "personal agency operates within a broad network of sociostructural influences" (2001, p.1). The goal of this dissertation is to identify any practical ways that teachers and teacher education programs can assist in the development of students' expectations for success in order to help them achieve and persist in science fields.

Previous research indicates that teachers and the practices they use in their classrooms can have a significant impact on student achievement, but is this also true for the development of student self-efficacy? The instructional practices that science teachers utilize and emphasize in their classrooms form a part of the social interactions that may contribute to the development of students' self-efficacy. Siegle and McCoach (2007) examined the effects of teaching practices designed to aid in the development of self-efficacy of fifth grade mathematics students. Mathematics teachers participated in a staff development training session on instructional practices that have been theorized to increase student self-efficacy, such as goal-setting, providing appropriate feedback, and modeling. At the end of a four week math unit, researchers found that teachers who effectively used the sources of self-efficacy (verbal persuasion, past performance, peer comparison) in their instructional practices were able to have a significant positive impact on students' levels of math self-efficacy. This indicates that teaching practices have the potential to aid in the development of student confidence; it remains to be understood how teaching practices specific to the science classroom can impact student self-efficacy in science. This study will examine teaching practices – such as the use of group work or inquiry based strategies – that employ various self-efficacy sources in order to understand how they may contribute to the development of students' science self-efficacy.

How often students work in groups in their science classrooms, and how these groups are organized, can set up social processes that may impact the formation of students' self-efficacy. The social construction of ideas in groups through discussion and problem solving can be a source of peer comparison and can provide students with mastery experience. In addition, the ways that groups are organized (i.e. homogeneous vs. heterogeneous grouping) can create either positive or negative comparisons between students.

Tobin (2001), in describing his experiences teaching science in an urban U.S. high school, writes of the importance of collaboration in the classroom in developing student agency, both at the individual and the collective level. He suggests suspending the emphasis on individual performance and competition seen in so many schools as a results of accountability measures brought about by reform efforts. Instead, collaboration and student choice, as in his teaching experience, have the potential to create a more positive classroom environment, a community of respect between teachers and educators, and greater student perseverance on learning activities. The current study will add to the understanding of the classroom effects of collaboration and cooperative learning on students by exploring the relationship between group work and student science self-efficacy.

The dynamics of group work have also been shown to differ by gender. Although girls have been shown in general to prefer classrooms involving group work, the impact of cooperative learning may differ based on academic subject. Kahle et al. (1993) reviewed data from two cross-cultural studies conducted in science classrooms in Australia and the United States, wherein science teachers were observed after participating in intervention workshops aimed at improving teaching strategies. A pattern of gender differences in group work emerged, showing the tendency of boys in science classes to "take over" the group, dominating the direction of the group, discussion, and the use of equipment. This inequity was only addressed by teachers in half of the classrooms in the immediate observation, and was not corrected at all in follow up observations. The authors concluded that all observed classes had organizational structures that disadvantaged girls when it came to group work experiences. For these reasons, the role of group work in the formation of science self-efficacy and the differences that group work and other teaching practices may have for students based on gender will be examined in this study.

Inquiry-based teaching is a practice that has been linked to improved student achievement in science. In a lab-based study of high school students, Wilson et al. (2010) compared students in inquiry based classes to those in more "commonplace instruction" classrooms, and found that the students in the inquiry classes showed significantly higher levels of achievement both immediately after the study and four weeks afterwards. In addition, there was an observed racial achievement gap in the commonplace classroom but not in the inquiry classroom. These findings indicate that inquiry based teaching practices have a significant positive impact on student science achievement; this study will determine if this relationship is the same for inquiry based teaching practices and student science self-efficacy.

Teacher Attitudes

Teacher characteristics go beyond what is measured by certification status and training history; teachers' perceptions of students and personal beliefs can influence their attitudes towards students and the ways in which teachers and students interact in the classroom. Previous work has shown that teacher expectations of students can differ based on students' race/ethnicity, gender, and social class. In an influential study of teachers working in schools serving students from various classes, Anyon (1981) discovered that the expectations that teachers held for students differed by school and influenced both the "curricula and curricula-in-use" in classrooms (p. 31). Anyon discusses the observed social stratification of knowledge in the schools studied, and the ways in which teacher expectations and practices may contribute to the reproduction of social structures. This work can be applied in the examination of the challenges currently facing STEM education. Social structures to this point have resulted in the consistent underrepresentation of specific groups in STEM fields (Blacks, Latinos, females, and students of lower socioeconomic status); it is important to examine the ways in which science educators may act, either passively or actively, to reinforce the inequities that currently exist for underrepresented groups in science.

In describing their philosophy of preparing teachers to meet the needs of an increasingly diverse student population, Villegas and Lucas (2002) write that one of the essential characteristics of culturally responsive teachers is that they “have affirming views of students from diverse backgrounds, seeing resources for learning in all students rather than viewing differences as problems to be solved” (p. xiv). Teachers who exhibit “affirming attitudes” believe that all students are capable of learning. The belief that all students can be successful is essential considering the challenges that students face in schools and classrooms and the many sources of self-doubt that can eventually lead to a student’s giving up on a particular class, or on school altogether. Furthermore, it can be assumed that students are more likely to develop positive relationships with teachers who they perceive to have affirming or positive attitudes. Previous research has shown that positive relationships between teachers and students can have a significant impact on student achievement. In a study examining the classroom practices of effective versus ineffective teachers, Stronge et al. (2011) first used student test gains to identify the most effective and least effective teachers from a sample of 307 fifth grade teachers, then independent observers used the Teacher Effectiveness Rating Form developed by the authors to compare classroom practices of the top and bottom quartile of teachers. Results showed that one of the few classroom practices affecting student achievement on reading and math tests was the relationship between the teacher and his or her students, indicating the importance of positive classroom interactions between teachers and students.

Previous research has examined the effects on students of teacher caring (Nodding, 1992; Noblit, 1993). Parsons (2001) observed how a teacher’s caring attitude was able to mediate white male privilege, equality, and equity in a diverse, urban fourth grade classroom. The teacher in Parsons’ study aimed to create success for all students, and through balancing her caring attitude with her power as a teacher was able to communicate this goal to students and create a classroom environment that supported equitable learning. Similar to Parsons' research, the perceived teacher attitudes analyzed in the current study include beliefs that all students can be successful and should be treated fairly.

In relation to the construct of self-efficacy, teachers who display affirming attitudes have the potential to provide students with the experiences they need to develop strong expectations for success. Student perceptions of teacher attitudes can impact students' self-efficacy: perceived positive and encouraging attitudes can increase self-efficacy while perceived negative attitudes have the opposite effect (Pajares, 1997). This indicates that teacher attitudes that convey that they respect and value students, and think that all students are capable of learning will positively impact student self-efficacy. Perceived expectations, such as whether or not a teacher thinks all students are capable of learning the material, have been shown to be a significant predictor of student self-efficacy. In a study of the effects of perceived teacher expectations on self-efficacy and engagement of middle school students, Tyler & Boelter (2008) found that student-reported perceptions of teacher expectations significantly predicted their reported levels of self-efficacy. This dissertation will examine the relationship between perceived teacher attitudes (such as valuing and respecting students, treating students fairly, and thinking all students can learn) and students' science self-efficacy, with the hypothesis that perceived positive, or "affirming", science teacher attitudes will have a positive impact on students' beliefs that they can be successful in their science class.

Teacher attitudes, expectations, and personal beliefs have been shown to affect student expectations for success. These values must be considered in relation to teacher quality, but are not measured by teacher qualification standards due to their subjective nature. In attempting to explore the effects of teacher attitudes on student achievement and the noncognitive factors that lead to achievement, such as self-efficacy, it is essential to consider how such attitudes are being measured. While many studies have relied on self-reporting of teacher attitudes, this dissertation will instead use student perceptions of teacher attitudes.

2.3 Contribution to the Field

This study will examine the ways that science teachers may influence students' science self-efficacy through their instructional practices, their perceived attitudes towards students, and other characteristics. In addition, student background characteristics and subjective task value will be considered in order to understand what students are already bringing into the classroom that may impact their science self-efficacy. By focusing primarily on factors that involve everyday classroom interactions between teachers and students, this study will help to determine practical changes that may be made in science classrooms in order to increase students' confidence in learning and doing science. These findings will be particularly useful to teacher educators and policymakers concerned with advancing student performance in science.

This study will distinguish itself from previous work by looking beyond the traditional measures of achievement (such as course grades, standardized test scores, and courses completed) and measures of teacher quality (such as certification status and scientific coursework) and instead focusing on the interactions that happen between teachers and students within science classrooms and the development of scientific self-efficacy as a measure of success. Findings will also fill a gap that exists in self-efficacy research by using nationally representative data to examine variations in the development of science self-efficacy based on students' gender and how these differences can be mediated through classroom practices in order to ensure that students from all groups develop expectations for success in science. Additionally, sorting the data by gender will provide insight into the discrepancies that currently exist in the research surrounding the variance in self-efficacy for male and female students.

Although this dissertation concentrates on ninth grade science classrooms, findings may be extended across multiple age levels and disciplines. The identification of teaching practices, attitudes, and other characteristics that positively influence the development of science self-efficacy can provide valuable information that science educators at many levels – elementary, middle, and high school – can use to improve science instruction, resulting in increased student achievement and persistence in science. Furthermore, findings may also extend beyond science to the other STEM disciplines – math, technology, and engineering – and will be of particular use to those teacher educators and education policymakers who have been charged with improving STEM education. Finally, the focus on variations in the development of self-efficacy by students' gender will be especially beneficial in that it will help educators to make changes in science education in order to advance the interest and involvement of girls in science and other STEM related fields.

Chapter Three: Methods

The previous chapters discussed literature on student self-efficacy with a specific focus on science as an academic domain. The current chapter will explain the methodology that this study will use to explore the research question generated from the review of previous literature. First, the introduction will provide a brief synopsis of the ways in which the literature and theory connect to the research question concerning the ways in which student and teacher level variables contribute to the development of student self-efficacy in high school science classrooms, and the methods that will be used to explore this question. From there, the current chapter moves on to a description of the dataset and analytic samples. Followed by an explanation of the variables and analytic strategy.

3.1 Introduction

Chapter 2 reviewed research on student-level variables and the development of self-efficacy along with the literature on various teacher characteristics, instructional practices, and attitudes that have the potential to impact student self-efficacy. In addition, four theoretical frameworks were discussed as they are applied in this dissertation. The use of ecological systems theory places the study within the microsystem of the classroom, at the same time recognizing the ways in which other subsystems may contribute to the development of students' attitudes towards science. Social cognitive theory emphasizes the social nature of learning and connects the construct of self-efficacy to the learning process. Motivation theory, specifically the expectancy-value model developed by Eccles and colleagues (2005) is used to examine the connections between students' expectations (the dependent variable in this study), values, and outcomes. Finally, achievement goal theory is used to consider the ways that teachers' instructional practices and attitudes towards students may influence the development of students' self-efficacy in science. What follows is a description of the dataset and analytical sample, measures, and the analytical plan.

This study utilizes data from the High School Longitudinal Study of 2009 (HSLS:09; Ingels et al., 2011) to investigate the relationship between various student, school, and teacher level variables and students' science self-efficacy. HSLS:09 is a nationally representative study that follows a cohort of 9th grade students through their secondary and postsecondary experiences. This dataset was chosen for the purposes of this study for a number of reasons. First, the use of a nationally representative sample allows for findings to be generalized to all 9th graders in the United States in 2009, of which there were over four million (Chen et al., 2011). In addition, HSLS:09 is the most recent in a series of nationally representative longitudinal studies, making it the most appropriate source of data when considering the effects of recent policies aimed at improving teacher quality. Finally, HSLS:09 has a much greater focus on STEM education than its predecessors, which will be discussed in the following section. Combined with the addition of science teachers to the survey population, HSLS:09 provides an unprecedented data source that allows for an examination of a variety of factors that may impact student success in science.

Bivariate analysis will be used to determine the relationship between the dependent variable of student science self-efficacy and the individual independent variables included in the four domains mentioned above. Ordinary Least Squares regression analysis will then be used to determine which independent variables have the greatest impact on student science self-efficacy. All analysis will be performed using SPSS software.

The remainder of this chapter is divided into four sections. First, *Dataset* will describe the design of HSLS:09 and the rationale for using it in this study. Second, *Analytic Samples* will explain the sampling procedures used by NCES and the school and student populations used for analysis. The third section, *Measures,* will provide a detailed description of the dependent and independent variables used in this study. Finally, *Analytic Strategy* will explain the methods used for data analysis.

3.2 Dataset

This study employs public-use data from the High School Longitudinal Study of 2009 (HSLS:09), which was conducted by the National Center for Education Statistics (NCES). HSLS:09 (Ingels et al., 2011) is the fifth in a series of longitudinal studies that follow students through their secondary and postsecondary experiences and beyond. One important difference between HSLS:09 and previous studies is its focus on STEM education; one specific goal of the study is to gain an understanding of the factors that lead students to choose science, technology, engineering, and mathematics courses, majors, and careers.

The Secondary Longitudinal Studies Program (SLSP) was introduced by NCES with the aim of studying the "educational, vocational, and personal development of students at various stages in their educational careers, and the personal, familial, social, institutional, and cultural factors that may affect that development" (Ingels et al., p.2). HSLS:09 is the most recent study being conducted as part of the SLSP; its four predecessors will now be described briefly in order to situate HSLS:09 within this program and to touch on the major contributions that previous studies have made to the field of science education and self-efficacy research.

Each of the five SLSP studies describes the educational experiences of students during the past decades – the 1970's, 1980's, 1990's, 2000's and finally the 2010's. The first three of these studies have been completed. The program began with the National Longitudinal Study of the high school class of 1972 (NLS-72) with the goal of providing data to inform education policymakers and researchers about students' secondary, postsecondary, and career experiences. A nationally representative sample of high school seniors completed questionnaires and assessments of verbal and nonverbal aptitude. Surveys of school administrators and student transcripts were also included as sources of data. Five follow ups were conducted by NCES, with the final being conducted in 1986, fourteen years after most students had graduated from high school. One major finding of NLS-72 that is relevant to this dissertation was that when controlling for background characteristics, there was a significant relationship between student achievement and attitude (measured as self-concept) which remained stable over time (Hunter, 1986). An additional finding of NLS-72 was the reciprocal relationship between student self-image and postsecondary involvement: students with a more positive self-image were found to have higher levels of postsecondary participation (Smart, 1985). These findings speak to the importance of noncognitive factors in regard to high school achievement and postsecondary involvement – whether the term is self-concept, self-image, or self-efficacy, the way that a student views him or herself has a direct impact on academic achievement and persistence. However, there is limited information on how these attitudes develop and nothing specific to science as an academic domain. The current study will add to the literature on the development of self-efficacy in the particular domain of high school science.

Following NLS-72 was the High School and Beyond (HS&B) study, which began with two student cohorts in the spring of 1980: high school sophomores and high school seniors. The addition of the sophomore cohort provided new information on students' early high school experiences. As with NLS-72, school principals were surveyed; parent and teacher surveys were also added in HS&B. Transcripts were collected and follow-ups were conducted in 1982, 1984, 1986, and 1992 (sophomore cohort only).

The third SLSP study was the National Education Longitudinal Study of 1988 (NELS:88). NELS:88 added to the understanding of student experiences by providing data on student achievement and status prior to high school entry; the base year survey included an 8th grade cohort of students, their parents, teachers, and school administrators. Follow-ups were conducted in 1990, 1992, 1994, and 2000. Secondary and postsecondary transcripts were also collected. Using the NELS:88 data, Mau (2003) found that math self-efficacy is one of the strongest predictors of student persistence in science and engineering careers. This finding speaks to the importance of self-efficacy in science, but does not provide information on science-specific self-efficacy.

The Education Longitudinal Study of 2002 (ELS:2002) was the fourth in the SLSP series of longitudinal studies. ELS:2002 began with surveying a cohort of 10th grade students, their parents, teachers, school administrators, and school library media center directors in 2002. Follow-ups were conducted in 2004, 2006, and 2012. There are a number of findings from ELS:2002 that confirm the relationship between self-efficacy and both academic achievement and persistence (Lucio et al., 2012; Liu & Koirala, 2009); however, most studies have concentrated either on general self-efficacy or, most often, on math self-efficacy. Wang (2013) also used ELS data to draw the connection between students' math self-efficacy and their intent to major in STEM related fields. These studies make it clear that self-efficacy is an important construct to be studied in relation to student achievement and persistence, but there is an obvious lack of information about how educators can aid in the development of students' self-efficacy beliefs. Furthermore, as self-efficacy is domain-specific, a need still exists for understanding the factors contributing to and outcomes resulting from increased self-efficacy in science. This leads us to the dataset used in this dissertation, the fifth longitudinal study conducted as part of the SLSP program and the first with an emphasis on STEM education.

HSLS:09 is the fifth iteration of the SLSP. Ninth grade students, teachers, parents, administrators, and school counselors were first surveyed in the fall semester of the 2009 – 2010 school year. Questionnaires were completed electronically; in addition, students took part in an algebraic reasoning assessment. The first follow up was conducted in the spring of 2012 when students were in the 11^{th} grade, but did not include teacher questionnaires. High school transcripts were collected in the fall of 2013. The third and fourth waves are planned for 2016 and 2021 and will document student progress through postsecondary education and into the workforce (Ingels et al., 2011). When completed, HSLS:09 will provide educators, researchers, and policymakers with a vast amount of information about students' secondary, postsecondary, and career experiences.

There are a number of differences between HSLS:09 and previous studies that are relevant to this study, the most obvious of which is the enhanced emphasis on STEM education. The collection of information about student experiences in the science classroom and the addition of science teacher questionnaires provides an unprecedented source of data for researchers in science education – previous national studies have not provided the depth of information on the high school science experience that HSLS:09 offers. There is also a noted increase in the emphasis placed on motivation, with the goal of exploring the factors that motivate students towards achievement and persistence in STEM course taking and careers

(Ingels et al., 2011). This includes self-efficacy and the other expectancy value constructs that it is intertwined with – identity, utility value, interest or intrinsic value, and cost perception - in fact, the expectancy value framework developed by Eccles and her colleagues was used in the design of HSLS:09 (Andersen & Ward, 2014). Additionally, by beginning with 9th graders in the fall of 2009, HSLS:09 allows for a greater understanding of the ways in which students' early high school experiences shape the remainder of their secondary and postsecondary careers.

This study utilizes HSLS:09 data from the public-use file provided by NCES. Student and science teacher survey responses comprise the majority of the data for analysis; parent and administrator survey responses provide a few additional contextual variables. After a careful review of the dataset, selected variables were downloaded using the EDAT data analysis tool on the NCES website.

3.3 Analytic Samples

A two-stage sampling process was used for the base year HSLS:09 data. A total of 1,889 schools were first identified through stratified random sampling, of which 944 participated. Target schools were regular public (including charter), Catholic, and other private schools within the United States with both 9th and 11th grade enrollment. Following school selection, 25,206 students were randomly sampled from 9th grade enrollment lists within the participating schools, with 21,444 students selected as the final student population (Ingels et al., 2011).

The 9th grade population is important for the purposes of this study on science self-efficacy. Students have been shown to be particularly vulnerable in school transitions such as the beginning of 9th grade; educators must be aware of the ways in which their actions can reinforce students feelings of self-doubt in order to avoid the "recursive effect" on student self-efficacy

(Farrington et al., 2012). Furthermore, success in 9th grade coursework has been shown to decrease the likelihood of school dropout (Roderick & Camburn, 1999; Allensworth & Easton, 2007). The use of a 9th grade student sample in this study will allow for the exploration of ways in which high school science teachers may aid students in successfully transitioning into high school with positive feelings of science self-efficacy, bolstering student achievement and decreasing the chances of student dropout.

HSLS:09 school and student samples are nationally representative, with the student being the primary unit of analysis. Four contextual respondent populations were also sampled and are attached to the student data: school administrators, lead counselors, mathematics and science teachers, and parents. Science teachers, one of the primary foci of this dissertation, were selected by virtue of teaching an HSLS:09 student; a total of 16,269 science teachers completed surveys (Ingels et al., 2011). Student and science teacher survey responses provide most of the information used in this study; responses on parent and administrator questionnaires provide additional contextual information that informs student and school demographic variables. This study uses base year data only, as science teacher questionnaires were not administered in subsequent follow-ups.

3.4 Measures

This dissertation employs data from the High School Longitudinal Study of 2009 to explore the impact of a series of student-, school- and teacher-level variables on the dependent variable of student science self-efficacy. Four hierarchical regression models will be used to examine which independent variables have the greatest effect on student science self-efficacy for the entire sample of students. All variables are derived from the HSLS:09 public-use file downloaded from NCES; some will be used in their original form while others will be recoded for the purposes of analysis through the use of SPSS software. The following sections describe the variables to be used in this dissertation.

Dependent Variable

The goal of this study is to explore the effects of various student and teacher variables on students' science self-efficacy. Defined as one's perceived capabilities for learning or performing actions at designated levels (Bandura, 1997), self-efficacy has been shown to be a predictor of students' effort, persistence, and resilience in various academic areas (Pajares, 1997) and is therefore an important construct to be studied in relation to student achievement in science. In order to examine this concept, this study uses the HSLS variable 'Scale of Student's Science Self-Efficacy' (X1SCIEFF) as a dependent variable.

X1SCIEFF is a scale of each student's self-efficacy constructed by NCES from four components on the student questionnaire (Cronbach's alpha = 0.88): '9th grader confident can do excellent job on fall 2009 science tests' (S1STESTS) '9th grader certain can understand fall 2009 science textbook' (S1STEXTBOOK) '9th grader certain can master skills in fall 2009 science course' (S1SSKILLS) '9th grader confident can do excellent job on fall 09 science assignments' (S1SASSEXCL). The range for this variable runs from -2.91 to 1.83, with higher values representing higher self-efficacy.

Independent Variables

A total of twenty-one independent variables are used in this study. Nominal variables were taken directly from the public-use file. As with the science self-efficacy variable, NCES researchers created other composite variables, a number of which are used as independent variables in this study. Some of the original NCES variables required recoding in order to fit the purposes of analysis in this study; recoding was completed with the aid of SPSS software and will be discussed when applicable in the following sections.

In order to examine the research question that is the focus of this dissertation, independent variables were grouped into four domains. Domain one includes all student and school level variables. This includes demographic information: sex, race, socioeconomic status at the student level and control and urbanicity at the school level. Student data measuring subjective task value (STV) – science identity, utility value, interest, and cost perception – is also included in domain one. Finally, the relationship between self-efficacy and various scientific disciplines is examined in domain one by the inclusion of the variable indicating the type of science course each student is enrolled in. Domain two encompasses teacher characteristic variables, including many of the characteristics that are currently used or have been proposed to be used as measures of teacher quality. Domain three measures the effects of teaching practices on students' science self-efficacy. Two variables are included in this domain: the use of group work and the emphasis that a teacher places on various instructional goals. Domain four measures student perceptions of teacher attitudes.

Student and School Level Variables

X1SEX 'Student's sex' was obtained from the base-year student questionnaire, parent questionnaire, and/or school-provided sampling roster. If the sex indicated by any of these three sources was inconsistent, it was coded based on manual review of the sample member's first name (Ingels et al., 2011). For purposes of analysis, a dummy variable was created which indicates whether the student is female=1 or male=0.

X1RACE 'Student's Race/ethnicity Composite' characterizes the sample member's race/ethnicity by summarizing the following six dichotomous race/ethnicity composites: X1HISPANIC, X1WHITE, X1BLACK, X1ASIAN, X1PACISLE, and X1AMINDIAN. This composite variable is based on data from the student survey, school-provided sampling roster, and/or parent survey. To aid in analysis, dummy variables were created to indicate that the student is Black=1 Hispanic=2 Asian/Pacific Islander=3 White=4 or Other Race=5, with White being used as the reference category.

X1SES 'Socio-economic status composite' was computed by NCES using the variables parent/guardians' education (X1PAR1EDU and X1PAR2EDU), occupation (X1PAR1OCC2 and X1PAR2OCC2), and family income (X1FAMINCOME). The range for this variable runs from -1.93 to 2.88.

Student's science achievement and self-efficacy has been shown to differ based on the particular kind of science course they are enrolled in, an effect that is compounded by gender differences in the science disciplines (Britner, 2008). To add to previous research and examine if this is true for the population of students in this study, the variable 'Student's Science Course' was created from the science teacher survey variable NICOURSE 'Student's fall 2009 science course'. Science course options were combined based on the three main branches of science: life, earth, and physical. The dummy variable LIFESCI was used as a reference category and indicates that the student is taking some form of life science (Life Science; Anatomy or Physiology; Biology I; Advanced Biology such as Biology II, AP, or IB; or other biological science such as botany, marine biology, or zoology). The dummy variable EARTHSCI indicates that the student is taking some form of earth or environmental science (Environmental Science; Earth Science; or other Earth/Environmental Science such as ecology, geology, oceanography, or meteorology). The dummy variable PHYSSCI indicates that the student is taking some form of physical science (Chemistry I; Advanced Chemistry such as Chemistry II, AP, or IB; Physics I; Advanced Physics such as Physics II, AP, or IB; Physical Science without Earth Science; Physical Science with Earth Science; or other Physical Science such as astronomy or electronics). The dummy variable OSCI indicates that the student is taking some other form of science (Integrated Science; General Science; or other science).

Four variables were used in order to examine the relationship between students' science self-efficacy and the remaining four components of Eccles' expectancy-value model (identity, utility, interest, and cost perception). 'Scale of student's science identity' (X1SCIID) is a scale score created by NCES by combining two student level variables (Cronbach's alpha = 0.83): SISPERSON1 '9th grader sees himself/herself as a science person' and SISPERSON2 'Others see 9th grader as a science person'. The range for this variable runs from -1.57 to 2.15.

'Scale of student's science utility' (X1SCIUTI) is another scale score created by NCES. Three student level variables were combined (Cronbach's alpha = 0.75): S1SUSELIFE '9th grader thinks fall 2009 science course is useful for everyday life'; S1SUSECLG '9th grader thinks fall 2009 science course will be useful for college'; and S1SUSEJOB '9th grader thinks fall 2009 science course is useful for future career'. The range for this variable runs from -3.10 to 1.69.

‘Scale of student's interest in fall 2009 science course’ (X1SCIINT) is a scale score created by NCES by combining six student survey variables (Cronbach’s alpha = 0.73): S1SENJOYING ‘9th grader is enjoying fall 2009 science course very much’; S1SWASTE ‘9th grader thinks fall 2009 science course is a waste of time’; S1SBORING ‘9th grader thinks fall 2009 science course is boring’; S1FAVSUBJ ‘9th grader’s favorite school subject’; S1LEASTSUBJ ‘9th grader’s least favorite school subject’; and S1SENJOYS ‘9th grader is taking fall 2009 science because he/she really enjoys science. The range for this variable runs from -2.59 to 2.03.

COSTPERCEPTION was created for the purposes of this study by combining four student level variables (Cronbach’s alpha = 0.75): S1TEFRNDS ‘Time/effort in math/science means not enough time with friends’; S1TEACTIV ‘Time/effort in math/science means not enough time for extracurriculars’; S1TEPOPULAR ‘Time/effort in math/science means 9th grader won't be popular’; and S1TEMAKEFUN ‘Time/effort in math/science means people will make fun of 9th grader’. Values for these variables were reversed to have higher scores reflect higher levels of cost perception. The range for this variable runs from 1 to 4.

X1CONTROL ‘School Control’ identifies the student’s school as being 1 = ‘Public’, or 2 = ‘Catholic or other private school’.

X1LOCALE ‘School locale (urbanicity)’ characterizes the student’s school as being 1 = ‘Urban’, 2 = ‘Suburban’, or 3 = ‘Rural’.

Teacher Characteristic Variables

A number of teacher characteristic variables were chosen as independent variables for this study. First, the demographic variables of teacher's sex and teacher's race were selected because of the importance of modeling in the development of self-efficacy (Bandura, 1977; Schunk, 1999; Britner, 2008) and the potential for these variables to cause passive teacher effects such as the "role model' effect (Dee, 2005). A series of other teacher characteristic variables were selected to reflect the characteristics that have been discussed as measures of teacher quality, including certification, degree, coursework, previous work experience, certification pathway, and years teaching. These characteristics have been debated in the literature on teacher quality in terms of their impact on student achievement (Goldhaber & Brewer, 2000; Darling-Hammond et al., 2005; Eckert, 2012; Hanushek et al., 2005; Rivkin et al., 2005), this dissertation will interrogate whether these same characteristics have a significant impact on student self-efficacy.

N1SEX 'Science Teacher's Sex' characterizes the Science teacher's sex as being 1 = 'male' or 2 = 'female'.

X1TSRACE 'Science Teacher's Race/Ethnicity Composite'X1TSRACE characterizes the race/ethnicity of the sample member's science teacher by summarizing the following science teacher questionnaire variables: N1HISP, N1WHITE, N1BLACK, N1ASIAN, N1PACISLE, and N1AMINDIAN. For the purposes of analysis, dummy variables were created to indicate that the science teacher is 1 = 'Black', 2 = 'Hispanic', 3 = 'Asian', 4 = 'White', or 5 = 'Other Race', with White being used as the reference category.

X1TSCERT ‘Science teacher's science teaching certification’ is a variable that characterizes the science teacher's certification status by grade level and type of certification. For the purposes of analysis, dummy variables were created to indicate 0 = ‘science teacher does not have regular certification’ or 1 = ‘science teacher has regular certification’. Non-regular certification includes the categories of no certification, regular elementary or middle school only, probationary, and emergency/temporary/waiver.

N1HIDEG ‘Science teacher's highest degree earned’ indicates the highest degree earned by the science teacher. Dummy variables were created for Bachelor’s degree, Master’s degree, Educational Specialist, and Advanced Professional degree.

SCICOURSEWORK is a count variable measuring the amount of college-level science courses science teachers have completed. Twenty-three teacher variables were counted for this variable, indicating if each teacher had taken any of the following college-level science courses: anatomy (N1ANATOMY), botany (N1BOTANY), cell biology (N1CELLBIO), ecology (NIECOLOGY), entomology (N1ENTOMOLOGY), genetics or evolution (N1GENETICS), microbiology (NIMICROBIO), zoology/animal behavior (N1ZOOLOGY), analytical chemistry (N1ANLYTICHEM), biochemistry (N1BIOCHEM), organic chemistry (N1ORGCHEM), physical chemistry (N1PHYSCHEM), astronomy (N1ASTRONOMY), environmental science (N1ENVSCI), geology (N1GEOLOGY), meteorology (N1METEOROLGY), oceanography (N1OCEAN), physical geography (N1PHYSGEOG), electricity/magnetism (N1ELECTRICTY), heat/thermodynamics (N1HEAT), mechanics (N1MECHANICS), modern/quantum physics (N1QUANTUM), nuclear physics (N1NUCLEAR), and optics (N1OPTICS). The range for this variable runs from 1 – 23.

N1SCIJOB 'Science teacher held science-related job prior to becoming a teacher' is a variable that characterizes whether a science teacher held a science-related job prior to becoming a teacher. The range for this variable runs from: 0 = 'no' to 1 = 'yes'.

N1ALTCERT 'Science teacher entered profession via alternative certification program' is a variable that characterizes whether a science teacher entered the teaching profession through an alternative certification pathway such as Teach for America or a teaching fellows program. The range for this variable runs from: 0 = 'no' to 1 = 'yes'.

N1SCIYRS912 'Years science teacher has taught high school science' is a variable that measures the amount of years a science teacher has taught science in 9^{th} through 12^{th} grades. The range for this variable runs from 1 – 26.

Teaching Practices Variables

Instructional practices have the potential to create learning experiences that provide students with Bandura's theorized sources of self-efficacy. Two variables were chosen to measure the impact of teaching practices on student science self-efficacy: the use of group work and the emphasis placed on teaching practices. The variable measuring group work was recoded from the teacher survey variable N1GROUP 'Science teacher has students work in small groups' and indicates if the science teacher has students work in small groups. The range from this variable runs from 0 = 'no group work' to 1 = 'group work'.

TPRACTICE is a scale of emphasis placed on various teaching practices created from eleven science teacher survey items. Science teachers were asked to rate how much emphasis they were placing on eleven objectives during the full duration of their fall 2009 science course.

The ratings ranged from 1 – 4: 1 = ‘No Emphasis’; 2 = ‘Minimal Emphasis’; 3 = ‘Moderate Emphasis’; 4 = ‘Heavy Emphasis’. All eleven variables were combined to indicate the science teacher’s level of emphasis on teaching practices (Cronbach’s alpha = 0.80): ‘Science teacher's emphasis on: N1INTEREST increasing students' interest in science N1CONCEPTS teaching basic science concepts N1TERMS important science terms/facts N1SKILLS science process/inquiry skills N1PREPARE preparation for further science study N1EVIDENCE evaluating arguments based on evidence N1IDEAS effectively communicating science ideas N1BUSINESS business/industry applications of science N1SOCIETY relationship between science/tech/society N1HISTORY history/nature of science N1TEST standardized test preparation’.

Teacher Attitude Variables

Student perceptions of teacher attitudes have the potential to affect their self-efficacy (Pajares, 1997; Tyler & Boelter, 2008). Students who perceive an “affirming attitude” from teachers are more likely to participate in activities that provide the potential sources of self-efficacy, such as mastery experiences and verbal persuasion. To measure perceived positive or affirming attitude, the scale variable AFFATT was created from seven student level variables (Cronbach’s alpha = 0.88): S1STCHVALUES ‘9th grader's fall 2009 science teacher values/listens to students' ideas’; S1STCHRESPCT ‘9th grader's fall 2009 science teacher treats students with respect’; S1STCHFAIR ‘9th grader's fall 2009 science teacher treats every student fairly’; S1STCHCONF ‘9th grader's fall 09 science teacher thinks all student can be successful’; S1STCHMISTKE ‘9th grader's fall 09 science teacher thinks mistakes OK if students learn’; S1STCHTREAT ‘9th grader's fall 09 science teacher treats some kids better than others’; and S1STCHMFDIFF ‘9th grader’s fall 09 science teacher treats males/females differently’.

Response categories for these variables ranged from 1 – 4: 1 = 'Strongly agree'; 2 = 'Agree'; 3 = 'Disagree'; 4 = 'Strongly disagree'. Values for the last two variables (S1STCHTREAT and S1STCHMFDIFF) were reversed to have higher scores reflect higher levels of perceived positive/affirming attitude.

3.5 Analytic Strategy

In order to examine the impact of student, school, and teacher level variables on student science self-efficacy, this dissertation will employ three distinct phases of analysis. Univariate analysis will first be used to provide descriptive statistics for all variables used in this study. Bivariate analysis will then be used to determine the relationships between the dependent variable and each independent variable. As the dependent variable in this study – student science self-efficacy – is a continuous variable, three bivariate tests will be utilized: T-tests, ANOVA, and Pearson's Correlations. T-tests will be used to explore the relationships between the dependent variable of student science self-efficacy and all categorical independent variables with two categories, namely student's sex, school control, science teacher's sex, science teacher certification, science teacher previously held a science job, science teacher entered through an alternative certification pathway, and science teacher has students work in small groups. A one-way analysis of variance (ANOVA) will be utilized to compare the mean student science self-efficacy for all categorical independent variables with three or more categories, including student's race, student's science course, urbanicity, science teacher's race, and science teacher's highest degree earned. Pearson's correlations will be used to investigate the relationship between student science self-efficacy and nine continuous independent variables, including student's socioeconomic status, student's science identity, student's science utility value, student's science interest, cost perception, teacher's amount of science coursework, years teacher has taught high school science, perceived affirming attitude, and emphasis on teaching practices.

Following univariate and bivariate analysis, Ordinary Least Squares (OLS) regression analysis will be employed to determine which independent variables have the greatest impact on predicting students' science self-efficacy. Four hierarchical models will be used in the regression.

Model I will examine the impact of student and school level variables on students' science self-efficacy and will include the demographic variables of students' sex, race/ethnicity and socioeconomic status; the science course that the student is enrolled in; students' science subjective task value (identity, utility value, interest, and cost perception); school control (public or private); and school locale or urbanicity. The demographic variables are important to consider in order to determine how science self-efficacy may vary by group and whether or not this variance is aligned with the underrepresentation of racial and ethnic minority, female, and low SES students in science. The science course will be considered as previous work has shown that student confidence may differ based on the type of course that the student is enrolled in. This is particularly true for females, who generally have higher levels of confidence in the life sciences than in other science fields. Finally, the inclusion of the subjective task value variables related to Eccles' expectancy value framework (identity, utility, interest and cost perception) will serve to explore the connections between student values in science and student expectations for success in science.

Model II will examine the impact of science teacher characteristic variables including sex, race, certification, highest degree earned, amount of science coursework, any previous science related job, certification pathway, and years teaching. A great deal of current discourse and policy surrounding improving achievement and persistence in science focuses on improving teacher quality (Goe, 2007). Teacher certification has been examined as a predictor of student achievement, both in terms of type of certification and the pathway to certification (Goldhaber & Brewer, 2000; Darling-Hammond et al., 2005). Content area coursework and time teaching have also been shown to have a positive impact on student achievement (Eckert, 2012). These variables need to be examined in terms of their impact on students' science self-efficacy.

Model III will focus on science teachers' self-reported teaching practices. First, the use of group work will be explored because the vicarious experience of group work can be a source of self-efficacy (Pajares, 1997). Group work involves social interaction between students and, when successfully implemented, has been shown to increase student competence and confidence in the material (Turner et al., 2011). Model III will also explore the impact of teachers' emphasis on various teaching objectives. Prior studies in achievement goal theory have shown that instructional objectives (also termed goals) play a key role in student engagement and achievement in science and other STEM related fields (Oakes 1990); this study will examine the impact of various instructional objectives on students' science self-efficacy.

Model IV will focus on students' perceptions of teacher attitudes, with specific emphasis on positive student-teacher interactions. Previous research has shown that teachers may treat students differently based on stereotypes surrounding race/ethnicity, gender, and socioeconomic status (Villegas & Lucas 2002, Nieto 1992). These differences may translate into behaviors that lead students to sense differences in teacher attitudes and variance in the verbal persuasion that has been shown to impact self-efficacy – perceived differences of students have been shown to translate into variance in positive or negative language (Tenenbaum & Ruck, 2007). Variables reflecting student perceptions of attitudes such as whether a teacher values all students, thinks all students can succeed, and treats students fairly will be used to represent what researchers have termed “affirming” attitudes or perspectives of student culture and diversity (Villegas and Lucas, 2002, Nieto 1992). Model IV will add the ‘perceived affirming attitude’ variable to determine the relationship between student-perceived positive attitudes and student science self-efficacy.

In light of the discrepancies in the research surrounding science self-efficacy by student gender, each model will be examined across genders (Models I – IV) and separately for female (Models V – VIII) and male (Models IX – XII) students. Splitting the data by gender will add to the understanding of how self-efficacy differs for male and female students as well as identify potential factors that may be used to improve the involvement of female students in science.

The previous chapter discussed a series of hypotheses in each of these domains. To test these hypotheses, OLS regression will be used to predict the relative impact of the variables within each domain on student science self-efficacy. Hypotheses include:

- Female students will have a lower science self-efficacy than male students.
- There will be a significant difference in the science self-efficacy of students based on race, with White students reporting a greater sense of self-efficacy than their Black and Latino counterparts.
- Socioeconomic status will have a positive impact on student science self-efficacy.
- The four subjective task value components will be significant predictors of student science self-efficacy, with student science identity, student science utility value, and student science interest having a positive relationship with student science self-efficacy and student cost perception having a negative one.

- The use of group work will have a positive impact on student science self-efficacy due to its potential to create mastery experiences, verbal persuasion, and peer comparison situations.
- Perceived affirming attitude will be a significant predictor of student science self-efficacy.

The goal of this dissertation is to explore the impact of student and school level variables, teacher characteristic variables, teaching practices variables, and teacher attitude variables on the dependent variable of student science self-efficacy. The following chapter will present the results of OLS regression designed to explore the ways in which the variables discussed above act to predict student science self-efficacy.

Chapter Four: Results

This chapter investigates the following question: How do student-level (demographics and subjective task value), school-level (control and urbanicity), and teacher-level (characteristics, practices, and attitudes) variables affect the science self-efficacy of 9th grade students?

In order to answer this question, this dissertation uses data from the National Center for Education Statistics (NCES) High School Longitudinal Study of 2009 (HSLS:09). HSLS:09 is a longitudinal study that follows a nationally representative cohort of 9th grade students as they progress through high school and into postsecondary schools and/or the labor market. Data in this study is from the base year of HSLS:09, collected in the fall semester of the 2009 – 2010 school year. Students, parents, mathematics and science teachers, school administrators, and school counselors were all surveyed in the base year; students are considered to be the principal unit of analysis, while information from other respondents is meant to be contextual. This study utilizes data primarily from student and science teacher surveys, with a small amount of additional contextual information from parent and school administrator surveys.

Analysis was conducted in three distinct stages. First, descriptive statistics were generated in order to characterize the student sample. Next, bivariate analysis was conducted to determine the empirical relationships among the variables. Finally, OLS regression was used to investigate the relative influence of twenty-one independent variables on the dependent variable of student science self-efficacy. Four hierarchical regression models were created, grouping the independent variables into four domains: Student/School Level Variables, Teacher Characteristic Variables, Teaching Practice Variables, and Teacher Attitude Variables. Regression analysis was performed for the entire sample of students (Models I through IV), for female students only (Models V through VIII), and for male students only (Models IX through XII).

4.1 Univariate Analysis

Table 4.1 presents descriptive statistics of means, standard deviations, ranges, and descriptions of variables for the entire sample of students in this study. This table allows for univariate analysis of the distribution of single variables. Table 4.1 provides a summary of the 9th grade student population used for analysis in this study.

Dependent Variable: Student Science Self-Efficacy

The scale of students' science self-efficacy (n = 17624) runs from -2.91to 1.83. The mean of .37 indicates that on average, students' science self-efficacy is towards the mid-high range of the scale; a standard deviation of 1.0 indicates a high level of variance in students' science self-efficacy.

Independent Variables

A total of twenty-one independent variables were selected for analysis in this study. These variables were grouped into four domains: student and school level variables, teacher characteristic variables, teaching practices variables, and teacher attitude variables.

Student and School Level Variables

After reviewing the literature on student and school factors affecting self-efficacy, academic achievement, and persistence in science, ten variables were chosen to measure student and school characteristics.

The range for the dummy variables created for student gender runs from 0 to 1. The mean for females was .49 and that for males was .51, indicating a fairly even ratio of female to male students in the entire sample (n = 23409).

The range for the dummy variables created for student race also runs from 0 – 1. Means indicate that the student population (n = 22409) is majority White, with a mean of .54 representing 54% of students. The second largest racial group in the student population is Hispanic, at 18%, followed by Black at 11%, Asian/Pacific Islander at 9%, and all students coded as Other Race at 9%.

Students' socioeconomic status is a composite variable with a range of -1.93 to 2.88. The mean of .05 tells us that the average student is just below average in SES; the standard deviation of .78 indicates that there is a wide dispersion in SES amongst the student population.

It has been noted that attitudes towards science may differ base on course discipline, with females being more likely to participate in biological or life sciences than in other fields of science (National Science Foundation, 2015). To further investigate this, four dummy variables were created to categorize the type of science course in which a student is enrolled. For those students enrolled in science in this student population (n = 12208), 42% are in a Life Science course, 34% are taking Physical Science, 15% are enrolled in an Earth/Environmental Science course, and the remaining 8% of students are taking a course coded as Other Science (e.g. General or Integrated Science).

Self-efficacy is one portion of the Expectancy-Value theory of motivation used as a framework for this study and in the original design of HSLS:09 (Ingels et al., 2011). The remaining four components make up the values portion of the framework and are often referred to as Subjective Task Value, or STV. Four variables were used to measure students STV: student's science identity, utility value, and science interest, which were all already composite variables created by NCES, and cost perception, which was created for the purposes of this study.

The scale of student's science identity runs from -1.57 to 2.15 (n = 21109). On average, students' science identity falls just about in the middle of this range, with a mean of .04. A standard deviation of 1.01 indicates a high level of dispersion in students' science identity.

The scale of student's science utility value is used to rate how useful a student believes his or her science course to be. The range for this variable runs from -3.10 to 1.69 (n = 17303). A mean of .01 indicate that on average students feel their science course is useful.

The STV component of Intrinsic Value is measured by students' level of interest in their science course. The range for this variable runs from -2.59 to 2.03 (n = 16929); students rated their course at a mean of .03 indicating that on average students are slightly interested in their fall 2009 science course.

Student's cost perception measures the perceived costs of trying to succeed in math or science, including loss of time to spend with friends or on extracurricular activities and negative social interactions such as not being popular or being made fun of by peers. On a scale of 1 – 4, with 4 representing higher cost, students had a cost perception mean of 2.94 (n = 20946), indicating that on average students are slightly concerned about the costs associated with success in math or science.

Two school level variables were selected for analysis to give a greater understanding of the demographics of the student population. School control characterizes a student's school as either public or nonpublic. 82% of students in the sample attend a public school; 18% of student are in a nonpublic school. In this study urbanicity categorizes a student's school as either urban, suburban, or rural. 36% of schools are suburban, another 36% are rural, and the remaining 28% are urban.

Teacher Characteristic Variables

After reviewing the literature on teacher quality, eight variables were chosen to measure teacher characteristics. The first two variables measure teacher demographics; the remaining variables are representative of characteristics that are either being used in current policy or have been proposed to be used in future policy as indicators of teacher quality.

Over half of the students in the study population (56%, n = 15557) have a female science teacher; 44% have a male science teacher.

The majority of students (88%) in the study population (n = 15497) have a White science teacher; 4% have a Black science teacher; 4% have a Hispanic science teacher; 2% of students have an Asian science teacher; the remaining 2% of students have a science teacher who has been categorized as Other Race.

The majority of students (81%) in the study population (n = 15439) have a teacher who is regularly certified to teach high school science. The remaining 19% of students have a teacher who is not regularly certified to teach high school science. This can include teachers with no certification, regular elementary or middle school only, probationary, and emergency/temporary certification or waiver.

Recent education policies have raised the level of degree that a teacher must earn in order to attain certification to teach. The dummy variables created for teacher's highest degree earned show that in this student population (n = 15559), 50% of students have a science teacher with a Master's degree as highest degree earned; 43% of students have a science teacher who has earned as high as a Bachelor's degree; 3% of students have a science teacher who has an Educational specialist diploma as highest degree earned; 3% of students have a science teacher who has an Advanced Professional degree such as an M.D., Ph.D., or law degree.

Prior studies have described the impact of the amount of subject area coursework that a teacher has on student achievement (Goldhaber & Brewer, 2000; Eckert, 2012). The science coursework variable is used to measure the amount of science classes a science teacher completed in college and runs from 1 – 23. On average, students have a science teacher who has completed 8.97 science courses (n = 15559). A standard deviation of 4.14 shows that there is a good amount of dispersion in the amount of science coursework a teacher has completed.

Of the students in the sample population, 34% have a science teacher who held a science-related job prior to entering the teaching profession.

The quality of alternative certification pathways to teacher certification has been highly debated (Darling-Hammond et al., 2005; Goldhaber & Brewer, 2000). In hard to fill fields such as science, students are more likely to have a teacher who has not gone through a traditional path to certification; 29% of students in the study population have a science teacher who entered the teaching profession through an alternative certification pathway.

The benefits of teaching time and experience has been discussed in the literature on teacher quality (Eckert 2012; Goe, 2007; Hanushek et al., 2005; Rivkin et al., 2005). In the current study, the average time a science teacher has taught high school science is 10.33 years; however, a standard deviation of 7.89 indicates a high level of dispersion in this variable.

Teaching Practices and Attitude Variables

Two variables were chosen to measure teaching practices: use of group work and emphasis on teaching practices. These variables were selected because of the potential they have to affect students' self-efficacy through the sources of mastery experience, verbal persuasion, and peer comparison.

A majority of science teachers (93%, n = 12141) indicate that they use some level of group work in their classroom.

The level of emphasis placed on various teaching practices runs from 2 – 4, with a mean of 3.3. This indicates that science teachers (n = 12176) place moderate to heavy emphasis on the eleven teaching practices included in this variable.

Student perceptions of teacher attitudes can impact students' self-efficacy: perceived positive and encouraging attitudes can increase self-efficacy while perceived negative attitudes have the opposite effect (Pajares, 1997). In this study, the variable 'Perceived positive attitude' was used to measure students' perceptions of their science teacher's attitude. A range of 1 – 4 measure teacher attitudes, with 1 being more negative and 4 being more positive or affirming. A mean of 1.83 indicates that on average, students perceive their science teacher to be slightly more negative in terms of attitude.

Table 4.1: Means, Standard Deviations, Ranges, and Description of Variables

Variable	N	Mean	S.D.	Range	Description: HSLS Variable NAME and Label
			Dependent Variable		
Student Science Self-Efficacy	17264	0.37	1.0	-2.91 – 1.83	X1SCIEFF ‘Scale of Student’s Science Self-Efficacy’
			Student Level Variables		
Student’s Gender					X1SEX ‘Student’s sex’
Student is Female	23409	.49	.50	0 – 1	
Student is Male	23409	.51	.50	0 – 1	
Student’s Race					X1RACE ‘Student’s Race/ethnicity Composite’
Student is Black	22409	.11	.31	0 – 1	
Student is Hispanic	22409	.18	.37	0 – 1	
Student is White	22409	.54	.50	0 – 1	
Student is Asian/Pacific Islander	22409	.09	.29	0 – 1	
Student is Other Race	22409	.09	.20	0 – 1	
Student’s Socioeconomic Status	21444	.05	.78	-1.93 – 2.88	X1SES ‘Socio-economic status composite’
Student’s Science Course					NICOURSE ‘Student’s fall 2009 science course’
Student is taking life science	12208	.42	.49	0 – 1	
Student is taking earth/environmental science	12208	.15	.36	0 – 1	
Student is taking physical science	12208	.34	.47	0 – 1	
Student is taking other science	12208	.08	.28	0 – 1	
Student’s Science Identity	21109	.04	1.01	-1.57 – 2.15	X1SCIID ‘Scale of student's science identity’
Student’s Science Utility Value	17303	.01	.99	-3.10 – 1.69	X1SCIUTI ‘Scale of student's science utility’

Table 4.1 (cont): Means, Standard Deviations, Ranges, and Description of Variables

Variable	N	Mean	S.D.	Range	Description: HSLS Variable NAME and Label
Student's Science Interest	16929	.03	.99	-2.59 – 2.03	X1SCIINT 'Scale of student's interest in fall 2009 science course'
Student's Cost Perception	20946	2.94	.56	1 – 4	Scale of cost perception from four variables: S1TEFRNDS 'Time/effort in math/science means not enough time with friends'; S1TEACTIV 'Time/effort in math/science means not enough time for extracurriculars'; S1TEPOPULAR 'Time/effort in math/science means 9th grader won't be popular'; S1TEMAKEFUN 'Time/effort in math/science means people will make fun of 9th grader'
School Level Variables					
Public School	23415	.82	.38	0 – 1	X1CONTROL 'School Control'
Urbanicity					
Urban School	23415	.28	.45	0 – 1	XILOCALE 'School Locale (Urbanicity)'
Suburban School	23415	.36	.48	0 – 1	
Rural School	23415	.36	.48	0 – 1	
Teacher Characteristic Variables					
Science Teacher's Gender					
Science Teacher is Female	15557	.56	.50	0 – 1	N1SEX 'Science Teacher's Sex'
Science Teacher is Male	15557	.44	.50	0 – 1	
Science Teacher's Race					
Science Teacher is Black	15497	.04	.20	0 – 1	X1TSRACE 'Science Teacher's Race/Ethnicity Composite'
Science Teacher is Hispanic	15497	.04	.19	0 – 1	
Science Teacher is Asian	15497	.02	.15	0 – 1	
Science Teacher is White	15497	.88	.33	0 – 1	
Science Teacher is Other Race	15497	.02	.14	0 – 1	

Table 4.1 (cont): Means, Standard Deviations, Ranges, and Description of Variables

Variable	N	Mean	S.D.	Range	Description: HSLS Variable NAME and Label
Teacher Certification Status					X1TSCERT 'Science teacher's science teaching certification'
Teacher Has Regular Certification	15439	.81	.39	0 – 1	
Teacher Does Not Have Regular Certification	15439	.19	.39	0 – 1	
Teacher's highest degree earned					N1HIDEG 'Science teacher's highest degree earned'
Bachelor's degree	15559	.43	.50	0 – 1	
Master's degree	15559	.50	.50	0 – 1	
Educational Specialist diploma	15559	.03	.18	0 – 1	
Advanced Professional degree	15559	.03	.18	0 – 1	
Teacher's science coursework	15559	8.97	4.14	1 – 23	Count of 23 variables
Teacher previously held science job	15491	.34	.47	0 – 1	N1SCIJOB 'Science teacher held science-related job prior to becoming a teacher'
Teacher entered through alternative certification pathway	15507	.29	.45	0 – 1	N1ALTCERT 'Science teacher entered profession through alternative certification program'
Years teacher has taught high school science	15514	10.33	7.89	1 – 26	N1SCIYRS912 'Years science teacher has taught high school science'

Table 4.1 (cont): Means, Standard Deviations, Ranges, and Description of Variables

Variable	N	Mean	S.D.	Range	Description: HSLS Variable NAME and Label
				Teaching Practices Variables	
Group work	12141	.93	.26	0 – 1	N1GROUP ‘Science teacher has students work in small groups’
Emphasis on teaching practices	12176	3.30	.37	2 – 4	Scale of teaching practice emphasis created from 11 variables: ‘Science teacher's emphasis on: N1INTEREST increasing students' interest in science N1CONCEPTS teaching basic science concepts N1TERMS important science terms/facts N1SKILLS science process/inquiry skills N1PREPARE preparation for further science study N1EVIDENCE evaluating arguments based on evidence N1IDEAS effectively communicating science ideas N1BUSINESS business/industry applications of science N1SOCIETY relationship between science/tech/society N1HISTORY history/nature of science N1TEST standardized test preparation’
				Teacher Attitude Variables	
Level of perceived affirming attitude	17550	1.83	.56	1 – 4	Scale of teacher attitude created from 7 variables: S1STCHVALUES ‘9th grader's fall 2009 science teacher values/listens to students' ideas’ S1STCHRESPCT ‘9th grader's fall 2009 science teacher treats students with respect’ S1STCHFAIR ‘9th grader's fall 2009 science teacher treats every student fairly’ S1STCHCONF ‘9th grader's fall 09 science teacher thinks all students can be successful’ S1STCHMISTKE ‘9th grader's fall 09 science teacher think mistakes OK if students learn’ S1STCHTREAT ‘9th grader's fall 09 science teacher treats some kids better than others’

4.2 Bivariate Analysis

Table 4.2 presents the results from T-tests performed on seven dummy variables to determine if their mean scores on the dependent variable ‘student science self-efficacy’ are significantly different. Bivariate analysis reveals the following about the students in the survey population:

‘Student gender’ appears to have a significant impact on student’s science self-efficacy. Male students report a higher science self-efficacy (N = .16) than female students (N = -.08); this difference is statistically significant at the .001 level.

‘Public school’ also appears to have a significant impact on student’s science self-efficacy. Students who attend a public school report having higher self-efficacy (N = .12) than students who do not attend a public school (N = .02). This difference is statistically significant at the .001 level.

Another variable that appears to have a significant impact on student’s science self-efficacy is ‘science teacher’s gender’. Students with male science teachers report lower science self-efficacy (N = .02) than students with female science teachers (N = .06). This difference is statistically significant at the .05 level.

The final dummy variable that has a significant impact on student’s science self-efficacy is ‘teacher previously held science job’. Students whose science teacher held a science job prior to entering the teaching profession score lower on the science self-efficacy scale (N = .02) than students whose science teacher did not have any science job experience (N = .06). This difference is statistically significant at the .05 level.

Bivariate analysis does not reveal any significant difference in student science self-efficacy for the variables ‘teacher has regular high school certification’, ‘teacher entered through alternative certification pathway’, or ‘teacher has students work in small groups’.

Table 4.2: Comparison of Means on Student Science Self-Efficacy by Independent Variables

Independent Variables	Student Science Self-Efficacy (N in Parentheses)
Student's Gender	
Male	.16*** (8619)
Female	-.08 (8645)
Public School	
No	.12*** (3474)
Yes	.02 (13790)
Science Teacher's Gender	
Male	.02* (5428)
Female	.06 (7140)
Teacher has regular HS certification	
No	.04 (2413)
Yes	.05 (10060)
Teacher previously held science job	
No	.06* (8269)
Yes	.02 (4249)
Teacher entered through alternative certification program	
No	.05 (9001)
Yes	.04 (3529)
Teacher has Students work in small groups	
No	.06 (699)
Yes	.05 (9090)

*p = .05 ***p = .001

Note: Within each predictor on the dependent variable, the superscript of the level of statistical significance is placed just on one of the two categories to indicate that the relative mean scores are statistically different from each other.

Table 4.3 presents the results from a one-way analysis of variance (ANOVA) performed to compare the mean science self-efficacy scores for dummy variables created for five independent variables. In regards to the cohort of students analyzed in this study, bivariate analysis reveals the following:

‘Student’s race’ has a significant impact on student’s science self-efficacy. Asian students report the highest level of science self-efficacy (N = .20), followed by Black students (N = .12), students coded as Other Race (N = .06, White students (N = .04) and Hispanic students (N = -.12). The mean for each racial group is statistically different from all other groups at the .05 level of significance.

‘Student’s science course’ also has a significant impact on student’s science self-efficacy. Students enrolled in a Life Science course report the highest level of science self-efficacy (N = .12), followed by students enrolled in a course coded as Other Science (N = .07), students in a Physical Science course (N = -.004) and finally students taking Earth/Environmental Science (N = -.01); however, the only group whose difference is statistically significant at the .05 level is students enrolled in Life Science, whose mean is different from that of students in all other courses.

‘Urbanicity’ appears to have a significant impact on student science self-efficacy. Students in rural schools score significantly lower on the science self-efficacy scale (N = -.03) than their peers in urban (N = .09) and suburban (N = .06) schools.

There is no statistically significant difference in the science self-efficacy of students for the independent variable ‘science teacher’s race’.

‘Teacher’s highest degree earned’ has a significant impact on student’s science self-efficacy. Students whose science teacher has an advanced degree score the highest on the science self-efficacy scale (N = .07), followed by students whose teacher has a highest degree of Master’s Degree (N = .06), Bachelor’s Degree (N = .03) , and Education Specialist Diploma (N = -.03). The means for Bachelor’s Degree and Master’s Degree are different from each other and both other groups.

Table 4.3: Weighted Comparison of Means on Student Science Self-Efficacy by Independent Variables (N in Parentheses)

Variable	Student Science Self-Efficacy
Student's Race	
Student is Black	.12[a] (1617)
Student is Hispanic	-.12[b] (2682)
Student is Asian/Pacific Islander	.20[c] (1489)
Student is White	.04[d] (9787)
Student is Other Race	.06 (1689)
Student's Science Course	
Life Science	.12[a] (4274)
Earth/Environmental Science	-.01[b] (1375)
Physical Science	-.004[b] (3386)
Other Science	.07[b] (807)
Urbanicity	
Urban	.09[a] (4961)
Suburban	.06[a] (6424)
Rural	-.03[b] (5879)
Science Teacher's Race	
Science Teacher is Black	.11 (489)
Science Teacher is Hispanic	.10 (450)
Science Teacher is Asian	.09 (272)
Science Teacher is White	.04 (11046)
Science Teacher is Other Race	.06 (262)

Table 4.3 (cont.): Weighted Comparison of Means on Student Science Self-Efficacy by Independent Variables (N in Parentheses)

Variable	Student Science Self-Efficacy
Teacher's Highest Degree Earned	
Bachelor's Degree	.03[a]
	(5396)
Master's Degree	.06[b]
	(6348)
Educational Specialist Diploma	-.03
	(392)
Advanced Degree (M.D./Ph.D./J.D.)	.07
	(433)

Note: Within the predictor on the dependent variable, two categories share a common superscript if their difference is not statistically significant at the .05 level. Those compared means without a common superscript do not differ from each other at any of the levels of statistical significance considered.

Table 4.4 presents the results from Pearson's Correlations that were performed to determine whether the continuous independent variables have a statistically significant association with the dependent variable 'student's science self-efficacy'. Correlation coefficients (Pearson's *r*) indicate the degree of linear relationship that each continuous independent variable has with the dependent variable and with each other. Pearson's Correlations reveal the following in relation to the population of students in this study:

Student's socioeconomic status has a weak positive correlation with every variable but cost perception. This relationship is statistically significant at the .01 level for the perceived affirming attitude and at the .001 level for student's science self-efficacy, science identity, science utility value, science interest, the number of years a student's teacher has taught high school science, and emphasis placed on teaching practices. The relationship is not significant for the amount of science coursework a student's teacher has completed. SES has a weak negative correlation with student cost perception, which is statistically significant at the .001 level.

Student's science identity has a moderate positive correlation with student's science self-efficacy, student's science utility value, and student's science interest; and a weak positive correlation with perceived affirming attitude ($p = .001$) emphasis on teaching practices ($p = .001$), and the number of years a teacher has taught high school science ($p = .05$). Student's science identity has a weak negative correlation with cost perception that is statistically significant at the .001 level.

Student's science utility value has a moderate positive correlation with student's science self-efficacy, this relationship is statistically significant at the .001 level. Student's science utility value also has a weak positive correlation with perceived affirming attitude, and emphasis on teaching practices, both of which are significant at the .001 level. Student's science utility value has a weak negative correlation with cost perception, this relationship is statistically significant at the .001 level.

Student’s science interest has a moderate positive correlation with student’s science self-efficacy and perceived affirming attitude. This relationship is statistically significant at the .001 level. Student’s science interest has a weak positive correlation with emphasis on teaching practices; this relationship is statistically significant at the .001 level. Student’s science interest has a weak negative correlation with cost perception ($p = .001$) and teacher’s amount of science coursework ($p = .05$).

Cost perception also has a weak negative correlation with perceived affirming attitude and emphasis on teaching practices. This relationship is statistically significant at the .001 level.

Teacher’s amount of science coursework has a weak positive correlation with years teaching high school science and a weak negative correlation with emphasis on teaching practices. Both relationships are statistically significant at the .001 level.

Years teacher has taught high school science also has a weak negative correlation with perceived affirming attitude and a weak positive correlation with emphasis on teaching practices. Both relationships are statistically significant at the .001 level.

There is a weak positive correlation between perceived affirming attitude and emphasis on teaching practices. This relationship is statistically significant at the .001 level.

Table 4.4: Pearson's Correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Student's Science Self-Efficacy	1	---	---	---	---	---	---	---	---
(2) Student's Socioeconomic Status	.15***	1	---	---	---	---	---	---	---
(3) Student's Science Identity	.50***	.18***	1	---	---	---	---	---	---
(4) Student's Science Utility Value	.40***	.03***	.42***	1	---	---	---	---	---
(5) Student's Science Interest	.51***	.07***	.48***	.50***	1	---	---	---	---
(6) Cost Perception	-.19***	-.06***	-.13***	-.17***	-.22***	1	---	---	---
(7) Teacher's Amount of Science Coursework	-.02	.02	-.01	-.01	-.03*	.00	1	---	---
(8) Years Teacher Has Taught High School Science	-.01	.09***	.03*	-.01	-.02	-.01	.09***	1	---
(9) Perceived Affirming Attitude	.29***	.03**	.16***	.27***	.48***	-.21***	-.01	-.05***	1
(10) Emphasis on Teaching Practices	.05***	.06***	.05***	.07***	.06***	-.03***	-.05***	.09***	.02*

*p = .05 **p = .01 ***p = .001

4.3 Multivariate Analysis

A central goal of this dissertation is to examine the multivariate influence that a number of student, school, and teacher level variables have on students' science self-efficacy. In order to accomplish this, OLS regression was used to determine the relative impact of selected independent variables in predicting the dependent variable of student science self-efficacy.

Four hierarchical regression models are used in this analysis. Model I examines the impact of student and school level variables on student science self-efficacy. This includes demographic variables that can be used to characterize students and variables that measure students' subjective task value (STV) in relation to science – their science identity, utility value, interest, and level of cost perception. Model II includes teacher characteristic variables that represent measures derived from current discourse on the assessment of teacher preparation and quality. Model III adds teaching practices variables that have the potential to create classroom conditions conducive to the development of self-efficacy. Finally, Model IV adds the teacher attitudes variable, which will examine the impact of perceived positive attitudes on students' science self-efficacy.

Each of these four models will be included in regression analysis for the entire sample of students (Models I – IV), for female students only (Models V through VIII), and for male students only (Models IX through XII).

Analysis and Interpretation of Science-Self-Efficacy for All Students

Table 4.5 presents Unstandardized Regression Coefficients for the dependent variable 'Student Science Self-Efficacy'. The four models in Table 4.5 – Models I, II, III, and IV – show the impact of student and school level variables, teacher characteristic variables, teaching practice variables, and teacher attitude variables in predicting student science self-efficacy for all students in the sample, irrespective of gender.

Table 4.5: Unstandardized Regression Coefficients (Beta in Parentheses) for Student Science Self-Efficacy for Entire Sample (N = 8822)

	Model I	Model II	Model III	Model IV
Student/School Level Variables				
Student is Female	-.20*** (-.10)	-.20*** (-.10)	-.20*** (-.10)	-.20*** (-.10)
Student's Race (Ref: White)				
Student is Black	.12*** (.03)	.10*** (.03)	.10*** (.03)	.10*** (.03)
Student is Hispanic	-.01 (-.004)	-.02 (-.01)	-.02 (-.01)	-.01 (-.004)
Student is Asian/Pacific Islander	.01 (.001)	.003 (.001)	.004 (.001)	.001 (.00)
Student is Other Race	.02 (.01)	.02 (.004)	.02 (.01)	.02 (.01)
Student's Socioeconomic Status	.09*** (.07)	.09*** (.07)	.09*** (.07)	.09*** (.07)
Student's Science Course (Ref: Life Science)				
Earth/Environmental Science	.05† (.02)	.06* (.02)	.06* (.02)	.07* (.02)
Physical Science	.04* (.02)	.05* (.02)	.05** (.02)	.05** (.03)
Other Science	.08* (.02)	.08* (.02)	.08* (.02)	.08** (.02)
Student's Science Identity	.27*** (.28)	.27*** (.28)	.27*** (.28)	.28*** (.30)
Student's Science Utility Value	.12*** (.12)	.12*** (.12)	.12*** (.12)	.11*** (.11)
Student's Science Interest	.30*** (.30)	.30*** (.30)	.29*** (.30)	.26*** (.26)
Student's Cost Perception	-.18*** (-.08)	-.18*** (-.08)	-.18*** (-.08)	-.16*** (-.07)

Table 4.5 (cont.): Unstandardized Regression Coefficients (Beta in Parentheses) for Student Science Self-Efficacy for Entire Sample (N = 8822)

	Model I	Model II	Model III	Model IV
Public School	.03 (.01)	.02 (.01)	.02 (.01)	.02 (.01)
Urbanicity (Ref: Suburban)				
Urban	.01 (.004)	.01 (.01)	.01 (.01)	.01 (.004)
Rural	-.04* (-.02)	-.04* (-.02)	-.04* (-.02)	-.04* (-.02)
Teacher Characteristic Variables				
Science Teacher is Male	---	-.04* (-.02)	-.04* (-.02)	-.05** (-.02)
Science Teacher's Race (Ref: White)				
Science Teacher is Black	---	.12** (.02)	.12** (.02)	.12** (.03)
Science Teacher is Hispanic	---	.02 (.004)	.02 (.003)	.03 (.01)
Science Teacher is Asian	---	.04 (.01)	.04 (.01)	.04 (.01)
Science Teacher is Other Race	---	-.01 (-.001)	-.01 (-.002)	-.02 (-.002)
Teacher Does Not Have Regular Certification	---	-.03 (-.01)	-.03 (-.01)	-.03 (-.01)
Teacher's Highest Degree (Ref: Master's)				
Bachelor's Degree	---	-.01 (-.01)	-.01 (-.01)	-.02 (-.01)
Education Specialist Diploma	---	-.10* (-.02)	-.10* (-.02)	-.09† (-.02)
Advanced Degree (M.D./Ph.D./J.D.)	---	-.03 (-.01)	-.03 (-.01)	-.03 (-.01)
Amount Of Teacher's Science Coursework	---	-.002 (-.01)	-.002 (-.01)	-.002 (-.01)
Teacher Previously Held Science Job	---	-.04* (-.02)	-.04* (-.02)	-.04* (-.02)

Table 4.5 (cont.): Unstandardized Regression Coefficients (Beta in Parentheses) for Student Science Self-Efficacy for Entire Sample (N = 8822)

	Model I	Model II	Model III	Model IV
Teacher Went Through Alternative Certification Pathway	---	-.001 (.00)	-.001 (-.001)	-.003 (-.001)
Years Teaching High School Science	---	-.002† (-.02)	-.002† (-.02)	-.002 (-.01)
Teaching Practice Variables				
Teacher Does Not Use Group Work	---	---	.03 (.01)	.03 (.01)
Level of Emphasis on Teaching Practices	---	---	.02 (.01)	.02 (.01)
Teacher Attitude Variables				
Perceived Affirming Attitude	---	---	---	.14*** (.08)
Constant	.32***	.41***	.33***	-.16
F	334.02***	185.62***	173.69***	171.69***
Adjusted R^2	.38	.38	.38	.38
R^2 Change	.38	.002	.000	.01

† p < .1 * p < .05 ** p < .01 *** p < .001

Student and School Level Variables

Models I through IV show significant gender differences in students' science self-efficacy. Controlling for all the other variables in each model, the science self-efficacy of female students is .20 units lower than that of male students. This relationship is robust and statistically significant at the .001 level for all four models.

Race appears to be an important factor only for science self-efficacy, but only between White and Black students. Controlling for all other variables in the models, the science self-efficacy of Black students is .12 units higher than that of their White counterparts in Model I, and .10 units higher in Models II through IV. This relationship is robust and statistically significant at the .001 level for all four models. There is no significant relationship between race and science self-efficacy for students coded as Hispanic, Asian/Pacific Islander, or Other race when compared with their White counterparts.

Students' socioeconomic status (SES) appears to be a significant predictor of students' science self-efficacy. Controlling for all the other variables in each model, for every unit increase in student SES, student science self-efficacy increases by .09 units. This relationship is robust and statistically significant at the .001 level for all four models.

The type of science course that a student is enrolled in is a significant predictor of students' science self-efficacy for each science content area in almost every model. Controlling for all other variables in Models I, II, III, and IV, students enrolled in an Earth or Environmental Science course score higher on the science self-efficacy scale by .05 units, .06 units, .06 units, and .07 units respectively than their counterparts enrolled in a Life Science course. This relationship is statistically significant at the .05 level when controlling for teacher characteristic, practice, and attitude variables in Models II through IV.

Controlling for all other variables in Models I, students enrolled in a Physical Science course score .04 units higher on the science self-efficacy scale than their counterparts enrolled in a Life Science course. Controlling for all other variables in Models II through IV, students in Physical Science score .05 units higher on the self-efficacy scale than their counterparts in Life Science. This relationship is statistically significant at the .05 level for Models I and II and at the .01 level for Models III and IV.

Controlling for all other variables in each model, students enrolled in a science course coded as Other Science score .08 units higher on the science self-efficacy scale than their counterparts enrolled in a Life Science course. This relationship is statistically significant at the .05 level for Models I through III and at the .01 level for Model IV.

Student science identity emerges as a powerful predictor of student science self-efficacy across all four models. Controlling for all other variables in each model, for every unit increase in student science identity, student science self-efficacy increased by .27 units in Models I through III and by .28 units in Model IV. This relationship is robust and statistically significant at the .001 level for all four models. Betas of .28, .28, .28, and .30 respectively show that student science identity is second only to student science interest when predicting student science self-efficacy in Models I through III and surpasses science interest to become the most powerful predictor when controlling for teacher attitudes in Model IV. Furthermore, student science identity is four times as powerful as SES (beta = .07 across all four models).

There is also a significant relationship between students' science self-efficacy and how they rate the usefulness of their science course. Controlling for all other variables in each model, for every unit increase in student science utility value, student science self-efficacy increased by

.12 units in Models I through III and by .11 units in Model IV. This relationship is robust and statistically significant at the .001 level for all four models.

Students' interest in their science course emerges at the most powerful predictor of their science self-efficacy across all four models. Controlling for all other variables in Model I, Model II, Model III, and Model IV, for every unit increase in student science interest, student science self-efficacy increased by .30, .30, .29, and .26 units respectively. This relationship is robust and statistically significant at the .001 level for all four models. Betas of .30 show science interest to be the greatest predictor of student science self-efficacy in Models I through III; however, when controlling for teacher attitudes in Model IV, the beta drops to .26 and science interest falls slightly below science identity.

The fourth component of STV, students' cost perception is also a significant predictor of students' science identity. Controlling for all other variables in each model, for every unit increase in student cost perception, student science self-efficacy decreased by .18 units in Models I through III and by .16 units in Model IV, meaning that the higher level of cost students associate with performing well in science, the lower their science self-efficacy. This relationship is robust and statistically significant at the .001 level for all four models.

The two school demographic variables, public school and urbanicity, are not significant predictors of students' science self-efficacy in any of the models.

In summary, a number of student and school level variables emerged as significant predictors of students' science self-efficacy across all four models. All four STV variables – students' science identity, science utility value, science interest, and cost perception – are significant, with science identity and science interest being the most powerful predictors of science self-efficacy. In terms of student demographics, female students have significantly lower science self-efficacy than their male counterparts; black students have significantly higher science self-efficacy than their white counterparts. SES is another significant predictor of students' science self-efficacy across all four models. Science course enrollment is also significant; students in every other scientific discipline (Earth, Environmental, Physical, and Other Science) have higher science self-efficacy than students in Life Science courses. School control and urbanicity do not have a significant impact on students' science self-efficacy.

Teacher Characteristic Variables

Science teacher gender is an important factor in predicting students' science self-efficacy. Controlling for all other variables in Models II, III, and IV, students with male science teachers score .04, .04, and .05 units lower respectively on the science self-efficacy scale than students with a female science teacher. This relationship is statistically significant at the .01 level in Models II and III; significance increases to the .001 level when controlling for teacher attitudes in Model IV.

Science teacher race is also significant in predicting students' science self-efficacy, but only when comparing Black science teachers with White science teachers. Controlling for all other variables in each model, the science self-efficacy of students whose science teacher is Black is .12 units higher than that of students with a White science teacher. This relationship is robust and statistically significant at the .01 level across all three models. Race is not a relevant factor when comparing students with White science teachers with students whose science teacher is Hispanic, Asian, or Other race.

The highest degree a science teacher has earned is slightly relevant to students' science self-efficacy. Controlling for all other variables in each model, students whose teacher has an education specialist diploma score .10. .10, and .09 units lower on the science self-efficacy scale in Models II, III, and IV, respectively, than students whose science teacher has a Master's degree as their highest degree earned. This relationship is statistically significant at the .05 level in Models II and III; significance disappears when controlling for teacher attitudes in Model IV.

A science teacher having held a science job prior to entering the teaching profession does not seem to benefit students' science self-efficacy. Controlling for all other variables in Models II through IV, students whose science teacher previously held a science job score .04 units lower on the science self-efficacy scale than students whose teacher did not have a science job prior to entering the teaching profession. This relationship is statistically significant at the .05 level for all three models.

The teacher characteristic variables of certification status, science coursework, certification pathway, and time teaching are not relevant to students' science self-efficacy.

Teaching Practices and Attitude Variables

Neither of the teaching practices variables – the use of group work and the emphasis placed on teaching practices – demonstrate any level of significance in predicting students' science self-efficacy.

Teacher attitude is a significant predictor of students' science self-efficacy. Students who perceive their science teacher to project an "affirming attitude" score .14 units higher on the science self-efficacy than their peers who do not perceive their science teacher to have an affirming attitude. This relationship is statistically significant at the .001 level. A beta of .08

signifies that teacher attitude is even slightly more powerful than SES (beta = .07) in predicting students' science self-efficacy.

In summary, the Adjusted R^2 for each model was .38, indicating that the variables in each model account for 38% of the variance in student science self-efficacy. The F-test for each model was statistically significant at the .001 level, confirming that the independent variables in each model are useful in predicting the outcome variable.

Analysis and Interpretation of Science-Self-Efficacy for Female Students

Table 4.6 presents Unstandardized Regression Coefficients for the dependent variable 'Student Science Self-Efficacy'. The four models in Table 4.6 – Models V, VI, VII, and VIII – show the impact of student and school level variables, teacher characteristic variables, teaching practice variables, and teacher attitude variables in predicting student science self-efficacy for female students only.

Table 4.6: Unstandardized Regression Coefficients (Beta in Parentheses) for Student Science Self-Efficacy for Females Only (N = 4470)

	Model V	Model VI	Model VII	Model VIII
Student/School Level Variables				
Race (Ref: White)				
Student is Black	.15***	.13**	.13**	.13**
	(.04)	(.04)	(.04)	(.04)
Student is Hispanic	-.02	-.03	-.03	-.03
	(-.01)	(-.01)	(-.01)	(-.01)
Student is Asian/Pacific Islander	-.04	-.04	-.04	-.04
	(-.01)	(-.01)	(-.01)	(-.01)
Student is Other Race	.06	.05	.05	.06
	(.02)	(.02)	(.02)	(.02)
Student's Socioeconomic Status	.08***	.08***	.08***	.08***
	(.06)	(.06)	(.06)	(.06)
Student's Science Course (Ref: Life Science)				
Earth/Environmental Science	.04	.05	.05	.06†
	(.02)	(.02)	(.02)	(.02)
Physical Science	.05	.05	.05†	.05†
	(.02)	(.02)	(.02)	(.03)
Other Science	.09*	.09*	.09*	.09*
	(.03)	(.03)	(.03)	(.03)
Student's Science Identity	.26***	.26***	.26***	.27***
	(.27)	(.26)	(.26)	(.28)
Student's Science Utility Value	.10***	.10***	.10***	.10***
	(.10)	(.10)	(.10)	(.10)
Student's Science Interest	.33***	.33***	.33***	.29***
	(.33)	(.33)	(.33)	(.29)
Student's Cost Perception	-.21***	-.21***	-.21***	-.18***
	(-.09)	(-.09)	(-.09)	(-.07)

Table 4.6 (cont.): Unstandardized Regression Coefficients (Beta in Parentheses) for Student Science Self-Efficacy for Females Only (N = 4470)

	Model V	Model VI	Model VII	Model VIII
Public School	.01 (.01)	.02 (.01)	.02 (.01)	.02 (.01)
Urbanicity (Ref: Suburban)				
Urban	-.01 (-.01)	-.01 (-.01)	-.01 (-.01)	-.01 (-.01)
Rural	-.07* (-.03)	-.07* (-.03)	-.07* (-.03)	-.07* (-.03)
Teacher Characteristic Variables				
Science Teacher is Male	---	-.06* (-.03)	-.06* (-.03)	-.06* (-.03)
Science Teacher's Race (Ref: White)				
Science Teacher is Black	---	.14* (.03)	.14* (.03)	.14* (.03)
Science Teacher is Hispanic	---	.02 (.003)	.01 (.002)	.03 (.01)
Science Teacher is Asian	---	.08 (.01)	.08 (.01)	.09 (.01)
Science Teacher is Other Race	---	-.03 (-.004)	-.03 (-.01)	-.03 (-.004)
Teacher Does Not Have Regular Certification	---	.01 (.01)	.01 (.01)	.01 (.004)
Teacher's Highest Degree (Ref: Master's)				
Bachelor's Degree	---	.01 (.01)	.01 (.01)	.01 (.01)
Education Specialist Diploma	---	-.09 (-.02)	-.10 (-.02)	-.09 (-.02)
Advanced Degree (M.D./Ph.D./J.D.)	---	.02 (.003)	.01 (.003)	.03 (.01)
Amount Of Teacher's Science Coursework	---	-.003 (-.01)	-.003 (-.01)	-.003 (-.01)
Teacher Previously Held Science Job	---	-.02 (-.01)	-.02 (-.01)	-.02 (-.01)

Table 4.6 (cont.): Unstandardized Regression Coefficients (Beta in Parentheses) for Student Science Self-Efficacy for Females Only (N = 4470)

	Model V	Model VI	Model VII	Model VIII
Teacher Went Through Alternative Certification Pathway	---	-.03 (-.02)	-.03 (-.02)	-.04 (-.02)
Years Teaching High School Science	---	-.001 (-.01)	-.001 (-.01)	.001 (-.01)
<u>*Teaching Practice Variables*</u>				
Teacher Does Not Use Group Work	---	---	.03 (.01)	.04 (.01)
Level of Emphasis on Teaching Practices	---	---	.02 (.01)	.03 (.01)
<u>*Teacher Attitude Variables*</u>				
Perceived Affirming Attitude	---	---	---	.15*** (.08)
Constant	.19***	.25***	.17	-.36*
F	173.30***	93.72***	87.48***	86.54***
Adjusted R^2	.37	.37	.37	.37
R^2 Change	.37	.003	.00	.01

† $p < .1$ * $p < .05$ ** $p < .01$ *** $p < .001$

Student and School Level Variables

Race is a relevant factor when comparing the science self-efficacy of Black female students with that of their White female peers. Controlling for all other variables in Models V through VIII, Black female students score higher on the science self-efficacy scale than their White female counterparts by .15 units in Model V, and .13 units in Models VI through VIII. This relationship is statistically significant at the .001 level in model V; significance drops to the .01 level when controlling for teacher variables in Models VI through VIII. Race is not a relevant factor when comparing the science self-efficacy of female students coded as Hispanic, Asian/Pacific Islander, or Other Race with their White counterparts.

Socioeconomic status is another significant predictor of science self-efficacy for female students. Controlling for all other variables in Models V through VIII, for every unit increase in SES, female students' science self-efficacy increases by .08 units. This relationship is robust and statistically significant at the .001 level across all four models.

The only science course that appears to be relevant to the science self-efficacy of female student is Other Science. Controlling for all other variables in Models V through VIII, female students enrolled in a science course categorized as Other Science score .09 units higher on the self-efficacy scale than their peers enrolled in Life Science. This relationship is statistically significant at the .05 level across all four models. Enrollment in Earth/Environmental or Physical Science is not a relevant factor in predicting the science self-efficacy of female 9th graders.

All four components of students' subjective task value appear to be significant predictors of science self-efficacy for female students.

Students' science identity is a powerful predictor of science self-efficacy for female students, second only to science interest. Controlling for all other variables in Models V through VIII, for every unit increase in student science identity, student science self-efficacy increases by .26 units in Models V through VII and by .27 units in Model VIII. This relationship is robust and statistically significant at the .001 level across all four models.

The second STV component, students' science utility value, is also a significant predictor of the science self-efficacy of female students. Controlling for all other variables in Models V through VIII, for every unit increase in student's science utility value, student science self-efficacy increases by .10 units. This relationship is statistically significant at the .001 level across all four models.

The most powerful predictor of science self-efficacy for female students across all four models is student's science interest. Controlling for all other variables in Models V through VIII, for every unit increase in student's science interest, student science self-efficacy increases by .33 units for Models V through VII, its influence drops to .26 units when controlling for teacher attitudes in Model VIII. This relationship is statistically significant at the .001 level across all four models.

Cost perception is also relevant to the science self-efficacy of female 9th graders. Controlling for all other variables in Models V through VIII, for every unit increase in student's cost perception, student science self-efficacy decreases by .21 units in Models V through VII and by .18 units in Model VIII. This relationship is statistically significant at the .001 level across all four models.

In terms of school demographic variables, school control (public versus private) does not impact science self-efficacy for female 9th graders; however, urbanicity does appear to be a relevant factor. Controlling for all other variables in Models V through VIII, the science self-efficacy of female students in rural schools is .07 units lower than that of their peers in suburban schools. This relationship is statistically significant at the .05 level across all four models. There is no significant difference in the self-efficacy of female students in urban schools compared to their peers in suburban schools.

Teacher Characteristic Variables

Two teacher characteristic variables are relevant to the science self-efficacy of female students. Science teacher gender is a significant predictor of science self-efficacy for female 9th graders. Controlling for all other variables in Models VI through VIII, the science self-efficacy of female students with a male science teacher is .06 units lower than that of female students with a female science teacher. This relationship is statistically significant at the .05 level across all three models.

Science teacher race is another significant predictor of science self-efficacy for female students whose science teacher is Black compared with female students whose science teacher is White. Controlling for all other variables in Models VI through VIII, the self-efficacy of female 9th graders with a Black science teacher is .14 units higher than that of their female peers whose science teacher is White. This relationship is statistically significant at the .05 level across all three models.

None of the other teacher characteristic variables – which include certification status, highest degree, science coursework, previously held science job, certification pathway, and years teaching high school science – exhibit a significant relationship with the science self-efficacy of female 9th grade students.

Teaching Practices and Attitude Variables

As with the regression results for the entire sample of students, neither of the teaching practices domain variables demonstrate any level of significance in predicting the science self-efficacy of female students. The use of group work and the level of emphasis placed on teaching practices are not relevant factors to the science self-efficacy of female 9th graders.

Controlling for all other variables in Model VIII, the science self-efficacy of female students who perceive an affirming attitude from their science teacher is .15 units higher than that of female students who do not perceive their science teacher to have an affirming attitude. A beta of .08 signifies that this variable is more powerful than many all other teacher variables and student demographic variables, including SES (beta = .06). When predicting students' science self-efficacy in this model, the only variables more powerful than perceived affirming attitude are the STV variables of students' science identity, science utility value, and science interest.

In summary, the Adjusted R^2 for each model was .37, indicating that the variables in each model account for 37% of the variance in student science self-efficacy for female 9th graders. The F-test for each model was statistically significant at the .001 level, confirming that the independent variables in each model are useful in predicting the outcome variable.

Analysis and Interpretation of Science-Self-Efficacy for Male Students

Table 4.7 presents Unstandardized Regression Coefficients for the dependent variable 'Student Science Self-Efficacy'. The four models in Table 4.7 – Models IX, X, XI, and XII – show the impact of student and school level variables, teacher characteristic variables, teaching practice variables, and teacher attitude variables in predicting student science self-efficacy for male students only.

Table 4.7: Unstandardized Regression Coefficients (Beta in Parentheses) for Student Science Self-Efficacy for Males Only (N = 4352)

	Model IX	Model X	Model XI	Model XII
Student/School Level Variables				
Race (Ref: White)				
Student is Black	.09*	.08†	.08†	.08†
	(.03)	(.02)	(.02)	(.02)
Student is Hispanic	-.003	-.01	-.01	-.002
	(-.001)	(-.002)	(-.002)	(-.001)
Student is Asian/Pacific Islander	.05	.05	.05	.05
	(.01)	(.01)	(.02)	(.01)
Student is Other Race	-.02	-.02	-.02	-.02
	(-.01)	(-.01)	(-.01)	(-.004)
Student's Socioeconomic Status	.11***	.11***	.11***	.11***
	(.09)	(.09)	(.09)	(.08)
Student's Science Course (Ref: Life Science)				
Earth/Environmental Science	.05	.05	.06	.06†
	(.02)	(.02)	(.02)	(.02)
Physical Science	.05	.05†	.05†	.05†
	(.02)	(.02)	(.02)	(.02)
Other Science	.06	.06	.07	.07
	(.02)	(.02)	(.02)	(.02)
Student's Science Identity	.29***	.29***	.29***	.29***
	(.30)	(.30)	(.30)	(.30)
Student's Science Utility Value	.13***	.13***	.13***	.13***
	(.13)	(.14)	(.14)	(.13)
Student's Science Interest	.27***	.27***	.27***	.23***
	(.27)	(.27)	(.27)	(.24)
Student's Cost Perception	-.15***	-.15***	-.15***	-.14***
	(-.07)	(-.07)	(-.07)	(-.06)

Table 4.7 (cont.): Unstandardized Regression Coefficients (Beta in Parentheses) for Student Science Self-Efficacy for Males Only (N = 4352)

	Model IX	Model X	Model XI	Model XII
Public School	.05 (.02)	.01 (.01)	.01 (.01)	.01 (.004)
Urbanicity (Ref: Suburban)				
Urban	.03 (.01)	.03 (.02)	.03 (.02)	.03 (.02)
Rural	-.02 (-.01)	-.02 (-.01)	-.02 (-.01)	-.02 (-.01)
Teacher Characteristic Variables				
Science Teacher is Male	---	-.02 (-.01)	-.02 (-.01)	-.03 (-.02)
Science Teacher's Race (Ref: White)				
Science Teacher is Black	---	.10 (.02)	.09 (.02)	.10 (.02)
Science Teacher is Hispanic	---	.02 (.003)	.02 (.003)	.02 (.004)
Science Teacher is Asian	---	-.03 (-.01)	-.03 (-.01)	-.04 (-.01)
Science Teacher is Other Race	---	.01 (.001)	.01 (.001)	.002 (.00)
Teacher Does Not Have Regular Certification	---	-.07* (-.03)	-.08* (-.03)	-.07* (-.03)
Teacher's Highest Degree (Ref: Master's)				
Bachelor's Degree	---	-.04 (-.02)	-.04 (-.02)	-.04 (-.02)
Education Specialist Diploma	---	-.09 (-.02)	-.09 (-.02)	-.08 (-.02)
Advanced Degree (M.D./Ph.D./J.D.)	---	-.08 (-.02)	-.08 (-.02)	-.08 (-.02)
Amount Of Teacher's Science Coursework	---	-.002 (-.01)	-.002 (-.01)	-.002 (-.01)
Teacher Previously Held Science Job	---	-.05† (-.03)	-.05* (-.03)	-.06* (-.03)

Table 4.7 (cont.): Unstandardized Regression Coefficients (Beta in Parentheses) for Student Science Self-Efficacy for Males Only (N = 4352)

	Model IX	Model X	Model XI	Model XII
Teacher Went Through Alternative Certification Pathway	---	.03 (.01)	.03 (.01)	.03 (.01)
Years Teaching High School Science	---	-.003 (-.02)	-.003† (-.03)	-.003† (-.02)
Years Teaching in Current School	---	-.001 (-.01)	-.001 (-.01)	.00 (-.002)
Teaching Practice Variables				
Teacher Does Not Use Group Work	---	---	.03 (.01)	.03 (.01)
Level of Emphasis on Teaching Practices	---	---	.03 (.01)	.02 (.01)
Teacher Attitude Variables				
Perceived Affirming Attitude	---	---	---	.14*** (.08)
Constant	.25***	.38***	.30*	-.16
F	171.26***	92.60***	86.43***	85.22***
Adjusted R^2	.37	.37	.37	.38
R^2 Change	.37	.003	.00	.004

† $p < .1$ * $p < .05$ ** $p < .01$ *** $p < .001$

Student and School Level Variables

Student race does not appear to be a relevant factor in determining the science self-efficacy of male 9th graders. Controlling for all other variable in Model IX, Black male students score .09 units higher on the science self-efficacy scale than their White male counterparts ($p < .05$); however, the statistical significance of this difference disappears after controlling for all teacher variables in Models X through XII. Race is not a relevant factor when comparing the science self-efficacy of male students coded as Hispanic, Asian/Pacific Islander, or Other Race with their White peers.

Socioeconomic status is also a significant predictor of science self-efficacy for male 9th graders. Controlling for all other variables in Models IX through XII, for every unit increase in SES, the science self-efficacy of male 9th graders increases by .11 units. This relationship is robust and statistically significant at the .001 level across all four models. It should also be noted that the SES coefficients for males are higher than those of females ($B = .08$ across all four models), suggesting that socioeconomic status may play a greater role in determining the science self-efficacy of male 9th graders than for female 9th graders.

As with female students, the STV components of science identity and science interest are the most powerful predictors of science self-efficacy for male 9th graders. Controlling for all other variables in Models IX through XII, for every unit increase in student's science identity, the science self-efficacy of male students increase by .29 units. This relationship is robust and statistically significant at the .001 level across all four models.

No other student or school level variables – including course enrollment, school control, and urbanicity – appear to be significant in predicting the science self-efficacy of male 9th grade students.

Teacher Characteristic Variables

Only two teacher characteristic variables are significant in predicting the science self-efficacy of male students, the first of which is certification status. Controlling for all other variables in Models X through XII, the science self-efficacy of male students whose science teacher does not have regular certification is .07 units lower in Models X and XII and .08 units lower in Model XI than that of their male peers whose teacher does have regular certification. This relationship is statistically significant at the .05 level for all three models.

The second significant teacher characteristic variable is science coursework. Controlling for all other characteristics in Models X through XII, the science self-efficacy of male students whose teacher held a science job prior to becoming a teacher is .05, .05, and .06 units lower respectively than that of their male peers whose teacher did not previously have a science job. This relationship is only statistically significant at the .05 level in Model XI and XII which control for teaching practices and teacher attitudes.

Teaching Practices and Attitude Variables

As with their female peers, neither of the teaching practices domain variables demonstrate any level of significance in predicting the science self-efficacy of male students. The use of group work and the level of emphasis placed on teaching practices are not relevant factors to the science self-efficacy of male 9^{th} graders.

Controlling for all other variables in Model XII, the science self-efficacy of male 9^{th} graders who perceive an affirming attitude from their science teacher is .14 units higher than that of male 9^{th} graders who do not perceive their science teacher to have an affirming attitude. This relationship is statistically significant at the .005 level. A beta of .08 places this variable on par with SES but below the STV variables of student science identity, utility value, and interest in terms of its power in predicting science self-efficacy in male 9th graders.

In summary, the Adjusted R^2 for Models IX through XI was .37, indicating that the variables in each model account for 37% of the variance in student science self-efficacy for male 9th graders. The Adjusted R^2 rose to .38 in Model XII, indicating that the variables in this model account for 38% of the variance in student science self-efficacy. The F-test for each model was statistically significant at the .001 level, confirming that the independent variables in each model are useful in predicting the outcome variable.

4.4 Summary of Results

A total of twelve regression models were used to examine the strength of student and school level variables, teacher characteristic variables, teaching practices variables, and teacher attitude variables in predicting the dependent variable of student science self-efficacy. Several independent variables proved to be significant predictors of student science self-efficacy. In brief, the effects of gender, race and socioeconomic status are robust throughout all twelve models. The student level variables of science identity and science interest appear to be powerful predictors of science self-efficacy for 9th graders across both genders. Teacher gender is a significant predictor of science self-efficacy for female students only. The self-efficacy of female students is also affected by urbanicity. Male students seem to be more sensitive to teacher certification. Finally, students who perceive affirming attitudes from their science teacher report higher levels of science self-efficacy. The following chapter will now develop these results in relation to the theoretical framework and relevant literature previously discussed in Chapter 2.

Chapter Five: Discussion

This dissertation employed ordinary least squares (OLS) regression analysis to examine the impact of multiple student, school, and teacher level variables in predicting ninth grade student science self-efficacy. As presented in Chapter Four, the results of this analysis indicate that multiple student and teacher level variables are significant predictors of science self-efficacy for ninth grade students. Salient findings include the powerful effects of student science identity and science interest on the science self-efficacy of all students, the importance of teacher gender for the science self-efficacy of female students, the significance of teacher certification for the science self-efficacy of male students, and the impact of positive teacher attitudes on the science self-efficacy of all students. The remainder of this chapter will discuss these results as they relate to the findings of previous research. Findings will also be contextualized within the framework of bioecological systems theory, social cognitive theory, and motivation and achievement goal theory.

5.1 Domains

A number of independent variables were selected for analysis in this dissertation based upon a review of the literature surrounding self-efficacy, teacher effects, and student success in science. These variables were grouped into four major domains: student and school level variables, teacher characteristic variables, teaching practices variables, and teacher attitude variables. The remainder of this chapter will discuss the findings regarding each of these domains in conjunction with both the literature and theory that informs this study.

Student and School Level Variables

Three student demographic variables were examined in this study: student gender, student race, and student socioeconomic status. For the most part, the findings from the current study corroborate previous research surrounding student demographics and student self-efficacy, both in general and in the specific domain of science.

Results from the current study indicate a significant gender gap in science self-efficacy; female ninth graders report lower levels of science self-efficacy than their male counterparts. This aligns with previous research on gender and self-efficacy in general (Gecas, 1989) and specifically in science (Sikora & Pokropek, 2012; Schunk & Pajares, 2002), with one exception. Britner and Pajares (2006) found that middle school girls reported higher levels of science self-efficacy than did boys; the authors theorized that this may be due to the tendency of middle school science to be more language based than high school courses. Findings from this study support that theory – girls in high school do indeed report lower levels of science self-efficacy than their male peers. Britner and Pajares also did not use a nationally representative sample of students in their study, which is another possible explanation of the discrepancy between their findings and the findings of both this study and previous research.

The existing literature on student self-efficacy and race presents mixed results; some argue that Blacks and Hispanics have lower general self-efficacy than their White peers (Gecas, 1989; Mayo & Christenfeld, 1999; Hackett et al., 1992), while others have found that racial minority students actually have higher levels of self-efficacy (White & Bowers, 2008). This discrepancy is most likely due to the domain specificity of self-efficacy; generalized self-efficacy may differ from self-efficacy in various academic subject areas, which will in turn differ from each other. To complicate this, self-efficacy beliefs change over time, with adolescence being a prime period for self-efficacy decline. Furthermore, not much of the existing research has examined student self-efficacy in the particular domain of high school science.

Results from the current study show that student race also has a significant impact on student science self-efficacy, with black students reporting higher levels of self-efficacy than their white peers. This aligns with some of the more current research on student race and self-efficacy (White & Bowers, 2008), but contrasts with some of the older research (Gecas, 1989; Hackett et al., 1992). As discussed above, this difference may be due to the fact that much of the previous research indicating lower self-efficacy in blacks examines generalized self-efficacy as opposed to science-specific self-efficacy. However, splitting the data by gender shows that this finding is only significant for female students; the difference between black male students and white male students loses significance when controlling for teacher characteristics, teaching practices, and teacher attitude variables. This finding is interesting as most prior studies have not separated students by gender when examining self-efficacy and race.

As expected, student socioeconomic status is a significant predictor of student science self-efficacy, confirming the findings of an already robust body of research on socioeconomic status and self-efficacy (Gecas, 1989; Han et al., 2015; Boardman & Robert, 2000; Battistich et al., 1995).

Previous research (Britner, 2008) has called for disaggregating science course data into the various domains of science, such as life, earth, and physical science. Results from the current study show that science course has a small but significant effect on student science self-efficacy, with students enrolled in earth/environmental science, physical science, or other science all reporting higher levels of science self-efficacy than their peers in life science. However, after the data is separated by gender most of these differences disappear; there are no differences in self-efficacy by science course for male and only female students enrolled in courses coded as other science reporting higher levels of self-efficacy than their counterparts enrolled in life science courses. This supports Britner's claim that data concerning student performance in science can be more informative when separated by specific courses. Britner also found that girls reported higher levels of anxiety in life and physical science courses, which is a possible explanation for the difference between girls in life science and girls in other science in the current study.

The four components of subjective task value based on the Eccles et al. expectancy value framework all proved to be significant predictors of science self-efficacy, with student science identity, science utility value, and science interest demonstrating a positive impact and student science cost perception having a negative one. In fact, the two variables of student science identity and student science interest emerged as the most powerful predictors of student science self-efficacy when controlling for all other variables across each model in the study. This finding holds true for both genders, and aligns with the expectancy-value framework of motivation theory, which states that expectancies (self-efficacy) and values (identity, utility, interest, cost perception) are highly related (Wigfield & Eccles, 2000) but should be considered independently in order to provide greater insight into the motivational dynamics that influence student achievement (Pintrich, 2000). As discussed in Chapter 2, there is a dearth of research on the ways in which the various components of the expectancy-value model act upon one another. Findings from the current study provide a basis for exploring the dynamics between motivational factors by revealing that although all five expectancy-value components are highly related, student identity and interest exert the most influence upon student self-efficacy in the domain of high school science. In fact, identity and interest are up to four times as powerful as socioeconomic status in predicting student science self-efficacy, a noteworthy result as socioeconomic status has long been established as a strong predictor of self-efficacy across multiple domains and age levels.

For the two school level variables, school control showed no effect on students' expectations for success in science; there was no significant difference in the science self-efficacy of students in public schools and their peers in nonpublic schools. On the other hand, urbanicity revealed one unanticipated result; girls in rural schools reported significantly lower levels of science self-efficacy than their peers in suburban schools. There is a relative dearth of research on education in rural versus suburban schools (Arnold et al., 2005), and even less concerning science education, gender, and self-efficacy. The findings that do exist in the current literature are inconclusive. Some researchers contend that students in rural schools have lower expectations than their peers in urban or suburban settings (Blanton & Harmon, 2005); others have found that rural students' general self-related competencies do not significantly differ from those of their urban or suburban peers (Yang & Fetsch, 2007). These studies do not consider science self-efficacy in particular, nor do they compare the expectations of female versus male students. The results of this study add to the existing literature by providing insight concerning gender differences in the science self-efficacy of rural ninth graders.

Teacher Characteristic Variables

As discussed in Chapter 2, there is a paucity of literature that examines the influence of teacher characteristics on student self-efficacy; most of the research on teacher characteristics instead uses student achievement as an outcome variable. However, results from this study indicate a number of interesting relationships between various teacher characteristics and student science self-efficacy.

The most striking results from the teacher characteristics domain concern teacher demographics. Science teacher gender and race both emerged as significant predictors of student science self-efficacy for girls only. Female ninth graders report higher levels of science self-efficacy when their science teacher is also female; female ninth graders whose science teacher is black report higher levels of science self-efficacy than their female peers whose science teacher is white. These findings are more informative regarding gender, as that is how the data file was split. In order to fully explore the finding concerning teacher race, it would be helpful to analyze this result for students from each racial group. The significance of science teacher gender in predicting the self-efficacy of female ninth graders corroborates the role model effect described in previous research (Dee, 2005; Bettinger & Long, 2005; Nixon & Robinson, 1999). This effect also confirms the findings of recent studies that have explored the importance of teacher gender for the success of girls in science (Bottia et al., 2015).

There is a deficiency of research on teacher certification status and student self-efficacy; most of the research on teacher certification instead examines its effect on student achievement (Darling-Hammond et al., 2005; Goldhaber & Brewer, 2000; Eckert, 2012). The current study provides additional insight into the effects of teacher certification on students by exploring the impact of certification status on student self-efficacy in science. Teacher certification status proves to be significant for the self-efficacy of boys only; male students whose science teacher holds regular certification report higher levels of science self-efficacy than male students whose teacher does not have regular certification. The effect of certification status is more important than that of factors such as race and gender for improving boys' science self-efficacy, indicating that teachers need to be well prepared in order to meet the needs of high school boys in science.

One unexpected result concerning teacher characteristics is that teachers who held a science related job prior to entering the teaching profession have a small but significant negative effect on the science self-efficacy of male students. Studies have shown that prior job experience has no significant effect on instructional quality (Scribner and Akiba, 2010). Results from this study do not dispute previous findings, as this study focuses on student self-efficacy rather than student achievement or instructional quality. However, it is worthwhile to note that although prior job experience does not affect instructional quality, it does have a negative impact on student self-efficacy – a proven antecedent to achievement – and thus warrants further investigation.

A number of teacher characteristic variables drawn from current policy discourse demonstrated no significant effect on student science self-efficacy. These variables include the amount of science coursework completed by a teacher, the type of pathway to certification, and the number of years teaching. Although prior research indicates that these three characteristics are important determinants of student achievement (Goldhaber & Brewer, 2000; Monk, 1994; Darling-Hammond et al., 2005; Hanushek et al., 2005), their influence does not appear to hold true for student self-efficacy.

Teaching Practices Variables

The use of group work was hypothesized to have a positive impact on student science self-efficacy due to the potential of cooperative learning activities to create mastery experiences, verbal persuasion, and peer comparison situations. Emphasis placed on various teaching practices was also considered as a variable because different teaching practices may provide varying levels of the theorized sources of self-efficacy. Additionally, teaching practices have been shown to varying effects on student self-efficacy and achievement (Siegle & McCoach, 2007; Wilson et al., 2010). Neither of the teaching practices variables – the use of group work or the amount of emphasis placed on teaching practices – were found to have a significant effect on student science self-efficacy.

Results would seem to refute previous research on the importance of teaching practices in relation to student self-efficacy as well as the theorized sources of self-efficacy that may be activated through the use of collaborative grouping in science classrooms (Siegle & McCoach, 2007; Farrington et al., 2012). However, these discrepancies are more likely due to the quantitative nature of this study and the limitations of survey data. The mere use of group work is not enough to contribute to student science self-efficacy; there are more intricate and subjective elements of collaborative group work and teaching practices that cannot be examined through general questionnaire items. Teacher self-reporting of instructional practices does not effectively capture the dynamic nature of classroom interactions that occur between teachers and students.

The teaching practices variables were selected based on a review of the literature surrounding self-efficacy and classroom instruction. Siegle and McCoach (2007) found that teachers who effectively used the theorized sources of self-efficacy in their instructional practices had a significant positive impact on student self-efficacy in mathematics; this was after teachers had received training on instructional practices believed to improve student self-efficacy and had employed these practices over the course of a four week unit. Self-efficacy was compared for students of teachers who had received and used the training techniques and for students of teachers who had not received or used training techniques. Siegle and McCoach specifically controlled for instructional practices theorized to influence student self-efficacy; data used in the current study does not have the same level of specificity in terms of teaching practices. Teachers merely reported which instructional practices they were planning to emphasize during the school year. In theory, there may be a difference between some of these practices in their potential to provide the sources of self-efficacy, but the HSLS questionnaire does not provide any further insight into how exactly these practices are employed in the classroom. Teaching practices are perhaps better explored through classroom observations, or at the least more detailed questionnaire items, that can account for differences in instructional techniques based on teacher individuality.

Teacher Attitude Variables

Aside from the findings on teacher demographic variables that may have a role model effect on student science self-efficacy, the most salient finding from the teacher level variables concerns student perceptions of teacher attitudes. Based on the literature surrounding teacher attitudes and expectations (Villegas & Lucas, 2002; Stronge et al, 2011; Pajares, 1997; Tyler & Boelter, 2008), positive teacher attitudes were hypothesized to have a positive impact on student self-efficacy. Indeed, students who perceived positive affirming attitudes from their science teachers reported significantly higher levels of science self-efficacy. This confirms that the findings of previous research regarding the influence of perceived teacher expectations on student self-efficacy (Tyler & Boelter, 2008) hold true for the specific domain of science at the high school level. In addition, this finding supports the assertion that students benefit from teachers who demonstrate affirming attitudes (Villegas & Lucas, 2002; Stronge et al., 2011) and that the development of such attitudes should be an important part of teacher recruitment and preparation programs.

5.2 Theoretical Discussion

A framework incorporating the ideas of four major theories was used to situate this study in the existing literature on student self-efficacy. The current study confirms the importance of person and environment in human development emphasized by bioecological theory as well as a few of the theorized sources of self-efficacy described in social cognitive theory. Results also align with the concepts of motivation theory, specifically the expectancy-value model of motivation. However, findings are not consistent with the ideas of achievement goal theory due to limitations that will be discussed in the following sections.

Bioecological Systems Theory

The bidirectional nature of influence between individuals and their environment emphasized in Urie Bronfenbrenner's bioecological systems theory was used to situate this study in the interactions of the science classroom while at the same time allowing for the consideration of both external factors and student individuality in relation to student science self-efficacy. Indeed, variables from within the students and in the various subsystems of their environments were found to have a significant influence on students' expectations for success in science.

In considering Bronfenbrenner's process-person-context-time model (PPCT), process refers to proximal processes, or "enduring forms of interaction in the immediate environment" (1997, p.38). In this dissertation, teaching practices and perceived teacher attitudes served as variables representing proximal processes of the science classroom. Perceived positive attitudes proved to have a significant positive effect on student science self-efficacy, demonstrating the influence of proximal process (teacher attitudes) on development (student science self-efficacy). While teaching practices did not demonstrate any significant effect on students' expectations for success in science, it can be argued that the quantitative nature of this study limits the understanding of the ways in which various teaching practices are utilized, and the means by which these practices influence the dynamics of classroom interactions.

Bronfenbrenner describes three types of personal characteristics that individuals bring into social situations: demand characteristics, resource characteristics, and force characteristics (Tudge et al., 2009). All three of these characteristics prove to be significant contributors to student science self-efficacy. Demand characteristics such as gender and race are important on both the student level and the teacher level. Resource characteristics, quantified in this study as student socioeconomic status, are another significant predictor of student science self-efficacy; the greater the amount of resources, the higher the level of reported self-efficacy. The final personal characteristic type, force characteristics, demonstrates the greatest effect on student science self-efficacy. Bronfenbrenner defines force characteristics as those personal characteristics having to do with an individual's temperament, motivation, and persistence (Tudge et al., 2009). Out of all the variables included in this study, the motivational constructs of student science identity and science interest have the greatest impact on student science self-efficacy.

Moving to Bronfenbrenner's systems, or the context portion of the PPCT model, we again observe that variables from across all systems have an impact on student science self-efficacy. The most powerful factors are from within the student – their science identity and science interest – however, these variables themselves may have been shaped by elements of each subsystem across a student's life experiences. In the context of the microsystem, teacher attitudes prove to have a significant impact on student science self-efficacy. Students' subjective task value – their science identity, science utility value, science interest, and cost perception –

was chosen as a set of variables from Bronfenbenner's mesosystem; these four values can be assumed to be influenced by factors from a student's various microsystems. All four STV variables proved to be significant predictors of student science self-efficacy, with science identity and science interest being the most powerful predictors of all variables included in the study. Teacher characteristics were used as examples of factors from the exosystem – variables that students have no control over but by which they are directly impacted. The most important of these factors, teacher gender and race, are significant only for girls. A few other variables from the exosystem, such as teacher certification and prior job experience, demonstrated small but significant results. Finally, factors such as student race, gender, and socioeconomic status were deemed to be representative of Bronfenbrenner's macrosystem as these variables reflect the larger culture of science, which lacks representation of girls, minorities, and economically disadvantaged groups. All three of these demographic variables were found to be significant predictors of student science self-efficacy. Overall, factors from each of Bronfenbrenner's subsystems were found to contribute to the development of student science self-efficacy, confirming the theory that the entire system must be considered in order to help support developmental growth.

In relation to the concept of time, or the chronosystem, this study provides insight into the science self-efficacy of ninth grade students at a particular point in time. The HSLS:09 base year data uses a nationally representative sample of students, student who have been influenced by a particular sequence of educational policies over the course of their academic careers. Their experiences can be assumed to be different from those of students from another time period, such as before the introduction of high stakes testing. Furthermore, as this study is driven by the need to improve the diversity of the STEM workforce, larger cultural and societal contexts should be accounted for. At the time of this study, women, minorities, and economically disadvantaged groups are woefully underrepresented in science careers; this context must be considered in terms of its potential influence on student attitudes towards science.

Social Cognitive Theory

The nature of social cognitive theory holds that learning occurs through social interactions, experiences, and observation of others. Similar to bioecological systems theory, both personal and environmental factors are theorized to influence observed behavior. This study considered a number of students' personal factors (demographics, subjective task value) and those of their science classroom environment (teacher characteristics, teaching practices, and teacher attitudes) in relation to the personal factor of science self-efficacy. Both personal and environmental variables were found to have a significant influence on student science self-efficacy, confirming the belief of social cognitive theory that both of these components are an important part of development.

Self-efficacy is a major construct of social cognitive theory. Findings from the current study confirm at least two of the theorized sources of self-efficacy: verbal persuasion, and peer comparison (Pajares, 1997). The remaining two sources of self-efficacy, mastery experiences and physiological factors, were neither confirmed nor rejected by the results of this study as the survey instrument used does not provide enough information to analyze these two factors.

The power of verbal persuasion in aiding in the development of self-efficacy is most obviously reflected in the findings concerning perceived teacher attitudes. The perceived positive attitude variable was composed from student responses to a series of questions regarding teacher attitudes, including whether they believe their science teacher values and listens to students' ideas, treats students with respect, treats every student fairly, thinks every student can be successful, and thinks mistakes are okay as long as all students learn. These attitudes are conveyed to students through teachers' actions in the classroom, including the ways in which they talk to students and choose to use words of encouragement, or the verbal persuasion that is theorized to be a source of self-efficacy (Pajares, 1997).

Another theorized source of self-efficacy confirmed by the results of this study is peer comparison, or the social comparisons that students make between themselves and other individuals (Pajares, 1997). This is closely related to the concept of modeling that social cognitive theory emphasizes for learning and development (Schunk, 1999). According to Schunk, the more alike an individual is to a model (such as a teacher), the greater the chances of self-efficacy formation. Results from this study concerning teacher demographic variables confirm the significance of gender-specific modeling, or the role model effect (Dee, 2005), but only for female students.

Motivation and Achievement Goal Theory

Results from this study fit well within the expectancy-value model of motivation theory. All five components of the model – self-efficacy, identity, utility value, interest, and cost perception – were found to be highly correlated. In addition, each of the subjective task value variables demonstrated significant effects on the expectancy component of self-efficacy. This confirms previous research which states that self-efficacy and the four STV components, while highly related, should be studied as independent factors in order to understand the motivational dynamics that influence achievement related decisions (Pintrich, 2000). A great deal of previous work has examined the impact of the expectancy-value framework on achievement related decisions; results from the current study give additional insight into the dynamics through which the motivational factors of the expectancy-value model act upon each other.

Achievement goal theory was applied in the design of this study due to the evidence that goals introduced by individuals that a student interacts with, such as teachers, may have an impact on a number of student outcomes including self-efficacy (Pintrich, 2000; Oakes, 1990). Teachers' goals for students were quantified by survey items on the emphasis placed on various teaching practices, such as preparing students for future science study or increasing students' interest in science. However, the quantitative nature of this study appears to be a limitation on the examination of teaching practices. The ways in which various teaching practices are actually employed in the classroom in relation to achievement goals are not reflected in the simple questionnaire items on the HSLS:09 survey. Furthermore, teaching practices reflecting achievement goals were not analyzed separately. Factor analysis revealed that all eleven teaching practice survey items were too highly correlated to be used as separate variables in regression analysis. Teachers who indicated that they were highly likely to emphasize preparing students for future science study were just as likely to emphasize increasing students' interest in science. This does not allow for the separate analysis of teaching practices that reflect performance oriented goals and those that represent mastery oriented goals, as was done is previous research (Pintrich, 2000; Oakes, 1990).

5.3 Summary

The goal of this study was to explore the ways in which student, school, and teacher level variables contribute to the development of student science self-efficacy. Findings indicate that a number of selected variables are significant predictors of student self-efficacy in science. The most noteworthy results concern student science identity and interest; finding ways to improve these two factors would improve the science self-efficacy of all students. Teacher gender is significant for female students, a result that is particularly significant considering the decline in female science teachers at the secondary and postsecondary levels. Finally, teacher attitudes – which are not included as factors in any existing policies regarding teacher qualifications – also emerged as powerful predictors of science self-efficacy for all students.

A number of findings are consistent with the existing literature on student self-efficacy, particularly those concerning student level variables such as race, class, and gender, and various motivational factors. Additionally, a handful of teacher level variables that had previously only been linked to student achievement also proved to be significant predictors of student self-efficacy. As self-efficacy is a proven antecedent to both achievement and persistence in science, the findings from this study have significant implications for researchers, educators, and policymakers aiming to improve student success in science. There is an increasing interest in education research in the influence of noncognitive factors such as self-efficacy on academic performance (Farrington et al., 2012). Findings from this study will contribute to this growing body of research by providing insight into various factors that influence the development of student self-efficacy in science. The implications of these findings for educator preparation, education policy, and future research will be discussed in the following chapter.

Chapter 6: Conclusion

This dissertation provides an analysis of various factors impacting student science self-efficacy, or expectations for success in science. The preceding chapter discussed the findings of the study in conjunction with the literature and theoretical framework. This final chapter includes four major components. First, the introduction will provide a summary of the dissertation, methods, and major findings. From there will follow a discussion of the limitations of the dissertation, then the implications of the study, and ending with areas for future research.

6.1 Introduction

This study set out to explore the ways in which students and teachers influence the development of students' expectations for success in their ninth grade science course. Student experiences in high school science courses are becoming increasingly important as science and other STEM disciplines prepare students to meet the demands of a growing STEM job market. Students who achieve and persist in science reap rewards in their professional careers, as STEM degree holders tend to earn higher salaries regardless of their career choices, and STEM workers face lower levels of unemployment (Langdon et al., 2011).

The United States government has exhibited acute interest in improving the performance of its students in science and other STEM fields, both to fill the occupational need for STEM workers and to improve the country's status as a top competitor in the global economy. A slew of educational reforms have aimed at advancing STEM education in order to increase the levels of student achievement and persistence in these fields. Additionally, education policies have been directed at increasing the diversity of the STEM profession by improving the science and math experiences of students from groups who have been historically underrepresented in STEM fields, specifically girls, non-Asian minorities, and students with lower socioeconomic status. Amongst a number of strategies for improvement, increasing science teacher quality, as measured by student test scores and teacher qualifications, has been one subject of recent STEM policies.

One concern with the current research informing educational policies surrounding science and other STEM related fields is the limited focus on student achievement as a measurement of success. There is a dearth of research on the noncognitive factors that contribute to student achievement and the ways that these factors can be used to improve student success in the classroom. Recent research suggests that the education community would benefit from a greater understanding of students' noncognitive factors, defined as the behaviors, skills, attitudes and strategies that are essential to academic performance (Farrington et al., 2012). These factors, which include the construct of self-efficacy, are thought to be developed both in the student as an individual and in the interactions between a student and the educational environment. For these reasons, this study set out to explore the student and teacher level variables that contribute to student science self-efficacy, a proven psychological antecedent to both achievement and persistence.

Originating in social cognitive theory, self-efficacy refers to an individual's expectations for success in completing a specific task, or the beliefs that an individual holds regarding his or her ability to be successful in a particular situation (Bandura, 1977, 1997). A vast body of literature has firmly established self-efficacy as a precursor to both academic achievement and persistence (Pajares, 1997; Britner & Pajares, 2006; Chemers et al., 2011; Fouad & Smith, 1996; Graham et al., 2013; Mau, 2003), but this information has yet to be fully capitalized on by the education community. Furthermore, there is a relative dearth of research on the ways that classroom teachers influence the development of student self-efficacy. In this study, a scale of student science self-efficacy measured a student's expectations for success in a ninth grade science course. For many students, science is an intimidating subject; students who lack confidence in science will not likely continue on the pathway to a STEM major and or career and the financial benefits that follow. Girls in particular tend to lack confidence and experience anxiety in science, even when controlling for achievement (Sikora & Pokropek, 2012; Britner, 2008). Focusing on academic achievement alone will not solve the problem of women being underrepresented in science. More attention must be given to factors that cause gender disparities in persisting in science coursework and pursuing science careers. This study sought to explore the ways in which student and teacher level variables impact student science self-efficacy in order to provide information that may be used at both the practical and at the policy level by the education community.

This dissertation employed data from a nationally representative sample of ninth grade students, the High School Longitudinal Study of 2009 (HSLS:09), conducted by the National Center for Education Statistics (Ingels et al., 2011). HSLS:09 is a longitudinal survey that follows over 21,000 students as they progress through their secondary, postsecondary, and career experiences. The present study utilized HSLS:09 base year data from questionnaires completed by ninth grade students and their science teachers, as well as contextual information from school administrator and parent surveys in order to explore the impact of selected student, school, and teacher level variables on student science self-efficacy.

Univariate analysis was first used to characterize the variables selected for this study. Bivariate analysis then determined the nature of the relationships between the dependent variable of student science self-efficacy and each independent variable. Finally, Ordinary Least Squares

(OLS) regression analysis was used to determine the impact of various student, school, and teacher level independent variables in predicting the science self-efficacy of ninth grade students. A series of four hierarchical regression models explored the impact of factors from four domains: student/school level variables, teacher characteristic variables, teaching practices variables, and teacher attitude variables. The relationships between the independent variables from these four domains and the dependent variable of student science self-efficacy were examined for the entire HSLS:09 population of students, and then separately for female and male students.

Findings from the current study reveal that multiple student and teacher level variables have a significant impact on student science self-efficacy. The most powerful effects arise from student-level variables. Student science identity and science interest proved to be the strongest predictors of student science self-efficacy for all students when controlling for all other variables in each model; an effect that was consistent for both genders. Student science utility value and science cost perception, two other variables derived from the expectancy-value framework of motivation, also proved to be significant predictors of student science self-efficacy. Student demographic factors all proved to be significant predictors of students' expectations for success in their science course, with female students reporting lower levels of science self-efficacy than males, black students reporting higher levels of science self-efficacy than their white peers, and socioeconomic status exhibiting a positive impact on student science self-efficacy. One noteworthy finding arose from the school level variables; girls in rural schools reported significantly lower levels of science self-efficacy than their peers in suburban schools.

The most significant finding from analysis of the teacher level variables concerns teacher gender. Female students reported higher levels of science self-efficacy when taught by a female science teacher, while teacher gender had no significant effect on the science self-efficacy of male ninth graders. Female students whose science teacher was black also experienced higher levels of science self-efficacy than girls whose science teacher was white. For boys, teacher certification status proves to be important. Male ninth graders reported higher levels of science self-efficacy when their science teacher held regular certification than when their teacher held some other form of certification. Boys were also sensitive to teachers' previous work experience. Science teachers who held a science related job prior to entering the teaching profession exhibited a small but significant negative effect on the science self-efficacy of male ninth graders. It should also be noted that most of the teacher characteristic variables derived from the literature on teacher qualification policies did not demonstrate any significant effects on student science self-efficacy, supporting the concerns of some researchers that current measures of teacher effectiveness are limited in nature and need to pay greater attention to students' affective and personal development (Goe et al., 2008).

Teaching practices had no significant effect on student science self-efficacy, possibly due to the limitations of this study. However, perceived teacher attitude proved to be an important predictor of student science self-efficacy; students had higher expectations for success in their science course when they perceived a positive attitude from their science teacher. The effect of positive teacher attitude was just as powerful as that of socioeconomic status for male students, and even stronger than that of SES for female students, indicating the importance of positive teacher-student classroom interactions.

Four interrelated theories influenced the design of this dissertation. Bioecological systems theory (Bronfenbrenner, 2005) was used to situate within the student-teacher interactions of the science classroom the study and to ensure that both person and context were considered in the exploration of student science self-efficacy. Social cognitive theory also stresses the reciprocal nature of interactions between personal, behavioral, and environmental factors in human development. This theory guided the selection of many of the important variables included for analysis in this study, particularly the dependent variable of self-efficacy, which originated in Albert Bandura's work in social cognitive theory (1977, 1997, 2011). Motivation theory, specifically the expectancy-value theory of motivation (Eccles, 2005) provided many of the student level variables, including those which demonstrated the strongest relationships: self-efficacy, identity, and interest. Achievement goal theory informed the selection of teacher level variables concerning instructional practices employed in the science classroom.

Results from this study have a number of implications for the education community, which will be discussed later in this chapter. Additionally, this study provides the foundation for multiple paths of future research. Before this can be discussed, however, there are a number of limitations to this study which will be addressed in the following section.

6.2 Limitations

This study includes a number of important findings regarding student expectations for success in high school science, including results that both confirm and add to the existing literature on science self-efficacy. However, there are a number of limitations to this study that must be taken into account before implications and future research can be discussed.

One evident limitation of this study is that it is purely quantitative in nature. This methodology was selected to meet the goal of this study, which was to identify factors that influence or predict a specific outcome (Creswell, 2009). Findings are limited to the identification of selected variables that have a significant impact on student science self-efficacy, and the strength and direction of these relationships. Self-efficacy in this study is only understood as a product affected by a set of selected variables. The processes through which student science self-efficacy is developed are not evident due to the quantitative methodology employed in this dissertation. In order to understand why and how the independent variables in this study effect student science self-efficacy, the research methodology must be extended beyond quantitative analysis.

An additional limitation of the survey data used in this study is the operationalization of variables that are more subjective in nature. Simple responses to questionnaire items do not give full insight into the complicated nature of certain factors. For instance, teacher level variables such as teaching practices and group work were operationalized for the purposes of the HSLS:09 survey, but do not reveal the nuanced ways in which these classroom procedures are employed. Simply stating that one uses group work does not give insight into how that work is carried out. Collaborative grouping can be utilized in a variety of ways ranging from ineffective to highly effective, and differences in group work design may create variances in the social dynamics that are theorized as potential sources of self-efficacy. Teacher inconsistencies in the utilization of collaborative grouping are not reflected in the current survey design, this factor would be better measured through direct observation or at the very least through the use of more detailed questionnaire items. Similar to the group work variable, the teaching practices variable only indicated the degree to which a teacher planned on emphasizing a series of instructional procedures, but did not give any insight as to how these practices were actually carried out in the classroom. Teaching practices is another concept that perhaps would be better explored through more detailed questions or through direct observation.

The current study utilized cross sectional data rather than longitudinal data, signifying that any understanding of student science self-efficacy arising from the results of this study can only be generalized to American ninth grade students in the 2009 – 2010 school year. While the use of this nationally representative sample of students has provided great insight into the factors that influence the development of student science self-efficacy, it must be kept in mind that these results arise from a particular chronological context in the history of science education. The classroom environment is shaped by the effects of education policies that change over time; the results of this study may not hold true in the context of other periods of time, both past and future. The timing of the HSLS:09 survey poses another hindrance that must be considered when examining the results of this study. The base year data employed in this study was obtained from the results of surveys distributed during the fall semester of students' ninth grade year. This resulted in a lower amount of student teacher exposure than if the survey had been completed in the spring semester, as was done in the first HSLS:09 follow up in 2012. The impact of teacher level variables on student self-efficacy may change over the course of the school year as students and teachers build upon their relationships and the proximal processes of the classroom environment become solidified. The data used in this study does not account for the long term patterns of interactions that occur between students and teachers over the course of an entire school year.

A further limitation of this study is the fact that the analytical sample is composed only of ninth grade students. Self-efficacy has been shown to change over time, with adolescence and entry to high school being a period of particular sensitivity and risk for decline in self-competence beliefs (Jacobs et al., 2002). School transition periods such as the beginning of ninth grade have the potential to create a recursive effect on student self-efficacy (Farrington et al., 2012), making student-teacher interactions that much more crucial to solidifying student confidence and expectations for success in science. This grade level specific characteristic of self-efficacy gives the current study significance in terms of understanding the factors that contribute to student academic mindsets at a vital point in their development; however, this can also be noted as a limitation to this study. Findings should be considered in the context of the ninth grade environment, an examination of student science self-efficacy at other grade levels may produce different results, as in Britner and Pajares' 2006 study of science self-efficacy in middle school students.

This dissertation is driven by the call of federal initiatives to improve student outcomes and increase diversity in science and other STEM fields. However, science is only one part of the STEM equation. While the current study provides insight into factors that contribute to the development of student expectations for success in science, it does not address other the STEM fields of technology, engineering, and mathematics, which may have influence student self-efficacy in very different ways. Additionally, federal policies aimed at improving STEM education focus primarily on student achievement as a measure of success. The current study does not give any insight into student achievement in science, but rather examines self-efficacy, a proven psychological antecedent to academic achievement and persistence.

The variables in this study were examined first for the entire group of ninth grade students and then separately for male and female students in the analytical sample. This was done to explore gender differences in the ways that student and teacher level variables may act differently in contributing to student science self-efficacy. Girls tend to experience greater levels of anxiety and to have lower levels of confidence in science, even when controlling for achievement (Britner, 2008; Sikora & Pokropek, 2012). Women make up one of the groups that have been historically underrepresented in science and that are the target of federal policies aimed at increasing the levels of diversity in science and STEM majors and careers. However, they are not the only group. While this study provides insight that has implications for improving the science self-efficacy of female students, it does not fully explore the variations in science self-efficacy based on student race or socioeconomic status, factors which categorize two other groups of students that lack equitable representation in science and STEM fields.

This dissertation focused primarily on student and teacher level variables as predictors of student science self-efficacy; however, a number of other available variables were not chosen for examination, such as many of those related to student experiences outside of the classroom environment. This was done purposely for the goal of this study, which was to explore the ways in which classroom dynamics between students and teachers affect student expectations for success in science. However, the inclusion of a number of other factors may add to the findings of this study. Previous research has suggested that factors outside of the classroom and school environment may perhaps play a greater role in student achievement than do those from inside the classroom; perhaps the most influential of which is the Equality of Education Opportunity report of 1966 (Coleman et al., 1966). The results of this study are hampered by the exclusion of a number of student background and parent level variables that may be additional determinants of student science self-efficacy.

Finally, the use of data from a national survey limits the results of this study to a single country. While findings from this study provide a good deal of insight into the science self-efficacy of American high school students, results may not be the same for students in other countries and systems of education. Educational policies shape students' school experiences, policies in other nations can create a school and classroom context that exert a vastly different influence on students' expectations for success in science. Furthermore, the cultural norms of different societies may create variance in student academic mindsets regarding the domain of science.

These limitations notwithstanding, this dissertation produced a number of significant findings regarding factors that contribute to the development of student self-efficacy in ninth grade science. The following sections will discuss the important implications and recommendations for future research based on the results of this study.

6.3 Implications

Recent policy initiatives have made it clear that the United States Department of Education places great priority on advancing the state of science education in order to increase the number of American students prepared to meet the needs of a growing STEM job market. Additionally, policymakers are concerned with improving the science trajectories of students from groups that have been historically underrepresented in STEM fields. The results of this dissertation provide a number of significant implications, at the policy level and the practical level, the micro level and the macro level, that should be considered in order to improve student science self-efficacy. As self-efficacy is a well-established antecedent to achievement and persistence, these implications have the potential to better position students along the pathways to science and STEM majors and careers.

Student Motivational Factors

The most salient results from this study concern student motivational factors derived from the expectancy value framework of motivation theory. All four variables representing the values portion of this framework – identity, interest, utility value, and cost perception – were found to be significant predictors of student science self-efficacy, which represents the expectancy part of the framework. However, the variables of student science identity and student science interest proved to be above and beyond the most powerful predictors of student science self-efficacy when compared to all other variables included in this study. This result demonstrates that improving students' science identity and interest are the most powerful things that can be done to improve the science self-efficacy of all students. While identity and interest are often discussed in the education and research community as predictors of student success, this dissertation adds to the discourse on motivation in science education by examining self-efficacy as an outcome variable, as opposed to the more commonly used measurement of student achievement. Additionally, the use of a nationally representative sample of students goes beyond the scope of much previous research on science self-efficacy and both reiterates and strengthens the call to understand student motivational factors in order to improve student achievement and persistence in science. Findings from this study regarding the impact of interest and identity of self-efficacy have significant implications for teachers and teacher educators, as well as for parents, school administrators, the higher education community, and policymakers. If, as previous research shows, science self-efficacy is considered to be an antecedent to student achievement and persistence in science, then all those concerned with improving students' science performance and opportunities in STEM majors and careers must carefully consider the findings from this dissertation.

There are a number of ways for educators to make practical use of the results of this study. One way that educators can increase student science interest and identity is to make course content relevant to students' lives. Recent studies have explored interventions that can be used to improve student interest and identity. Hulleman et al. (2009) found that students' science motivation improved when they were required to reflect on how their science course was relevant to their lives. In a similar study, college psychology students experienced increased interest and utility value in their courses when they were asked to write essays describing the relevance of course material to their own lives (Hulleman et al., 2010). Activities that require students to draw a connection between their science course and their own lives can increase their interest in science and strengthen their science identity; these factors in turn work to improve students' expectations for success in science. This has implications not only for teachers, but also for students. Teachers can improve the self-efficacy of their students by making course content relevant for students. Students can improve their own self-confidence in science by reflecting on how science course material connects to their own lives. Another way for teachers to improve student science self-efficacy is to make science interesting for all students – by connecting coursework to students' lives, allowing them to take ownership of class activities by using student- , project-, and inquiry-based instruction methods, and designing labs and other activities that let students observe and question how science works within their worlds. Above all, for teachers to have an impact on students' science self-efficacy, they need to incorporate practices that improve student identity and interest in science, and this must be supported by school administrators in reviewing lessons and providing professional development for their science teachers, and by teacher preparation programs who must train science teachers to make their classes relevant, interesting, and fun for students. In a time when shifting educational policies place a great deal of pressure on teachers to improve student achievement, these ideas can often be lost. Dense and ever-changing volumes of standards must be met, and teachers of content heavy subject areas such as science all too often feel the need to rush to "cover" the material and prepare students for standardized exams, the results of which can have long term consequences for both teachers and students. This can lead to superficial class activities and rote memorization of material, which results in student disinterest in and disengagement with science. Designing lessons and activities that help to develop student science interest and identity must be emphasized to science teachers as a tool to improve student self-efficacy – and thus achievement – in science.

Aside from reviewing lessons and providing opportunities for their science teachers to better their teaching practice, school administrators can also find school-wide ways to improve student science identity and interest. This can include organizing school wide events such as science fairs and competitions, providing interesting science-related extracurricular activities and recruiting students to join them, hosting guest speakers from science and STEM fields, and organizing mentoring and internship opportunities between students and science professionals and organizations. The main idea that school administrators should take away regarding student motivation in science is that science needs to be interesting and relevant to students, and should be just as visible and prioritized a subject area as other academic subjects such as English or math.

Improving students' science identity and interest extends beyond the classroom and school into the home and community, or the various subsystems that impact students' development. Parents should consider the importance of developing childrens' science identity and interest in relation to their levels of confidence in science. This is especially important for parents of girls, who generally experience lower levels of science self-efficacy yet could benefit from pursuing a science degree and career. In a study of parents and children in the greater Detroit area, Jacobs and Bleeker (2004) found that parental math- and science-promotive activities such as purchasing math and science related toys, participating in math and science activities with their children, and modeling math behaviors were related to children's later interest and involvement in math and science.

The National Science Teachers Association (NSTA) published a position statement on parental involvement in science education in 2009. Likewise, the United States Department of Education has outlined ideas for ways that parents can improve their children's performance in science (Lehr, 2005). Both documents recommend activities that would encourage student interest in science and help students develop a stronger science identity, such as encouraging children to observe and ask questions in order to make sense of the world around them; encouraging critical thinking and problem solving in everyday household tasks; reading science related books or watching science programs with children and then talking to them about what they read or saw; providing science learning activities in simple outdoor play or in visits to parks, nature centers, zoos, museums, and science connected events; purchasing science related toys and games; encouraging children to participate in science-based extracurricular activities; getting to know their children's science teacher and school science curriculum so they can reinforce learning at home; introducing children to friends and acquaintances who have science related jobs; and encouraging students in science while maintaining high expectations for success. All of these recommendations have the potential to increase students' interest in and identity with science, which will result in greater expectations for success; findings from this dissertation, which reveal the strength of science interest and identity in predicting self-efficacy in a nationally representative sample of students, emphasize the importance of recommendations such as those described above.

Finally, findings regarding student science identity and interest have implications for those who design education policy and the teacher preparation programs that operate under said policies. Policymakers concerned with improving student performance in STEM must consider the importance of student science identity and interest when deciding how to evaluate teacher and teacher candidates. Teacher preparation programs should also emphasize the importance of these two motivational factor to science teacher candidates, and hold them accountable for the development of curricula and pedagogy that make science relevant and interesting to students. This can be supported in student teaching and fieldwork experiences, and by requiring potential teachers to demonstrate that the ways in which they can develop student science interest and identity through summative program assessments such as teacher candidate portfolios.

Teacher Characteristics

Moving on from identity and interest, results from the current study also indicate that female ninth graders develop greater science self-efficacy when taught by a female science teacher, while teacher gender has no effect on the science self-efficacy of male students. The benefits of having a female science teacher are reinforced by findings from recent studies that link science teacher gender matching and improved STEM college course enrollment for girls (Bottia et al., 2015). Although most of the literature on the gender gap in science has focused on the postsecondary level and above, researchers have demonstrated the importance of pre-college experiences in shaping students' postsecondary decisions (Maltese & Tai, 2011). If the science gender gap is to be narrowed and girls more equitably represented in STEM majors and careers, there must be an initiative to attract more women to become certified and employed as high school science teachers.

According to the most recent Schools and Staffing Survey, which includes data from the 2011-2012 school year, the majority of American public school teachers are female: 76.3% in elementary and secondary schools overall, 58.1% at the high school level (National Center for

Education Statistics, 2013). However, these numbers decline when it comes to high school science. Only 53.6% of teachers with 2011-2012 teaching assignments classified as natural sciences were female. There is a greater lack of female teachers in the physical sciences; according to data from the State Indicators of Science and Mathematics (National Science Teachers Association), in 2002, 52% of biology teachers, 47% of chemistry teachers, and 30% of physics teachers were women. With the results of this study in mind, the decline of female science teachers at the secondary level will have a negative effect on the science self-efficacy – and this achievement and persistence – of high school girls.

A great deal of attention has been rightly been paid to getting more men into the teaching profession, which has historically been dominated by women. However, the findings from this study demonstrate that female teachers are more essential in the particular domain of science education. If the goal of getting more girls to pursue science and STEM careers is to be met, girls must first believe that they can be successful in science. This study demonstrates the importance of female teachers for the development of female ninth graders' science self-efficacy; additionally, the science self-efficacy of ninth grade boys is not affected by teacher gender. A push to get more female teachers into the science classroom would benefit girls without having any deleterious effect on the self-efficacy of boys. Policymakers must consider this when developing initiatives to get more girls into STEM majors and careers; recruitment efforts need to focus on getting more qualified female teacher candidates to go into teaching high school science. Additionally, principals and other school administrators must keep in mind the benefit of female science teachers in hiring and supporting their teaching staff.

Race was also found to have an impact on student science self-efficacy – analysis of data reveals that female students report higher levels of science self-efficacy when their science teacher is black, as opposed to when their science teacher is white. This result is extremely significant because it is not only for black female students, as would be expected based on Dee's role model theory, but for all female students – even white female students report higher levels of science self-efficacy with a black science teacher. Although greater exploration of this finding is needed, it is still a result that holds extreme import to policymakers and school administrators on a number of levels. Blacks are one of the underrepresented groups in STEM that the federal government has vowed to serve more equitably. Black teachers are also underrepresented; in the 2011 – 2012 school year only 6.8 percent of public school teachers were black, the numbers were even lower – 3.6 percent – for teachers in private schools (National Center for Education Statistics, 2013). These findings reveal an interesting intersection of student gender and teacher race. If female science students – another underrepresented group which STEM initiatives are focused on – benefit from black science teachers, policymakers must do something to address the inequitable representation of black sin the teaching profession. Those concerned with the importance of recruiting and retaining black teachers need to be aware of all of the ways in which black teachers are a benefit to the students, including those revealed by the current study. School administrators must also be cognizant of the importance of hiring more black science teachers in order to improve the science self-efficacy of their female student population.

While teacher gender is significant for the development of science self-efficacy in ninth grade girls, teacher certification proves to be a more important factor for that of ninth grade boys. If boys are to believe that they can be successful in science, they need more certified science teachers. Recent education reforms have pushed for more teachers to be regularly certified; however, alternative types of certification are common in areas like science which are considered high needs, or hard to fill. Alternative certification programs aimed at recruiting science teacher candidates have resulted in more science teachers holding temporary or probationary certification. Furthermore, many high school science teachers are teaching out of their license area for at least some portion of their teaching assignment, again due to staffing issues in science fields. The challenges of recruiting qualified science teacher candidates notwithstanding, teacher certification cannot be compromised. Policymakers and teacher preparation programs must take into account the importance of teacher certification for the science self-efficacy of high school boys and find ways to get more certified science teachers in all science classrooms. Additionally, school administrators need to consider teacher certification status not only in the hiring process, but also in programming and teacher placement. It is important that teachers be placed in the science subject area and grade level which they are certified to teach – programming decisions such as having a chemistry teacher teach one extra section of earth science, or a middle school certified teacher taking on a section of high school science, have a significant impact on student science self-efficacy.

Findings regarding the significance of teacher certification also call for further examination of the effects of teacher certification status on the science self-efficacy of students in the younger grades. The problem with high school science certification generally lies in teachers having nontraditional certification status – for example provisional certification – or being certified outside of their grade or content area – for example a teacher certified in biology teaching a section of environmental science, or a teacher certified at the middle school level teaching ninth grade; certification issues in science become greater at the elementary level, where one classroom teacher is usually responsible for teaching multiple subjects – English, math, science, and so on – to one class. While elementary science certification does exist, it is not as common as science certification at the secondary level, where classes and teachers become subject specific. If teacher certification status is found to have a significant impact on the science self-efficacy of younger students, there will be significant implications for teacher educators and policymakers regarding certification processes, training, and professional development for teachers in grades below the high school level. The results of this study suggest that knowing how to teach science is important for student self-efficacy; while it is improbable to suggest that every teacher become certified to teach science, it is important that teachers in the younger grades receive proper training, during both the certification process and continuing throughout their career through professional development experiences, that will increase their knowledge of and confidence in teaching science.

Teacher Attitudes

Another important but often overlooked teacher characteristic is the attitude that teachers convey to their students. As this study demonstrates, perceived positive teacher attitudes have a significant effect on student science self-efficacy. Previous work has demonstrated that teachers do not always exhibit positive attitudes towards students and that attitudes often differ based on student race, class, and gender (Anyon, 1981; Tenenbaum & Ruck, 2007; Stronge et al., 2011, Kumar & Hamer, 2013). Teacher educators play a crucial role in helping aspiring teachers understand the importance of developing and conveying positive attitudes towards all students. Findings from this dissertation add to the significance of perceived positive teacher attitudes in predicting student science self-efficacy through the use of a nationally representative sample of students; data from over 21,000 students and 16,000 science teachers indicates that positive teacher attitudes play an important role in student science motivation. The implications of these results must be considered and incorporated in the philosophy of education of teacher preparation programs and in policies surrounding teacher certification. One way that this can be accomplished is by stressing the importance of positive, affirming attitudes towards students in education courses. Additionally, student teaching experiences can help teacher candidates reflect on the attitudes they exhibit in the classroom. When student teachers are observed, supervisors can give feedback as to how teacher attitudes were perceived, as teachers may not be as aware of student perceptions as would an outside observer. Field supervisors can also solicit feedback on student teacher attitudes from students in the class. Teaching candidates can the reflect on the successes they have in conveying a positive attitude and any dissonance that may exist between how think they are acting towards students and the ways in which their attitudes are actually perceived.

In a case study of science teacher candidates' understanding of culturally responsive teaching, Atwater et al. (2010) conclude that, as in other disciplines, science teacher candidates struggle with their ideas regarding student diversity and their own ability to teach in a culturally responsive manner. The authors assert that science teacher preparation programs must make multicultural education more of a priority and infuse the ideas of culturally responsive teaching throughout teacher candidates' preparation experiences. They also suggest that teacher preparation programs pair students with mentor teachers who have an established commitment to culturally responsive teaching practices. Science teacher preparation programs must commit to assisting students in developing the positive attitudes that can improve student science self-efficacy for a diverse student population.

Unfortunately, despite assertions of the research community regarding the importance of positive affirming attitudes for student performance and general well-being, especially for that of students from diverse backgrounds (Villegas & Lucas, 2002, Nieto, 1992), teacher attitudes have not been a significant part of any political discourse on teacher quality or qualifications. The results of this study demonstrate that the characteristics traditionally used in education policy as indicators of teacher quality, such as subject area, certification status, and years teaching, are not as significant as teacher attitudes in predicting student science self-efficacy. Policymakers must realize that although there may be merit to the current measures of teacher quality, there are additional attributes that teachers need to possess in order to encourage the development of students' academic mindsets that lead to improved academic achievement and persistence in science and other academic domains. Findings from the current study, which employs data from over 21,000 students and 16,000 science teachers, can add to and bolster the call of recent research that insists educators and policymakers realize the importance of noncognitive factors such as self-efficacy in advancing students' academic performance.

6.4 Future Research

As stated previously, one of the primary limitations of this study is its quantitative nature. In order to address this limitation and give further insight into why and how the identified variables influence student science self-efficacy, further study is needed that goes beyond the survey data used in this dissertation. Creswell (2009) describes the benefits of mixed-methods research and the methodological approaches that may be used to combine the strengths of quantitative and qualitative research in order to provide a greater understanding of complex research problems. The current study provides the foundation for a sequential explanatory mixed methods design (Creswell, 2009), wherein a second phase of research would employ qualitative data collection and analysis to build on the results of this study. Wherein this study provided the "what" of student science self-efficacy, the "why" and the "how" must next be explored through quantitative procedures such as observations of science classrooms and subsequent interviews with teachers. Such methods would assist in answering some of the questions raised by this study.

A great deal of previous research examines self-efficacy as an antecedent to achievement and persistence in academic fields. The current study instead considered self-efficacy as an outcome variable, exploring student, school and teacher level factors that were hypothesized to contribute to student science self-efficacy. Future research can capitalize on the vast amount of longitudinal data available from the HSLS:09 survey in order to explore the relationship between science self-efficacy, academic achievement, and persistence in science and other STEM related fields. While HSLS:09 student achievement data was not available at the time of this study, it is expected to be released by NCES in late 2015. Student transcripts will provide the more traditional measures of student achievement that can serve as outcome variables in an exploration of science self-efficacy and student achievement. The self-efficacy variable examined as an output in the current study can instead be used as an independent variable in future studies in order to determine if the relationship between self-efficacy and academic achievement and persistence demonstrated by a wealth of previous research (Pajares, 1997; Britner & Pajares, 2006; Chemers et al., 2011; Fouad & Smith, 1996; Graham et al., 2013; Mau, 2003) holds true for the domain of science and for the nationally representative cohort of ninth graders that make up the HSLS:09 sample.

The longitudinal nature of HSLS:09 provides additional avenues for future research on student science self-efficacy over time. Data from HSLS:09 follow up can be used in studies examining the long term impact of ninth grade science self-efficacy on academic achievement and persistence in high school, choice of science majors in college, and eventual decisions regarding science and STEM careers. The factors impacting science self-efficacy for ninth graders can also be compared with those affecting science self-efficacy in older students, who are not in the same vulnerable transitional period. In turn, the results of this study are specific to the time period of the HSLS:09 survey. It is worth exploring whether student science self-efficacy would be influenced in the same way in other time periods. Students in the HSLS:09 sample have the unique characteristic of growing up in the era of high stakes testing. Would results for students in school prior to No Child Left Behind and other educational reforms have the same expectations for success in science? Future research may utilize existing datasets similar to HSLS:09, such as the NELS or ELS, to determine if student and teacher level variables have the same influence on student confidence in science as seen in the current study. This comparison may provide insight into the longitudinal impact of current education policies that have made high stakes testing a significant part of students' lives at a very early age.

The HSLS:09 dataset may also be used to explore whether the findings from this study hold true for other academic fields, especially that of mathematics, another STEM component. The science teacher questionnaire items used for the current study are replicated in the surveys that were administered to mathematics teachers. This study may be duplicated using math variables in place of science variables to determine of the student and teacher level factors explored in this study have a similar relationship with student math self-efficacy.

Federal education initiatives have set a priority of improving the representation of girls, non-Asian minorities, and economically disadvantaged students in science and other STEM fields. The current study demonstrates the importance of science teacher gender for the science self-efficacy of female ninth graders. Future research should consider the ways that student and teacher level variables influence student self-efficacy by race and socioeconomic status. The variables and analysis used in the current study can be replicated but split by student race or by student level of socioeconomic status instead of by gender. Additionally, the intersectional nature of race, class, and gender must be considered. What would results be like for black girls compared to their white peers? What about upper class students from various racial groups compared to their middle and lower class counterparts? These questions warrant further investigation as self-efficacy has been shown to differ based on student race, class, and gender. Additionally, the findings regarding science teacher race warrant further investigation. Results show that all female students, regardless of their own race, report higher levels of science self-efficacy when their science teacher is black. This goes beyond the demographic matching, "role model" effect described by Dee and others – black science teachers specifically have a positive influence on the science self-efficacy of all female students. This result must be investigated further as it has great implications for policies concerned with teacher recruitment, placement, and retention.

Much of the existing literature on STEM career pathways focuses on students' postsecondary experiences. However, research has shown that students' educational and career related decisions and aspirations are in fact shaped much earlier on in development (Eccles et al., 2004; Morgan et al., 2013; Maltese & Tai, 2011). The current study demonstrates a number of ways that students' science self-efficacy is influenced by early high school classroom experiences. As self-efficacy is a known antecedent to both the academic achievement that students need to get into college and the resilient mindsets that will allow them to persist in college science courses, it is worth further exploring this construct throughout the high school level as well as in the younger grades. Would the variables explored in this study have the same impact on science self-efficacy of students in the later stages of high school, who are not as subjected to the vulnerability of self-confidence experienced in the transitory ninth grade year? Would student science self-efficacy be impacted in the same way in middle or elementary schools, where students are in much different stages of development and science is taught in a different manner than in high school, as suggested by Britner and Pajares (2006)? Walls (2014) discusses the ways in which females, and particularly females of color, are excluded from science throughout their academic trajectory. He contends that this process of exclusion begins as early as kindergarten, with the development of stereotypically acceptable male and female social behaviors. There is a need for future research regarding the ways that student science self-efficacy is developed in classrooms at various grade levels.

This study resulted in two unanticipated findings that provide additional opportunities for future research, as there is a lack of literature surrounding both. First there is the finding that girls in rural schools have lower levels of self-efficacy than their peers in suburban schools. Not much research has explored gender differences in science for rural girls as compared to their urban and suburban peers; even less is known about differences in science self-efficacy based on urbanicity. This finding warrants further examination so that the influence of gender and locale on student self-efficacy can be further understood. Secondly, the teacher characteristic of previous job experience resulted in significantly lower levels of science self-efficacy for male students. This finding is important considering the need for more qualified science teachers often leads to recruiting science “career changers” in alternative certification programs such as the New York City Teaching Fellows, programs that tout candidates’ previous science work experience as a characteristic that would benefit students. The relationship between prior work experience and boys’ science self-efficacy needs to be more fully explored.

The variables in this study were found to explain up to 38% of the variance in science self-efficacy for ninth grade students. The question remains as to what other factors influence students’ expectations for success in science. One limitation of the current study is that variables were limited to students and teachers; other important factors from outside of the classroom environment were not included. One way that this limitation can be addressed by the design of a future study that explores the impact of variables derived from the HSLS:09 parent questionnaires on student science self-efficacy. However, if science self-efficacy is to be fully understood, the research must extend even further to question the ways in which larger cultural and societal factors influence students' expectations for success in science. The use of a different theoretical lens, such as that of sociocultural theory, may aid in the design of a research plan that would examine such factors.

In describing the use of sociocultural theory, or the "sociocultural perspective" in science education research, Lemke (2001) discusses the ways that researchers must consider the various institutional and cultural frameworks within which social activities and interactions take place. In the Vygotskyan view of sociocultural theory, social interactions are an essential part of teaching and learning – as in the social interactions between teachers and students analyzed in the current study. However, Lemke posits that a sociocultural lens sees interactions such as these as only "the smallest scale of the social" (2001, p.6); to better understand the development of constructs such as self-efficacy the realm of factors must expand to include those from larger scale institutions such as students' families, churches and community organizations, and even larger societal and cultural organizations. As Lemke states, the work that is done within classroom communities is important, but "the greatest promise of sociocultural approaches lies in looking both within and beyond the classroom" (2001, p. 305). This notion aligns with Bronfenbrenner's ecological systems theory discussed as part of the theoretical framework for the current study in that students' science related beliefs – such as self-efficacy – function across multiple domains, or subsystems, and are affected by factors from each. Our understanding of science self-efficacy would benefit from future research that expands beyond the microsystem of the classroom analyzed in this dissertation in order to investigate the ways that larger societal and cultural institutions may contribute to student motivation and expectations for success in science. Aside from the parental factors discussed above, future work should question the ways that schools, communities and community organizations, and larger societal structures and policies contribute to the development of students' science self-efficacy.

A final avenue for future research lies in broadening the scope of study to include data from countries other than the United States. The dataset used for the purposes of this dissertation provided information on a nationally representative sample of high school students. While this data provides valuable insight into the science self-efficacy of American students, it does not allow for generalization of findings to students from other countries. One of the driving forces behind the push for improved STEM education is the results of American student performance on international assessments of science and math, such as the Trends in International Mathematics and Science Study (TIMSS) or the Program for International Student Assessment (PISA). The country's latest rankings on such surveys are not at a desired level; it would be informative to explore concepts such as science self-efficacy in countries that outrank the United States in science achievement scores. Is the relationship between self-efficacy and achievement the same at the international level? If so, how do the variables included in this study – student and teacher level – impact the self-efficacy of students in other countries? What other factors, such as those at the parent or larger societal level, play a role in the development of science self-efficacy? Understanding student motivational factors such as self-efficacy in countries that outscore us in science can provide knowledge that may be used to improve our own science achievement status.

While science education has been deemed an important priority for current education policy, the achievement centric approach to evaluating student and teacher progress has limited our understanding of the underlying factors that contribute to improved student achievement and persistence in science. In order to meet the dual goal of improving student science performance and increasing the diversity of students who go in to be represented in science majors and careers, research must extend beyond the traditional means and measures of achievement and explore the academic mindsets that have been shown to be precursors of achievement, such as self-efficacy. This dissertation provides an important link between the psychological and education communities in the literature on science self-efficacy. Results provide an understanding of the ways that students and teachers contribute to the development of student science self-efficacy. Science can be an intimidating field. If students are to pursue scientific studies and careers they must first believe that they can be successful. This study provides all those concerned with students' science education with insights and ideas for improving all students' confidence in science so that they may go on to become the innovators, the inventors, the explorers and the experts that will advance the nation's competitiveness and participation in the global economy.

References

Allensworth, E., and Easton, J.Q. (2007) What matters for staying on-track and graduating in Chicago Public Schools. Chicago: University of Chicago Consortium on Chicago School Research

Andersen, L., & Ward, T. J. (2014). Expectancy-value models for the STEM persistence plans of ninth-grade, high-ability Students: A comparison between black, hispanic, and white students. *Science Education*, *98*(2), 216-242.

Anyon, J. (1981). Social class and school knowledge. *Curriculum Inquiry*, 11(1), 3-42.

Arnold, M. L., Newman, J. H., Gaddy, B. B., & Dean, C. B. (2005). A look at the condition of rural education research: Setting a direction for future research. *Journal of research in Rural Education*, *20*(6), 20-6.

Atwater, M. M., Freeman, T. B., Butler, M. B., & Draper-Morris, J. (2010). A Case Study of Science Teacher Candidates' Understandings and Actions Related to the Culturally Responsive Teaching of" Other" Students. *International Journal of Environmental and Science Education*, *5*(3), 287-318.

Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychological Review*, *84*(2), 191.

Bandura, A. (1986). The explanatory and predictive scope of self-efficacy theory. *Journal of Social and Clinical Psychology*, *4*(3), 359-373.

Bandura, A. (1997). Self-efficacy: The exercise of control. Macmillan.

Bandura, A. (2001). Social cognitive theory: An agentic perspective. Annual review of psychology, 52(1), 1-26.

Bandura, A. (2011). Social cognitive theory. Handbook of social psychological theories, 349-373.

Battistich, V., Solomon, D., Kim, D. I., Watson, M., & Schaps, E. (1995). Schools as communities, poverty levels of student populations, and students' attitudes, motives, and performance: A multilevel analysis. *American Educational Research Journal*, *32*(3), 627-658.

Bettinger, E. P., & Long, B. T. (2005). Do faculty serve as role models? The impact of instructor gender on female students. *American Economic Review*, 152-157.

Blanton, R.E., & Harmon, H.L. (2005). Building capacity for continuous improvement of math and science education in rural schools. *Rural Educator*, *26*(2), 6-11.

Boardman, J. D., & Robert, S. A. (2000). Neighborhood socioeconomic status and perceptions of self-efficacy. *Sociological Perspectives*, *43*(1), 117-136.

Bottia, M. C., Stearns, E., Mickelson, R. A., Moller, S., & Valentino, L. (2015). Growing the roots of STEM majors: Female math and science high school faculty and the participation of students in STEM. *Economics of Education Review*, *45*, 14-27.

Britner, S. L. (2008). Motivation in high school science students: A comparison of gender differences in life, physical, and earth science classes. *Journal of Research in Science Teaching*, 45(8), 955-970.

Britner, S. L., & Pajares, F. (2006). Sources of science self-efficacy beliefs of middle school students. *Journal of Research in Science Teaching*, *43*(5), 485-499.

Bronfenbrenner, U. (1997). Ecological models of human development. *Readings on the Development of Children*, *5*.

Bronfenbrenner, U. (2005). Making human beings human: Bioecological perspectives on human development. SAGE.

Bronfenbrenner, U., & Morris, P. A. (2006). The bioecological model of human development. Handbook of child psychology.

Bybee, R. W. (2007). Science teaching and international assessments: An introduction to PISA and TIMSS. *The Science Teacher*, *74*(8), 41.

Chemers, M. M., Zurbriggen, E. L., Syed, M., Goza, B. K., & Bearman, S. (2011). The role of efficacy and identity in science career commitment among underrepresented minority students. *Journal of Social Issues*, *67*(3), 469-491.

Chen, C., Sable, J., & Liu, F. (2011). Documentation to the Common Core of Data state nonfiscal survey of public elementary/secondary education: School year 2009–10 (NCES 2011-350). Washington, DC: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics

Coleman, J. S., Campbell, E. Q., Hobson, C. J., McPartland, J., Mood, A. M., Weinfeld, F. D., & York, R. (1966). Equality of educational opportunity. *Washington, DC*, 1066-5684.

Creswell, J. W. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches* (3rd ed.). Thousand Oaks, CA: SAGE Publications, Incorporated.

Darling-Hammond, L., & Youngs, P. (2002). Defining" highly qualified teachers": What does "scientifically-based research" actually tell us? *Educational Researcher*, 13-25.

Darling-Hammond, L., Holtzman, D. J., Gatlin, S. J., & Heilig, J. V. (2005). Does Teacher Preparation Matter? Evidence about Teacher Certification, Teach for America, and Teacher Effectiveness. *Education Policy Analysis Archives*, *13*(42), 42.

Dee, T. S. (2005). A teacher like me: Does race, ethnicity, or gender matter?. *American Economic Review*, 158-165.

Eccles, J. (2009). Who am I and what am I going to do with my life? Personal and collective identities as motivators of action. *Educational Psychologist*, *44*(2), 78-89.

Eccles, J. S. (2005). Subjective task value and the Eccles et al. model of achievement-related choices. Handbook of competence and motivation, 105-121.

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology*, *53*(1), 109-132.

Eccles, J. S., Vida, M. N., & Barber, B. (2004). The relation of early adolescents' college plans and both academic ability and task-value beliefs to subsequent college enrollment. *The Journal of Early Adolescence*, *24*(1), 63-77.

Eckert, S. A. (2012). What do teaching qualifications mean in urban schools? A mixed-methods study of teacher preparation and qualification. *Journal of Teacher Education*.

Farrington, C.A., Roderick, M., Allensworth, E., Nagaoka, J., Keyes, T.S., Johnson, D.W., & Beechum, N.O. (2012). *Teaching adolescents to become learners. The role of noncognitive factors in shaping school performance: A critical literature review*. Chicago: University of Chicago Consortium on Chicago School Research.

Fouad, N. A., & Smith, P. L. (1996). A test of a social cognitive model for middle school students: Math and science. *Journal of Counseling Psychology*, *43*(3), 338.

Gecas, V. (1989). The social psychology of self-efficacy. *Annual Review of Sociology*, 291-316.

Goe, L. (2007). The Link between Teacher Quality and Student Outcomes: A Research Synthesis. Washington, DC: National Comprehensive Center for Teacher Quality.

Goe, L., Bell, C., & Little, O. (2008). Approaches to evaluation teacher effectiveness: A Research Synthesis. Washington, DC: National Comprehensive Center for Teacher Quality.

Goldhaber, D. D., & Brewer, D. J. (2000). Does teacher certification matter? High school teacher certification status and student achievement. *Educational Evaluation and Policy Analysis*, *22*(2), 129-145.

Graham, M. J., Frederick, J., Byars-Winston, A., Hunter, A. B., & Handelsman, J. (2013). Increasing Persistence of College Students in STEM. *Science*, *341*(6153), 1455-1456.

Grant, H., & Dweck, C. S. (2003). Clarifying achievement goals and their impact. *Journal of Personality and Social Psychology*, 85(3), 541.

Hackett, G., Betz, N. E., Casas, J. M., & Rocha-Singh, I. A. (1992). Gender, ethnicity, and social cognitive factors predicting the academic achievement of students in engineering. *Journal of Counseling Psychology*, *39*(4), 527.

Han, J., Chu, X., Song, H., & Li, Y. (2015). Social Capital, Socioeconomic Status and Self-efficacy. *Applied Economics and Finance*, *2*(1), 1-10.

Hanushek, E. A., Kain, J. F., O'Brien, D. M., & Rivkin, S. G. (2005). *The market for teacher quality* (No. w11154). National Bureau of Economic Research.

Hewson, P. W., Kahle, J. B., Scantlebury, K., & Davies, D. (2001). Equitable science education in urban middle schools: Do reform efforts make a difference? *Journal of Research in Science Teaching*, *38*(10), 1130-1144.

Hill, J. G., & Dalton, B. (2013). Student Math Achievement and Out-of-Field Teaching. *Educational Researcher*, 42(7), 403-405.

Hulleman, C. S., & Harackiewicz, J. M. (2009). Promoting interest and performance in high school science classes. *Science*, *326*(5958), 1410-1412.

Hulleman, C. S., Godes, O., Hendricks, B. L., & Harackiewicz, J. M. (2010). Enhancing interest and performance with a utility value intervention. *Journal of Educational Psychology*, *102*(4), 880.

Hunter, Vincent Curtis. 1986 Academic Achievement and Self Attitudes: A Longitudinal Study with Backgound Controlled. ED 303 526

Ingels, S.J., Pratt, D.J., Herget, D.R., Burns, L.J., Dever, J.A., Ottem, R., Rogers, J.E., Jin, Y., and Leinwand, S. (2011). *High School Longitudinal Study of 2009 (HSLS:09). Base-Year Data File Documentation* (NCES 2011-328). U.S. Department of Education. Washington, DC: National Center for Education Statistics.

Jacobs, J. E., & Bleeker, M. M. (2004). Girls' and boys' developing interests in math and science: Do parents matter?. *New Directions for Child and Adolescent Development*, *2004*(106), 5-21.

Jacobs, J. E., Lanza, S., Osgood, D. W., Eccles, J. S., & Wigfield, A. (2002). Changes in children's self-competence and values: Gender and domain differences across grades one through twelve. *Child Development*, *73*(2), 509-527.

Kahle, J. B., Parker, L. H., Rennie, L. J., & Riley, D. (1993). Gender differences in science education: Building a model. Educational Psychologist, 28(4), 379-404.

Kumar, R., & Hamer, L. (2013). Preservice Teachers' Attitudes and Beliefs Toward Student Diversity and Proposed Instructional Practices A Sequential Design Study. *Journal of Teacher Education*, *64*(2), 162-177.

Langdon, D., McKittrick, G., Beede, D., Khan, B., & Doms, M. (2011). STEM: Good Jobs Now and for the Future. ESA Issue Brief# 03-11. *US Department of Commerce*.

Lee, O., & Brophy, J. (1996). Motivational patterns observed in sixth-grade science classrooms. *Journal of Research in Science Teaching*, *33*(3), 303-318.

Lehr, F. (2005). Helping Your Child Learn Science, with Activities for Children in Preschool through Grade 5. Revised. *US Department of Education*.

Lemke, J. L. (2001). Articulating communities: Sociocultural perspectives on science education. *Journal of research in science teaching*, *38*(3), 296-316.

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

Liu, X., & Koirala, H. (2009). The effect of mathematics self-efficacy on mathematics achievement of high school students.

Lucio, R., Hunt, E., & Bornovalova, M. (2012). Identifying the necessary and sufficient number of risk factors for predicting academic failure. Developmental psychology, 48(2), 422.

Maltese, A. V., & Tai, R. H. (2011). Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among US students. *Science Education*, *95*(5), 877-907.

Mau, W. C. (2003). Factors that influence persistence in science and engineering career aspirations. The Career Development Quarterly, 51(3), 234-243.

Mayo, M. W., & Christenfeld, N. (1999). Gender, race, and performance expectations of college students. *Journal of Multicultural Counseling and Development*, *27*(2), 93-104.

Meece, J. L., & Scantlebury, K. (2006). Gender and schooling: Progress and persistent barriers. *Handbook of Girls' and Womens' Psychological Health*, 283-291.

Monk, D. H. (1994). Subject area preparation of secondary mathematics and science teachers and student achievement. Economics of Education Review, 13(2), 125-145.

Morgan, S. L., Gelbgiser, D., & Weeden, K. A. (2013). Feeding the pipeline: Gender, occupational plans, and college major selection. *Social Science Research*, *42*(4), 989-1005.

National Center for Education Statistics, Schools and Staffing Survey (SASS), Public School Teacher Data File, 2011-12.

National Science Foundation (2013). Women, Minorities, and Persons with Disabilities in Science and Engineering: 2011 (NSF 11309), Arlington, VA: National Science Foundation.

National Science Teachers Association (2009). Position Statement: Parent Involvement in Science Learning. Retrieved from http://www.nsta.org/about/positions/parents.aspx

Nieto, S. (1992). *Affirming diversity: The sociopolitical context of multicultural education*. Longman, 10 Bank Street, White Plains, NY 10606.

Nixon, L. A., & Robinson, M. D. (1999). The educational attainment of young women: Role model effects of female high school faculty. *Demography*, *36*(2), 185-194.

Noblit, G. W. (1993). Power and caring. *American Educational Research Journal*, *30*(1), 23-38.

Noddings, N. (1992). *The Challenge to Care in Schools: An Alternative Approach to Education*. New York: Teachers College Press.

Nye, B., S. Konstantopoulos, and L. V. Hedges (2004). How large are teacher effects? *Educational Evaluation and Policy Analysis, 26*, 237–257.

Oakes, J. (1990). Multiplying Inequalities: The Effects of Race, Social Class, and Tracking on Opportunities to Learn Mathematics and Science.

OECD (2014), PISA 2012 Results: What Students Know and Can Do – Student Performance in Mathematics, Reading and Science (Volume I, Revised edition, February 2014), PISA, OECD Publishing.

Owens, T.M. (2009). Improving Science Achievement through Changes in Education Policy S*cience Educator,* 18(2), 49-55.

Pajares, F. (1997). Current directions in self-efficacy research. *Advances in Motivation and Achievement*, *10*(149), 1-49.

Parsons, E. C. (2001). Using power and caring to mediate White male privilege, equality, and equity in an urban elementary classroom: Implications for teacher preparation. *The Urban Review*, *33*(4), 321-338.

Pintrich, P. R. (2000). An achievement goal theory perspective on issues in motivation terminology, theory, and research. *Contemporary Educational Psychology*, *25*(1), 92-104.

Rivkin, S. G., Hanushek, E. A., & Kain, J. F. (2005). Teachers, schools, and academic achievement. *Econometrica,* 73(2), 417–458.

Roderick, M., and Camburn, E. (1999) Risk and recovery from course failure in the early years of high school. American Educational Research Journal, 36(2), 303-343.

Schunk, D. H. (1995). Self-efficacy and education and instruction. *Self-efficacy, Adaptation, and Adjustment* (281-303). Springer US.

Schunk, D. H. (1999). Social-self interaction and achievement behavior. *Educational Psychologist*, 34(4), 219-227.

Schunk, D. H., & Meece, J. L. (2006). Self-efficacy development in adolescence. *Self-efficacy beliefs of adolescents*, *5*, 71-96.

Scribner, J. P., & Akiba, M. (2010). Exploring the Relationship Between Prior Career Experience and Instructional Quality Among Mathematics and Science Teachers in Alternative Teacher Certification Programs. *Educational Policy*, *24*(4), 602-627.

Siegle, D., & McCoach, D. B. (2007). Increasing student mathematics self-efficacy through teacher training. *Journal of Advanced Academics*, *18*(2), 278-312.

Sikora, J., & Pokropek, A. (2012). Gender segregation of adolescent science career plans in 50 countries. *Science Education*, *96*(2), 234-264.

Simpkins, S. D., Davis-Kean, P. E., & Eccles, J. S. (2006). Math and science motivation: A longitudinal examination of the links between choices and beliefs. *Developmental Psychology*, *42*(1), 70.

Smart, John C., and others. 1985. "Self-Concept and Career Orientation Developmental Patterns During the College Years." Paper presented at the Annual Meeting of the American Educational Research Association, Chicago, IL, March 31-April 4. ED 261 620

Stronge, J. H., Ward, T. J., & Grant, L. W. (2011). What makes good teachers good? A cross-case analysis of the connection between teacher effectiveness and student achievement. *Journal of Teacher Education*, *62*(4), 339-355.

Tenenbaum, H. R., & Ruck, M. D. (2007). Are teachers' expectations different for racial minority than for European American students? A meta-analysis. *Journal of Educational Psychology*, *99*(2), 253.

Tobin, K. (2011). Global reproduction and transformation of science education. *Cultural Studies of Science Education*, *6*(1), 127-142.

Tudge, J. R., Mokrova, I., Hatfield, B. E., & Karnik, R. B. (2009). Uses and misuses of Bronfenbrenner's bioecological theory of human development. *Journal of Family Theory & Review*, 1(4), 198-210.

Turner, J. C., Warzon, K. B., & Christensen, A. (2011). Motivating Mathematics Learning Changes in Teachers' Practices and Beliefs During a Nine-Month Collaboration. *American Educational Research Journal*, *48*(3), 718-762.

Tyler, K. M., & Boelter, C. M. (2008). Linking Black Middle School Students' Perceptions of Teachers' Expectations to Academic Engagement and Efficacy. *Negro Educational Review*, *59*, 27-44.

United States Department of Education (2009). Race to the Top Executive Summary. Retrieved from http://www2.ed.gov/programs/racetothetop/index.html

Usher, E. L., & Pajares, F. (2006). Sources of academic and self-regulatory efficacy beliefs of entering middle school students. *Contemporary Educational Psychology*, 31(2), 125-141.

Villegas, A. M., & Lucas, T. (2002). *Educating culturally responsive teachers: A coherent approach*. SUNY Press.

Walls, L. (2014). Science Education and Females of Color: The Play Within a Play. In *Multicultural Science Education* (pp. 41-59). Springer Netherlands.

Wang, X. (2013). Why students choose STEM majors motivation, high school learning, and postsecondary context of support. *American Educational Research Journal*,

Wenglinsky, H. (2002). How schools matter: The link between teacher classroom practices and student academic performance. *Education Policy Analysis Archives*, 10(12).

White, A. R., & Bowers, D. C. (2008). *The relationship among race, gender, and high school students' self-efficacy in English language arts*. ProQuest.

The White House, Office of the Press Secretary. (2015). Remarks by the President at White House Science Fair [Press release]. Retrieved from https://www.whitehouse.gov/the-press-office/2015/03/23/remarks-president-white-house-science-fair

The White House, Office of the Press Secretary. (2009). President Obama Launches "Educate to Innovate" Campaign for Excellence in Science, Technology, Engineering & Math (Stem) Education [Press Release]. Retrieved from https://www.whitehouse.gov/the-press-office/president-obama-launches-educate-innovate-campaign-excellence-science-technology-en

Wigfield, A., & Eccles, J. S. (2000). Expectancy–value theory of achievement motivation. *Contemporary Educational Psychology*, *25*(1), 68-81.

Wigfield, A., Eccles, J.S., Schiefele, U., Roser, R.W., Davis-Kean, P. (2006). The development of achievement motivation. In N. Eisenberg (Ed.), *Handbook of child psychology* (Vol. 3, 6th ed.). New York: Wiley.

Wilson, C. D., Taylor, J. A., Kowalski, S. M., & Carlson, J. (2010). The relative effects and equity of inquiry-based and commonplace science teaching on students' knowledge, reasoning, and argumentation. *Journal of Research in Science Teaching*, *47*(3), 276-301.

Yang, R.K., & Fetsch, R.J. (2007). The self-esteem of rural children. Journal of Research in Rural Education, *22*, 1-7.

Zeldin, A. L., & Pajares, F. (2000). Against the odds: Self-efficacy beliefs of women in mathematical, scientific, and technological careers. *American Educational Research Journal*, *37*(1), 215-246.

Zeldin, A. L., Britner, S. L., & Pajares, F. (2008). A comparative study of the self-efficacy beliefs of successful men and women in mathematics, science, and technology careers. Journal of Research in Science Teaching, *45*(9), 1036-1058.

Zimmerman, B. J., Bandura, A., & Martinez-Pons, M. (1992). Self-motivation for academic attainment: The role of self-efficacy beliefs and personal goal setting. *American Educational Research Journal*, *29*(3), 663-676.