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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

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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\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**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.

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**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

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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.

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**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

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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.

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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

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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

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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.

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**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.

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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

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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 **s**cience 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

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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

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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.

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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,

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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

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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

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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.

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***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

Ecological Systems Theory (Bronfenbrenner) Social Cognitive Theory (Bandura)

Motivation Theory (Eccles Expectancy Value) Achievement Goal Theory (Oakes, Pintrich)

Current study

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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

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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.

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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

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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

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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

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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,

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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

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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.

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**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

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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

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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

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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

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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

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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

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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.

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*Figure 2.1 Study variables situated within Bronfenbrenner’s ecological systems*

Macrosystem: *Student and School Demographics*

Exosystem: *Teacher Characteristics*

Mesosystem: *Subjective Task Value*

Microsystem: *Teaching Practices Perceived Teacher Attitudes*

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).

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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.

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**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

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(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.

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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

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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

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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,

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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

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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

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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

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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

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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

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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

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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

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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.

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(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.

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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.

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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

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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.

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**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

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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

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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

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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

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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.

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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

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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

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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

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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.

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**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’

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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.

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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.

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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

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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

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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 11th 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

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(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

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(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

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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

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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

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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

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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.

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‘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’.