SCIENCE TEACHERS' EFFICACY BELIEFS, MASTERY-FOCUSED INSTRUCTION, AND STUDENTS' EFFICACY BELIEFS: A MULTILEVEL STRUCTURAL EQUATION MODEL

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ABSTRACT

Belle B. Booker**:** Science Teachers' Efficacy Beliefs, Mastery-Focused Instruction, and Students' Efficacy Beliefs: A Multilevel Structural Equation Model
(Under the direction of Dr. Judith L. Meece)

Given the rigor of science learning continues to gain momentum with the Next Generation Science Standard reforms (National Research Council, NRC, 2013), never before has it been so essential to inspire, motivate, and properly prepare the next generation of scientifically literate, innovative thinkers. Applying a lens of Self Efficacy theory (Banura, 1977), this investigation combined science education and educational psychology literatures to examine how proximal processes (Hamre & Pianta, 2010) operate within the context of the high school science classroom. A large scale, national data set (i.e., High School Longitudinal Study of 2009, Ingles et al., 2011) and multilevel structural equation modeling (Muthen & Muthen, 2007) was used to explore (a) the degree to which science teachers' efficacy beliefs, teacher and student perceptions of the instructional environment, and students' efficacy beliefs for science learning are related and (b) whether or not student and teacher perceptions of mastery-focused instruction (Meece, Anderman, & Anderman, 2003) partially mediate the relation between science teachers' efficacy beliefs and students' efficacy beliefs for science learning. A sample of 3,557 Biology students and their teachers was used for analyses. Statistically significant results indicated teachers' efficacy beliefs predicted teachers' perceptions of their use of mastery-focused instructional practices in science; science teachers' efficacy beliefs predicted students' efficacy beliefs for science learning; and within classrooms, students' perceptions of their teacher's use of mastery-focused instruction predicted students' efficacy beliefs for science learning. However, between classrooms, students' perceptions of mastery-focused instruction did not predict students' efficacy beliefs for science learning, teachers' efficacy beliefs did not predict students' perceptions of mastery-focused instruction, and teachers' perceptions of mastery-focused instruction did not predict students' efficacy beliefs for science learning. Taken together, findings highlight the importance of individual differences in student perceptions of the classroom instructional environment and the motivational beliefs of science teachers in contributing to high school students' motivation for science learning. Contributions for science education and educational psychology and suggestions for future research are discussed.

Keywords: Efficacy, high school, mastery-focused instruction, motivation, science

DEDICATION

I dedicate this work to my mother and father, who were my first and remain the most influential teachers in my life. They provided me with the skills, confidence, and unwavering support to dream big and go after it; to never stand still; to never stop learning; and most importantly, that life is a physical, emotional, and intellectual journey and to enjoy the ride…

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CHAPTER ONE

INTRODUCTION

Science learning has become critical for regaining and sustaining America's competitiveness in a global society. Recent reports indicate that 80% of the jobs created in the United States in the next decade will require science skills (Carnevale, Smith, & Strohl, 2010). Students who develop critical skills necessary to become the next innovative thinkers and leaders undoubtedly will benefit from more career choices and higher earning potential than those who do not develop these skills. Never before has it been so essential to inspire, motivate, and properly prepare the next generation of scientifically literate, innovative thinkers. However, when compared to 64 other countries, the students in the United States rank only 23rd in science achievement (National Center for Education Statistics, NCES, 2012), and according to the National Assessment of Educational Progress' (NAEP), The Nation's Report Card: Science 2011 (NCES, 2012), only 2% of the nation's eighth graders perform at an advanced level in science. Thus, cultivating an interest in and motivation toward science learning not only is imperative for job creation but for moving American students from the middle of the pack to the top in science achievement.

In an effort to explore classroom factors that may contribute to students' motivation for science learning, this dissertation study focused on high school science students' and teachers' motivational beliefs and perceptions of the classroom instructional environment. Specifically, my intent was to examine the role of science teachers' instructional practices in mediating the relation between the motivational beliefs of science teachers and their students. This dissertation study bridges a gap between bodies of literature in science education and educational psychology regarding motivation and instructional practices in high school science classrooms. Furthermore, this study used a large scale, national data set and advanced statistical techniques (i.e., structural equation modeling (SEM)) to assess a multilevel mediation model. Therefore, this study contributes to educational research in both fields by using advanced statistical techniques and extending research on motivational beliefs and classroom instruction to high school science classrooms, which may inform future professional developments focused on improving student motivation and learning through quality instructional practices.

This first chapter presents the rationale for the study. First, reforms in science education are discussed to highlight the emphasis on mastery learning, which motivational researchers characterize as active participation, higher-order thinking, and cognitive engagement (Meece, Blumenfeld, & Hoyle, 1988). Second, the importance of the classroom environment is described to underline how the instructional climate contributes to students' motivation for learning science. Third, the theoretical framework of Self-Efficacy Theory (Bandura, 1977) is briefly discussed to provide a lens through which the conceptual model is viewed. Fourth, science teachers' motivational beliefs as a potential antecedent to their classroom instruction are explained. Fifth and finally, the statement of the problem, purpose, and contributions of the study are presented to warrant the investigation.

New Reforms in Science Education Emphasize Mastery

To prepare students to meet the challenges of a global society, the Committee on a Conceptual Framework for New K-12 Science Education Standards developed a set of expectations for students in science known as the Framework for K-12 Science Education

(National Research Council, NRC, 2012). This revisionary framework builds on previous reforms, such as Science for All Americans (American Association for the Advancement of Science, AAAS, 1989), Benchmarks for Science Literacy (AAAS, 1993), and the National Science Education Standards (NRC, 1996). The new framework is being used to develop the Next Generation Science Standards (NRC, 2013), which is expected to act as a prelude to common core standards in science. The committee contends this new framework reflects the field's understanding of science, science teaching, and science learning.

The reformed framework emphasizes the importance of individual inquiry, collaborative learning, problem solving, and mastery of key science concepts. Specifically, the committee charged with developing the framework recommended science education address three dimensions: (a) scientific and engineering practices, (b) concepts that cut across content fields, and (c) core ideas in physical sciences, life sciences, earth and space sciences, and engineering and application sciences (NRC, 2012, p. 2). While the language in the second and third dimensions focuses more on science content, the language in the first dimension of scientific and engineering practices focuses more on deep levels of cognitive engagement, higher-order thinking skills, and content mastery, rather than on rote learning and memorization of science facts. This first dimension of the reform framework requires active forms of learning: Students should be able to ask questions and define problems; develop and use models; plan, organize, and carry out scientific investigations; analyze and interpret scientific data; use mathematics; construct scientific explanations and design solutions; engage in arguments based on scientific evidence; and obtain, evaluate, and communicate scientific information to others (NRC, 2012, p.3). The emphasis on active participation, deep cognitive engagement, and higher-order thinking characterize mastery learning of key concepts in science (Meece, Blumenfeld, & Hoyle, 1988). In order for these new reforms to be effective and students to develop a mastery approach to learning, it is important to examine how the classroom context contributes to the development of students' motivation toward science learning.

Classroom as Context for Student Motivation and Learning

The classroom environment is critical for facilitating student motivation and learning (Eccles & Roeser, 2011; Meece, Anderman, & Anderman, 2006), and teachers play a critical role in creating classroom instructional environments that foster active participation, higher order thinking, and deep engagement in learning (Midgley, Anderman, & Hicks, 1995; Patrick, Anderman, Ryan, Edelin, & Midgley, 2001; Turner, 2011; Turner et al., 2002; Urdan, 2004; Wiesman, 2012). Specifically, when teachers focus on the value of learning, press for student understanding, set high academic expectations for their students, emphasize conceptual understanding of content, and offer motivational support during learning, the classroom instructional climate is focused on mastering content (Stipek & Kowalski, 1989; Turner et al., 2002). When students perceive a classroom emphasis on mastery-focused instruction, they tend to be more motivated toward learning (Meece, 1991; Meece, Herman, & McCombs, 2003), cope better with challenging academic tasks (Kaplan & Maehr, 1999), adopt personal mastery goals (Anderman & Midgley, 1997; Wolters, 2004), and have a high sense of efficacy (Bong, 2009; Urdan & Midgley, 2003). Hence, by creating classrooms with emphases on mastery-focused instruction, science teachers convey to their students that everyone can learn science, develop scientific skills, persist through challenging reform-based science tasks, and develop a high sense of efficacy in learning science.

Teachers' instructional practices are often tied to their beliefs and values about teaching (Kagan, 1992; Stipek, Givvin, Salmon, & MacGyvers, 2001; Thompson, 1992). The shift away from traditional, textbook-based instruction toward mastery-focused instruction represents a critical shift in teacher beliefs and practices. Particularly, it shows a movement away from the teacher's role as the transmitter of knowledge toward the role of facilitator or guide through the science learning process. This shift in the way teachers think about teaching and facilitate learning requires considerable knowledge of science content and pedagogy as well as confidence in both areas. Teachers make classroom decisions each day with respect to instructional policies and practices, such as choosing science activities, grouping students, providing feedback, differentiating instruction to individual learners, and evaluating their students. These instructional decisions help determine the degree to which students have opportunities to master scientific concepts and skills and build their confidence in their own science learning. Thus, it is critical to examine the beliefs and values teachers hold that contribute to these instructional decisions and practices.

Teacher Beliefs as Antecedent to Classroom Instructional Practices

An essential teacher belief, which has become a focal point in research among educational psychologists, is teachers' sense of efficacy. Self-efficacy is defined as the "belief in one's capabilities to organize and execute the courses of action required to manage prospective situations" (Bandura, 1977, p. 3). This conceptual definition has been expanded to include teachers' sense of efficacy, defined as teachers' judgments of their own capabilities to produce desired outcomes of student learning and engagement, even among difficult or unmotivated students (Tschannen-Moran & Woolfolk Hoy, 2001). Today, most theorists agree that teachers' sense of efficacy is context-specific and involves the individual evaluation of their own teaching competence as well as analysis of the teaching task (Klassen, Tze, Betts & Gordon, 2011).

Considerable research documents the role of teachers' sense of efficacy in predicting teachers' instructional practices and behavior in the classroom. Teachers with a high sense of efficacy tend to be more responsive to student needs (Ashton & Webb, 1986), are more likely to use a variety of instructional strategies to meet the needs of their students (Gibson & Dembo, 1984), are more willing to try new instructional practices (Ross, 1998), and tend to be more flexible and provide more effective feedback to their students (Gibson & Dembo, 1984). Thus, across studies, teachers' efficacy beliefs have been shown to contribute to critical aspects of instructional practices as well as student academic motivation. Yet, no published studies were found that examine teachers' efficacy beliefs, mastery-focused instruction, and students' efficacy beliefs in high school science classrooms. To address this gap in the literature, Self-Efficacy theory (Bandura, 1977) was used as a lens to examine the relation among teachers' and students' efficacy beliefs and mastery-focused instruction in high school science classrooms.

Application of Self-Efficacy Theory to Current Study

Teaching and learning are intricately connected processes (Mayer, 2003), and teachers' instructional practices should be evaluated by their impact on key indicators of student motivation and learning (Nie & Lau, 2010). One particularly salient indicator of student motivation toward learning is self-efficacy beliefs, which are defined as "beliefs in one's capabilities to organize and execute the courses of action required to manage prospective situations" (Bandura, 1997, p. 3). Efficacy beliefs act as one of the most influential mediators for human behavior, and both student and teacher motivation toward participating in academic tasks are highest when they possess high self-efficacy (Bandura, 1977). Mastery experiences, defined as the individual's interpretation of purposive performance, are the most influential source of efficacy beliefs, and when individuals have repeated success with mastery experiences, they are more inclined to raise their own level of mastery expectation (Bandura, 1977). For example, when students have multiple, successful mastery experiences in the science classroom (e.g., balancing a chemistry equation correctly), they may raise their own interpretation of mastery (e.g., moving on to a more difficult chemistry equation) as well as raise their efficacy for the science task (e.g., balancing chemistry equations). When students' efficacy beliefs for science tasks are high, they are more likely to engage and persist with the tasks, but when students' efficacy beliefs are low, they are less likely to do so. Hence, providing students with continuous opportunities for mastery experiences in science classrooms is critical for fostering their motivation toward science learning.

The responsibility of providing students these mastery experiences falls to classroom teachers who play a critical role in facilitating student motivation for learning science. It is through mastery-focused instruction (i.e., pressing for student understanding of major science concepts, allowing for mistakes during learning, encouraging incremental cognitive growth, etc.) that teachers establish science classrooms that present students with repeated opportunities for mastery experiences and efficacy building. Furthermore and as discussed previously, while teachers with high efficacy for particular instructional tasks are more inclined to engage and persist with those tasks, teachers with low efficacy are less inclined to do so. Thus, when examining the classroom through the lens of self-efficacy theory, it is hypothesized that science teachers with high efficacy will use mastery-focused instruction more frequently than teachers with low efficacy, which in turn will provide students with the mastery experiences necessary to build their efficacy for science learning. These links are discussed in more detail in the next chapter.

Statement of the Problem

Given that the rigor of science learning continues to gain momentum with the Next Generation Science Standard (NRC, 2013) reforms, it is necessary to identify the state of science teachers' efficacy beliefs for science teaching, their emphasis on mastery-focused instruction, and students' own efficacy beliefs for learning science. As described later in the next chapter, students' efficacy beliefs are key predictors of numerous behaviors associated with science achievement outcomes. Furthermore, understanding the role that instruction plays in connecting teacher and student beliefs is important for gaining a better understanding of the dynamic and complex nature of student motivation. Although links between teacher beliefs and instructional practices (see Klassen, Tze, Betts & Gordon, 2011 for a review of teachers' self efficacy) and teacher beliefs and student academic motivation (e.g., Ashton & Webb, 1986) have been demonstrated, only one study was found that examined the relation among teachers' efficacy beliefs, instructional practice, and students' efficacy beliefs in a single model (Thoonen, Sleegers, Peetsma, & Ooart, 2011). This study examined the role of instruction in mediating the relation between teacher and student efficacy beliefs (Thoonen et al., 2011). Although the study supported the idea that instruction mediates teacher and student efficacy beliefs, the generalizability of the findings are limited by a small, homogeneous sample of elementary school teachers and students in the Netherlands. Currently, no published studies were found that have investigated these constructs using a large, heterogeneous sample of students within the context of high school classrooms in the United States with sophisticated statistical techniques such as structural equation modeling. This study addressed gaps in the literature concerning science teachers' beliefs, mastery-focused instruction, and student motivational outcomes. The study used multilevel structural equation modeling techniques to examine the role of mastery-focused instruction as mediating the relation between teachers' efficacy beliefs and student efficacy beliefs within the context of high school science classrooms.

Purpose of the Study

The purpose of this investigation was to examine the relations among high school science teachers' efficacy beliefs, teacher and student perceptions of mastery-focused instruction, and students' efficacy beliefs for learning science. Specifically, the purposes of this study were to (a) explore the degree to which high school science teachers' sense of efficacy relates to teachers' perceptions of mastery-focused instruction in their high school science classroom; (b) explore the degree to which high school science teachers' perception of mastery-focused instruction aligns with high school students' perceptions mastery-focused instruction in the science classroom; (c) explore the degree to which high school science teachers' sense of efficacy relates to their students' sense of efficacy for learning science; (d) explore the degree to which mastery-focused instruction in the high school science classroom relates to students' sense of efficacy for learning science; and (e) examine whether high school science teachers' and students' perceptions of their science teachers' focus on mastery instruction in the science classroom partially mediate the relation between high school science teachers' sense of efficacy for teaching science and high school science students' sense of efficacy for learning science. Specific research questions and hypotheses are discussed in the second chapter of this dissertation.

Potential Contributions of the Study

Although this study offers many potential contributions, five main contributions are presented. First, an empirical investigation of the potential relation among these variables can add to the extant body of literature in educational psychology and science education and can bridge a gap between the two fields. Second, empirical findings from this study could provide teachers, administrators, policymakers, and researchers with additional information about the current state of U.S. ninth grade students' efficacy beliefs for learning science and for their perceptions of their science teachers' use of mastery-focused instruction in the science classroom. Third, empirical findings could provide teachers, administrators, policymakers, and researchers with a glimpse into how well aligned students' and teachers' perceptions are of science teachers' use of mastery-focused instruction. Fourth, empirical evidence from this investigation also could add to our understanding of how science teacher efficacy beliefs contribute to their instructional practice and how their efficacy beliefs and instruction contribute to the formation of their students' perceptions of their teachers' classroom practices and their efficacy beliefs in science. Fifth, empirical evidence examining how science teachers' efficacy beliefs relate to their classroom practices also would inform researchers and practitioners as they design interventions and professional developments based on the Framework for K-12 Science Education (NRC, 2012) and on the Next Generation Science Standards (NRC, 2013).

Summary

In summary, this study relies on data from a national dataset to explore the relation between high school science teachers' efficacy beliefs and their students' efficacy beliefs for learning science as mediated by both teacher and student perceptions of mastery-focused instruction. This study is grounded in self-efficacy theory (Bandura, 1977) and seeks to add to the current understanding of teacher and student motivation. The findings may add to understandings of how certain proximal processes within the classroom environment contribute to students' motivation to learn science. Furthermore, the findings may inform science educators and policymakers on both the importance of teachers' efficacy beliefs in guiding science mastery-focused instruction as well as on the importance of teachers' and students' perceptions of mastery-focused instruction and how those perceptions contribute to students' efficacy beliefs for learning science.

CHAPTER TWO

LITERATURE REVIEW

This dissertation study examined the role of the classroom instructional environment in mediating the relation between teacher and student motivation. Specifically, mastery-focused instruction was hypothesized to mediate the relationship between science teachers' efficacy beliefs and science students' efficacy beliefs. In this chapter, the conceptual model is described and broken into individual components to show how the current study contributes to bodies of literature in science education and educational psychology. First, the importance of the classroom as context for student learning and motivation is discussed. Second, the theoretical framework of self-efficacy is reviewed and then applied as a lens through which the conceptual model (see *Figure 2.2*, p. 19) is viewed. Third, the use of students' efficacy beliefs as a proximal indicator of distal achievement-related outcomes is presented. Fourth, the conceptual model is then broken down and evidence for each link is reviewed with particular attention paid to science education literature. Finally, the purpose, research questions, hypotheses, and structural model are presented.

Classroom Environment as Context for Student Development

Currently within educational psychology and developmental science there is a focus on how the classroom environment relates to students' development (Eccles & Roeser, 2011; Meece, Anderman, & Anderman, 2006; Lerner, 1998). According to Hamre and Pianta (2010), "Children's experiences in classrooms constitute the majority of their day and thus constitute the majority of school-based proximal processes" (p. 26). These proximal processes (see *Figure 2.1*, p. 14) include various aspects of the classroom, such as teachers' beliefs, instructional strategies, curriculum tasks, relationships between teachers and students, and students' performance and motivation, which all interact to shape development (Eccles & Roeser, 2003). Although researchers have examined different processes within the classroom and used various theoretical lenses (e.g., Stage Environment Fit Theory, Eccles & Midgley, 1989; Self Determination Theory, Deci & Ryan, 1985), much of this research has centered on students' experiences within the classroom and the ways in which their experiences uniquely contribute to their academic development. After all, it is the experiences students have in the classroom that are most closely related to student outcomes (Hamre & Pianta, 2010; Nye, Konstantopoulos, & Hedges, 2004).

One particularly salient aspect of students' classroom experience involves the instructional climate shaped by teachers. Specifically, it is through instructional interactions with teachers that students are exposed to different beliefs and instructional processes that help shape their academic development (Eccles & Roeser, 2003; 2011). Hence, the goal of this dissertation study is to examine the classroom instructional environment created by teachers and how that instruction fosters or hinders students' motivation toward science learning. For the purposes of this study, three different proximal processes are examined within the high school science classroom concerning teacher and student beliefs, student beliefs and teacher practices, and teacher beliefs and teacher practices (see *Figure 2.1* p. 14). Specifically, the current study focused on teachers' instructional practices and how instructional practices are understood within the classroom environmental context. This includes understanding how teachers and students perceive classroom instruction, if and how teachers' motivational self-beliefs shape the use of particular instructional practices, and how these instructional practices contribute to students' motivational self-beliefs. These internal beliefs and external practices are continuously changing as new information is gathered, internalized, and evaluated. In order to explain the key concepts that underlie the conceptual model, the major tenets of self-efficacy theory are described first in the next section. Then, the conceptual model is described through the lens of self-efficacy theory (Bandura, 1977).

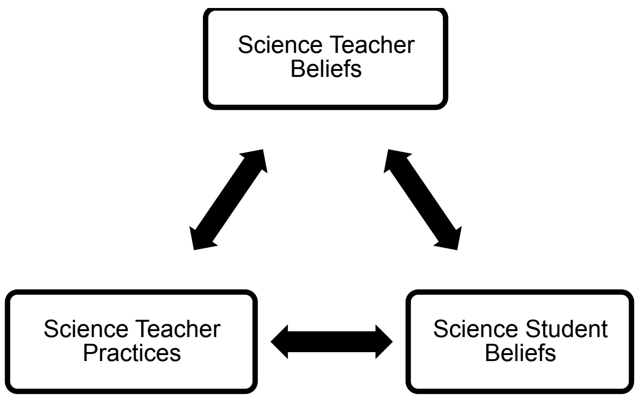

Figure 2.1. Proximal Processes within the Science Classroom Environment (Adapted from Hamre & Pianta, 2010)

A Theoretical Lens of Self-Efficacy Theory

Albert Bandura's Self-Efficacy Theory (Bandura, 1977) was used to frame this study because it explains how motivational beliefs develop and how they contribute to classroom behaviors, such as teachers' instructional practices and students' academic performance. Bandura (1977) theorized that individuals' cognitive processes (e.g., agency) act as a mechanism that mediates a stimulus and a response. He defined agency as an intentional pursuit of courses of action, characterized by intentionality, forethought, self-regulation, self-reflectiveness, quality of functioning, and the meaning of one's own life pursuits (Bandura, 2006, p. 167). Therefore, individuals' behavior can be predicted by their beliefs about their own capabilities, or self-efficacy. Specifically, Bandura defined *self-efficac*y as "beliefs in one's capabilities to organize and execute the courses of action required to manage prospective situations" (Bandura, 1997, p.

3). These self-efficacy beliefs can act as a mediator between the task and outcome behaviors. In addition, self-efficacy beliefs are characterized by self-perception of competence rather than by the actual level of competence. This distinction is critical because many individuals misestimate their ability, which may have consequences in their participation in or effort expended in particular activities (Schunk & Pajares, 2005).

Efficacy beliefs are further differentiated into two dimensions of expectations: efficacy expectations and outcome expectations (Bandura, 1977). First, *efficacy expectations* are defined as the personal beliefs that one can successfully execute behaviors necessary to complete certain tasks. These beliefs act as mechanisms by which individuals engage in behaviors. Second, *outcome expectations* are defined as the expectations that certain behaviors will result in certain outcomes. For example, teachers may believe certain instructional practices can produce student learning (outcome expectations), but if teachers do not believe they can successfully execute the instructional practices to produce student learning (efficacy expectations), they may not engage in those instructional practices. Consistent with Bandura's theory, efficacy beliefs are shaped by the individual's interactions with the environment. Four sources shape efficacy expectations: *mastery experiences*, *vicarious experiences*, *verbal persuasion*, and *physiological states* (Bandura, 1977). As mentioned in the first chapter, personal mastery experiences are characterized as the individual's interpretation of purposive performances and are the most influential source of efficacy, for repeated success can raise mastery expectations. After individuals develop strong efficacy expectations, the negative impact of rare failures is likely to decline. For example, students who perform well at a task (e.g., earning a high grade in a high school science class) are likely to be more highly efficacious about their capabilities and may raise their standards of mastery. When individuals have less experience with a task, they are typically less certain about their own capabilities to perform that task with success, and therefore tend to rely on vicarious experiences with others. Vicarious experiences are characterized by observations of others performing activities without adverse consequences (e.g., observing teachers or other students they perceive to be similar to themselves correctly model a science laboratory investigation). Furthermore, social persuasions are described as verbal judgments and other social messages such as corrective feedback, where individuals can be socially persuaded that they have the capabilities necessary to achieve success at a particular task (e.g., receiving encouragement from their science teacher). Finally, physiological states, such as anxiety, stress, and fatigue also act as sources of efficacy expectations. These physiological reactions to particular tasks (e.g., butterflies in their stomach when asked to complete the equation for photosynthesis) provide cues for the anticipated success or failure of the outcomes.

These four sources combine to form teacher and student efficacy beliefs and when efficacy beliefs are high, teachers and students are more likely to engage in particular classroom behaviors, such as instructional practices or learning activities (Bandura, 1977). For example, while students with low efficacy for science tasks may avoid activities or may not expend much effort because they do not believe they possess adequate competence to complete them with success, students with high efficacy may persevere when faced with difficult science tasks because they believe they do possess adequate competence to successfully complete them. Efficacy beliefs are domain specific and even situation specific, meaning they change depending on self-perceptions of competence in cognitive skills or actions required for adequate performance in a specific subject or task, and they guide students' choice of activities, amount of effort, and level of persistence with science classes or tasks (Bong & Clark, 1999; Pajares, 1996).

For the current study, students form efficacy beliefs regarding their capabilities to learn science while teachers form efficacy beliefs regarding their capability to influence students' science learning. Students' self-efficacy in science (i.e., efficacy beliefs) was the primary outcome variable for this dissertation study. As described next, efficacy beliefs act as a proxy for more distal outcomes in science.

Efficacy beliefs as proxy for achievement-related outcomes. Students' self-efficacy in science acts as a predictor of students' achievement level and their engagement in science-related activities (Kupermintz, 2002; Lau & Roeser, 2002). Students' beliefs in their capabilities to succeed in science tasks relate to their choices of science-related activities, the effort they expend on those activities, the persistence when encountering difficulty, and the success they experience (Britner & Pajares, 2006; Kupermintz, 2002; Lau & Roeser, 2002). Research has shown students' efficacy beliefs for science are associated with achievement-related outcomes across grade levels (e.g., Britner, 2008; Britner & Pajares, 2006). Regarding middle school students' efficacy beliefs for science, Britner and Pajares (2001; 2006) asked students to rate their confidence related to earning a high grade in science, and correlational analysis confirmed a strong relationship between science self-efficacy and science achievement as measured by students' final grades in science. In other words, students' efficacy beliefs for earning a high grade in science acted as a proxy for achievement in science class.

When examining high school students' efficacy beliefs for science, researchers (e.g., Kupermintz, 2002; Lodewyk & Winne, 2005) showed students' efficacy for science predicts both science achievement and engagement in science tasks. For example, Lau and Roeser (2002) investigated the relationship between high school science students' engagement and achievement in science and students' efficacy beliefs, which included their perceived efficacy for mastering science content, test-specific efficacy, and science confidence beliefs. Particularly important for this dissertation study, Lau and Roeser found efficacy beliefs explained a portion of the variance in science test scores and final grades above and beyond the variance accounted for by students' prior ability level. Efficacy beliefs were also found to be the strongest predictor of students' engagement in science tasks and expected science-related college major and career choices. Furthermore, efficacy beliefs were a stronger predictor of student outcomes than demographic characteristics, such as students' ethnicity, gender, and parents' educational level. Similar results have been found with college students enrolled in science courses. Researchers found students with higher efficacy beliefs tend to earn higher grades in science courses (Andrew, 1998), persist in science-related undergraduate majors (Dalgety & Coll, 2006), and express interest in science-related career choices (Gwilliam & Betz, 2001; Lent, Larkin & Brown, 1989). Based on these findings, students' efficacy beliefs in science can act as a proximal indicator of more distal science achievement-related outcomes, such as science performance and choice and persistence in undergraduate majors and careers. Hence, students' efficacy beliefs represent the motivational outcome variable in this study because students' efficacy beliefs are essential achievement-related motivational beliefs for science educators and stakeholders who want to create classroom environments that facilitate motivation and achievement in science.

Summary. Students evaluate their capabilities and skills related to a particular proxy domain or task and then translate their skills into behaviors (Schunk & Pajares, 2002). Students' efficacy beliefs can be defined as people's beliefs in their own capabilities to organize and execute the actions necessary to manage situations (Bandura, 1997). Efficacy beliefs are domain and situation-specific and derive from vicarious experiences, verbal persuasions, physiological arousal, and most importantly mastery experiences. For the purposes of this study, students' efficacy beliefs for science are viewed as a proximal indicator of more distal outcomes (e.g., science achievement, persistence in science majors, and career choices).

Applying a Lens of Self-Efficacy Theory to the Classroom Environment

Embedded in the larger school environment, the science classroom is similar to a petri dish in which students' experiences with various proximal processes shape their academic development (Hamre & Pianta, 2010). The conceptual model of classroom proximal processes (see *Figure 2.2*) proposes the mechanism that underlies the relation between science teachers' efficacy beliefs and students' efficacy beliefs may actually lie in the instructional environment that teachers establish in their classrooms. Specifically, teachers' efficacy beliefs for teaching science is proposed as a precursor to classroom instruction in science, which in turn is proposed as a precursor to students' efficacy beliefs for learning science.

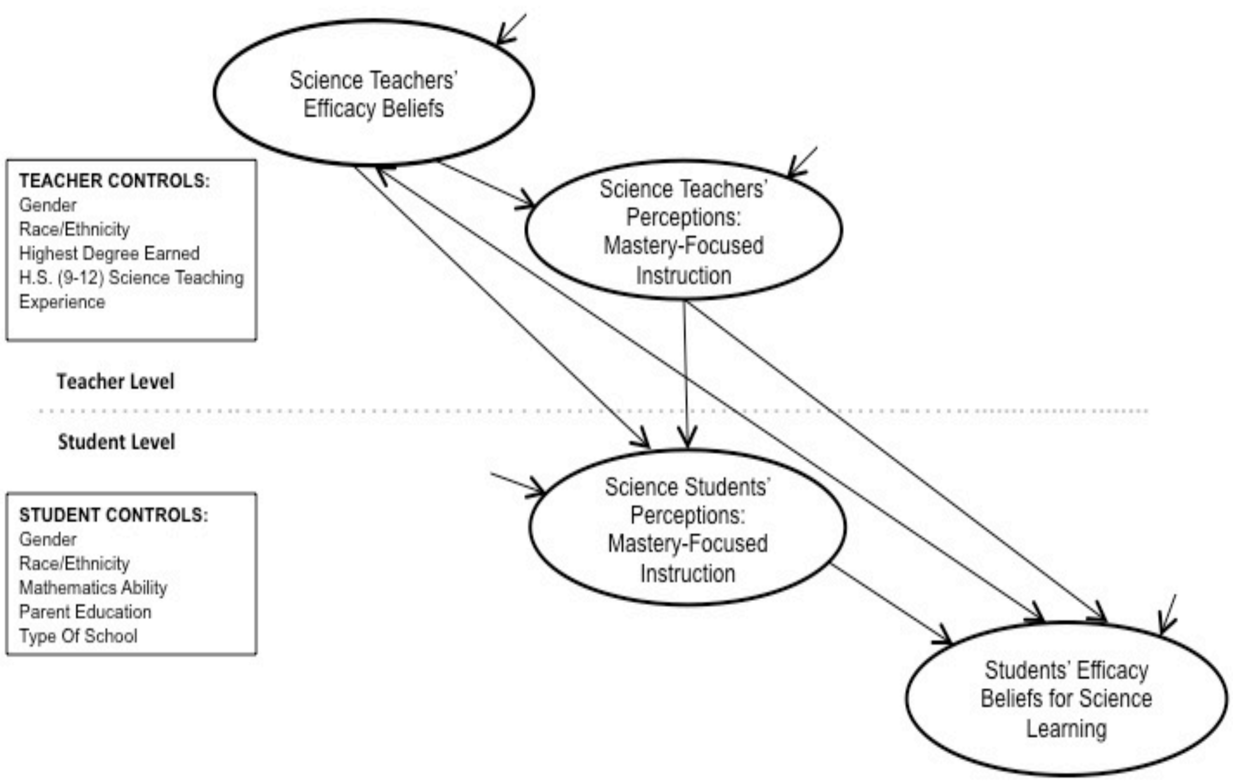

Figure 2.2 Conceptual Model of Science Student's Efficacy Beliefs for Science Learning

Teachers' instructional practices are key to science learning and motivation. Teachers play a critical role in students' motivation in the science classroom. Teachers' instructional practices and beliefs about their instruction contribute to the formation of their students' motivational beliefs. Science teachers are responsible for the frequency and duration of the situations in which students experience verbal persuasions (e.g., receiving corrective feedback and encouragement from the teacher), participate in vicarious learning activities (e.g., watching the teacher model how to decipher animal cells from plant cells), and engage in mastery experiences in science class (e.g., identifying animal cells from plant cells on their own). The success or failure students have with these experiences, particularly mastery experiences, contributes to the development of their own efficacy judgments for science learning. Science teachers can use instruction that provides students with multiple opportunities to engage in mastery experiences. Because mastery experiences are one of the most influential sources of students' efficacy beliefs (Bandura, 1977), teachers' instructional emphasis on mastery is a primary focus of this dissertation study.

Consistent with this focus on mastery experiences, recent reforms in science education have called for instructional practices to emphasize conceptual understanding (NRC, 2012), moving from students' understanding of their declarative ('knowing what") and procedural ('knowing how") knowledge to their ability to connect big ideas to prior knowledge and abstract principles (Byrnes, 2003; 2001). The need for higher-level science knowledge and abstract principles is necessary to combat misconceptions and faulty ideas (Beatty, Reese, Perksy, & Carr, 1996). Hence, science teachers are asked to emphasize the development of scientific conceptual knowledge by providing opportunities for students to make connections between prior knowledge and new information, to apply procedures to solve scientific problems, and to analyze, evaluate, and synthesize information in order to draw conclusions based on scientific criteria (Mayer, 2003; 2002). Furthermore, science teachers are asked to make their instruction meaningful and relevant to students, which can facilitate understanding, application, evaluation, and creation of new ideas about science topics (Stipek; 2005; Stipek & Seal, 2002). Teachers who use instructional practices aimed at concept development and meaningful learning tend to have students who make larger gains in achievement (Alparslan, Tekkaya, & Geban, 2003; Romberg, Carpenter, & Kwako, 2005).

The call for science teaching practices that emphasize conceptual understanding and meaningful learning are also consistent with motivational researchers' call for teaching practices that emphasize mastery learning, which they refer to as *mastery-focused instruction* (Meece, Herman, & McCombs, 2003). Mastery learning occurs when students are actively participating, cognitively engaged in a task, and continually receiving constructive verbal feedback on their performance through the task (Meece et al., 2003). Evidence suggests that in order for students to successfully complete challenging and meaningful tasks (i.e., mastery learning experiences) they need effective and multidimensional instructional support and guidance from their teacher (Pintrich & Schunk, 2002; Stipek & Seal, 2002). Looking across subject areas, Meece (1991) characterized mastery-focused instruction to include an emphasis on students' understanding rather than on rote memorization of facts, recognition and praise of students' effort and persistence through challenging academic tasks, and acceptance of mistakes as being part of the learning process. Teachers using mastery-focused instruction emphasize the importance of trying difficult tasks, pursuing new ideas and interests, and taking responsibility for their learning. Furthermore, when teachers tailor their instruction to meet the needs of the individual learners, encourage autonomy and collaboration, and connect new learning to prior knowledge, students are more likely to perceive a classroom environment that emphasizes mastery-focused instruction (Meece, 1991).

In science, mastery-focused teachers use instructional activities that provide opportunities to develop higher order thinking skills and encourage students to take risks (Anderman, Sinatra, & Gray, 2012; Meece, 1991). For the purposes of this dissertation, mastery-focused instruction in science is characterized by teachers' promotion of interest in science, teaching science processes and inquiry skills, and teaching students to develop higher order thinking skills (e.g., evaluating arguments based on scientific evidence, communicating science ideas effectively, and establishing connections between science and society, such as technology, business, and industry). Motivational researchers agree that teachers play a critical role in creating classrooms that are intellectually challenging and developmentally supportive (Anderman, Andrzejewski, & Allen, 2011; Meece, 1991; Meece et al., 2003; Turner et al., 2002). With respect to creating classrooms that foster motivation and achievement, it is important to examine other classroom proximal processes as well. In the past, researchers have examined classroom instruction and motivation separately, but over the past few decades, researchers have begun to look toward the motivation and classroom practices of teachers as contributing to the explanation of student success in the classroom (e.g., Angle & Moseley, 2009; Meece, 1991). Researchers now are examining teachers' beliefs and classroom instructional practices as potential predictors of students' efficacy beliefs. Understanding the dynamic of these relationships could contribute to promoting science learning in the United States.

Teachers' beliefs help shape teachers' classroom instructional practices. Evidence suggests teachers' efficacy beliefs play a role in the frequency of and duration of particular instructional practices (Klassen, Tze, Betz & Gordon, 2011). Building on Bandura's (1997) ideas, Tschannen-Moran, Hoy, and Hoy (1998) also argued teachers' sense of efficacy varies across teaching tasks and contexts. Teachers' efficacy beliefs are defined as teachers' judgments of their own capabilities to produce desired outcomes of student learning and engagement, even among difficult or unmotivated students (Tschannen-Moran & Woolfolk Hoy, 2001). Similar to students' evaluations of efficacy, teachers continuously evaluate their own teaching competence as well as the difficulty of the science-teaching task (Klassen et al., 2011). Teachers are continually receiving and processing cues from the classroom that contribute to the development of their overall teaching efficacy. For example, if teachers engage in instruction focused on students' concept development and mastery learning (i.e., mastery-focused instruction) and experience success in student engagement and learning outcomes, then their efficacy beliefs for engaging in mastery-focused instruction will likely rise (Bandura, 1997). However, if teachers perceive failure in student learning after engaging in mastery activities, their efficacy beliefs are likely to decline, leading them to possibly withdraw from engaging in mastery-focused instructional practices in the future. Teachers' efficacy beliefs are associated with teachers' goals, effort, and persistence with teaching tasks, which in turn are associated with their teaching behaviors (e.g., choice in instructional strategies, feedback to students), and actual teaching performances serve as mastery experiences for future efficacy judgments.

A focus of the current study was to examine how teachers' efficacy beliefs contribute to their instructional practices, which could potentially alter students' efficacy beliefs. Teachers' efficacy beliefs have been shown to relate to their instructional practices (Tschannen-Moran & Woolfolk Hoy, 2001). For example, teachers with low efficacy may avoid planning lessons that may exceed their science content or pedagogical knowledge, be unlikely to persist with struggling students, and expend little effort to reteach content when students have misconceptions (Tschannen-Moran & Woolfolk Hoy, 2001). In contrast, teachers with high efficacy beliefs may spend more time developing challenging inquiry activities, persist with helping struggling students, and create a classroom climate focused on all students learning (Tschannen-Moran & Woolfolk Hoy, 2001). Thus, teachers' efficacy beliefs may contribute to the degree to which they engage in mastery-focused instruction and the degree to which their students' perceive mastery-focused instruction in the classroom. In turn, these perceptions of mastery-focused instruction may help shape the formation of students' efficacy beliefs for learning science. Finally, completing the cycle of proximal processes within the classroom (see *Figure 2.1*, p. 14), students' efficacy beliefs may contribute to the formation of teachers' efficacy beliefs for teaching science.

Summary. Recent investigations in educational psychology (e.g., Anderman, Andrzejewski & Allen, 2012; Meece et al., 2006; Turner, 2011) and science education (e.g., Anderman, Sinatra, & Gray, 2012; Angle & Moseley, 2009; Appleton & Lawrenz, 2011; Britner, 2008; Bybee, 2010) have focused on how the classroom instructional climate promotes positive student development. Together these bodies of literature emphasize how the quality of instruction optimizes student motivation and learning. For the purposes of this study, mastery-focused instruction is key to promoting students' efficacy beliefs for learning science (Meece, 1991). Whether or not teachers engage in mastery-focused instruction may relate to their own efficacy beliefs for promoting student learning in science. Key proximal processes represented in the conceptual model (see *Figure 2.2*, p. 19) are teacher efficacy beliefs and student efficacy beliefs, teacher efficacy beliefs and teacher instructional practices, and teacher instructional practices and student efficacy beliefs. These processes continuously occur in each science classroom and contribute to students' science learning and motivation (Meece, 1991; Turner, Christensen, & Meyer, 2009). In the next sections, the conceptual model is broken down and each proximal process is further explored.

Breaking Down the Conceptual Model: Proximal Processes at Work in the Classroom

The conceptual model (see *Figure 2.2*, p. 19) is composed of hypothesized relations among students' efficacy beliefs and mastery-focused instruction, teachers' and students' efficacy beliefs, and teachers' efficacy beliefs and mastery-focused instruction. In the previous section, an explanation of how these processes work together within the classroom context to promote students' efficacy beliefs for science learning is described. In the following section, research supporting each linkage is reviewed in more detail.

Connecting mastery-focused instruction and students' efficacy beliefs. To date, few studies have examined the relation between mastery-focused instruction and students' efficacy beliefs in high school classrooms. The majority of these studies have focused on classroom achievement goals (e.g., Bong, 2009; Gutman, 2006; Wolters & Daughtery, 2007). Achievement goal theory (Ames, 1992) suggests that individuals form types of goals: *mastery goals*, which are concerned with developing new skills and improving on past performance, and *performance goals,* which are concerned with being judged and outperforming others. Although achievement goals were not a focus of this dissertation, some research on mastery-goal orientations aligns with mastery-focused instruction (e.g., helping students set objectives or goals and evaluating effort toward them). Drawing on this literature, researchers have found that teachers of higher grade-levels tend to report less emphasis on mastery-focused instruction in the classroom than do teachers of lower grade levels (Wolters & Daughtery, 2007).

A similar pattern is found for students' self-reports of an emphasis on mastery goals in the classroom (Bong, 2009). However, students who perceive their high school classroom as emphasizing mastery-focused instruction may experience more positive changes in their efficacy beliefs as they move up in grade level (Gutman, 2006). The use of mastery-focused instruction has been shown to predict student efficacy beliefs (Anderman & Young, 1994; Meece et al., 2003; Siegle & McCoach, 2007). When students perceive that their teacher emphasizes mastery-focused instructional practices, they are more likely to report higher efficacy beliefs (Meece et al., 2003). In a recent investigation, Siegle and McCoach (2007) demonstrated the role of mastery-focused instruction in promoting elementary-aged students' efficacy beliefs in mathematics. Specifically, they found teachers posted daily lesson objectives in classrooms and reviewed the previous day's accomplishments toward meeting these objectives, which helped students evaluate their own growth. Another instructional strategy teachers used was appropriate feedback, meaning they complimented students' on effort and growth toward specific skills and away from attributing failure to a lack of ability. These findings were consistent with other motivational researchers who suggest providing students with appropriate and meaningful feedback on progress can help raise students' efficacy beliefs (Schunk & Meece, 2006). Therefore, how a teacher structures lessons, provides feedback to students, and evaluates student performance help mold students' efficacy beliefs about learning (Anderman, Eccles, Yoon, Roeser, Wigfield, & Blumenfeld, 2001; Meece, Anderman, & Anderman, 2006).

Research specific to science education. Currently, no studies have been published examining mastery-focused instruction and student efficacy beliefs in high school science. However, Anderman and Young (1994) investigated this connection in middle school science classrooms. The researchers administered the Patterns of Adaptive Learning Survey (PALS) (Midgley et al., 1997) to middle school science students and teachers and found that students of teachers who emphasized more ability-focused instructional practices (e.g., pointing out the highest achieving students as examples to other students) rather than mastery-focused instructional practices (e.g., emphasizing individual effort and persistence over competition) also reported lower efficacy beliefs for learning science. Additional studies are needed to connect teachers' mastery-focused instruction to students' efficacy beliefs in high school science classrooms.

Teacher versus student reports of mastery-focused instruction. Whether the instructional climate of classrooms should be measured through teacher or student reports is a critical question and is debated by researchers (Desimone, Smith & Frisvold, 2010). The issue is particularly important with the implementation of standards-based instruction in the classroom (Pianta & Hamre, 2009). Some researchers have argued that teacher self-reports of their instructional practices are unreliable (e.g., Spillane & Zeuli, 1999; Stigler, Gonzales, Kawanaka, Knoll, & Serrano, 1999). These researchers contended that relative to student reports, teachers tend to view their classroom climate more positively and overestimate their use of particular instructional practices (Fisher & Fraser, 1983).

Consistent with this view, other researchers argued that student reports of classroom climates are more useful because students are active interpreters of classroom instructional experiences and filter experiences through individual differences in motivation and achievement. For example, Meece and colleagues (2003) showed student reports of teachers' instructional practices added significantly to predicting students' efficacy beliefs and goal orientations. Furthermore, some researchers (Kahle, Meece, & Scantlebury, 2000; Scantlebury, Boone, Kahle, & Fraser, 2001) have suggested student reports of classroom climate have been shown to act as better predictors of student outcomes in science and mathematics. These researchers contended, "student perceptions of teaching may not resemble the teachers' self-reported or observed practices" (Meece et al., 2003, p. 471) and suggest the inclusion of student reports of classroom climates.

On the other hand, other researchers have argued that teacher and student reports of classroom climates are unique contributors, and it is necessary to consider both. For example, Urdan and colleagues (1998) found low positive correlations between teacher and student reports of the same mastery emphasis, and both teacher and student reports of classroom instructional emphasis contributed uniquely to predicting student outcomes. Desimone, Smith, and Frisvold (2010) used data from the National Assessment of Education Progress (NAEP) to compare middle school mathematics teacher and student reports of mathematics instruction. The researchers found low correlations between students' and teachers' reports. Specifically, teacher and student reports were more similar when more objective questions (e.g., frequency of computer use) were asked rather than more subjective (e.g., types of strategies). Desimone and colleagues (2010) reasoned that teachers and students may have different conceptualizations of what counts as a "class discussion" or "inquiry," which may reflect particular responses to survey items. Due to inconsistencies across studies, it is necessary to attend to teacher and student perceptions of the instructional environment when examining instruction and student academic or motivational outcomes.

Summary. Based on previous definitions (e.g., Meece, 1991), mastery-focused instruction in science refers to teachers' use of promoting students' interest in science, teaching science process and inquiry skills, and helping students develop higher order thinking skills. To date, no studies were found that have examined the relation between mastery-focused instruction and students' efficacy beliefs within the context of high school science classrooms. Furthermore, researchers debate whether the instructional climate of classrooms should be measured through teacher or student reports. Therefore, this study includes both teacher and student reports when examining the connection between mastery-focused instruction and students' efficacy beliefs within the context of high school science classrooms.

Connecting teacher and student efficacy beliefs. A limited body of literature exists that directly links teachers' sense of efficacy to students' sense of efficacy, and to-date no published studies were found that establish this connection within the domain of high school science. However, the studies that have been conducted outside of high school science do show support for the connection between constructs. For example, Anderson and colleagues (1988) found the level of teaching efficacy that teachers held at the beginning of the school year was significantly related to the development of their students' efficacy beliefs. The researchers also showed that teachers' sense of efficacy contributed to students' level of efficacy in language arts and social studies. In another study, Ross and colleagues (2001) examined teachers' efficacy beliefs for computer instruction, students' use of computers, and students' efficacy beliefs for using computers. The researchers found that teachers' efficacy beliefs contributed to the promotion of students' efficacy beliefs by fostering their involvement in class activities and toward difficult computer-related tasks. However, Ross and colleagues found only modest bivariate correlations between teacher and student efficacy beliefs.

In a more recent investigation, Corkett, Hatt, and Benevides (2011) administered three measures of efficacy: (a) a teacher self-efficacy questionnaire, (b) a student literacy self-efficacy questionnaire, and (c) a teacher version of the student questionnaire to measure a teacher's perception of individual student's self-efficacy for reading and writing. First, the researchers found teachers' perceptions, but not students' own perceptions, of students' self-efficacy significantly correlated with students' literacy abilities. Second, they found no relationship between teacher and student perceptions of students' literacy efficacy beliefs. Third, the researchers found that teachers' efficacy beliefs were associated with teachers' perception of students' efficacy beliefs but were not associated with students' reports of their efficacy beliefs.

Although empirical links between teacher and student efficacy beliefs have been explored, the direction of the relation is still not clear. Theoretically speaking, based on Bandura's (1997) and Tschannen-Moran and colleagues' (1998) description of teacher efficacy, the relation could be bidirectional due to the dynamic nature of the constructs. In other words, students' and teachers' efficacy beliefs are constantly influencing and being influenced by individuals' experiences and thought processes in the classroom (Henson, 2001). Specifically, the mastery experiences, vicarious experiences, and verbal persuasions that teachers provide during instruction could contribute to the development of their students' efficacy beliefs. Reciprocally, student efficacy beliefs could also contribute to the formation of teachers' beliefs through the same experiences. For example, when teachers engage in mastery-focused instruction, they practice teaching tasks in the same way students practice learning tasks. During instruction, they continually receive, process, and evaluate feedback from their students, such as excitement or boredom, persistence or withdrawal from difficult tasks, correctly or incorrectly answering the teachers' questions or performing a science activity. These mastery teaching experiences and feedback from students provide valuable insight toward the formation of teachers' efficacy judgments. Therefore, because mastery experience is the most critical source of efficacy beliefs (Bandura, 1977), perhaps the mechanism underlying the potential association between teacher and student efficacy beliefs lies in the classroom instructional environment established by the teacher.

Summary. Previous research explores connections between teacher and student efficacy beliefs. However, additional research is needed to understand the direction of the relation and the mechanism that may connect these two types of beliefs. Furthermore, future research needs to extend to high school classrooms, particularly high school science classrooms. Hence, in the next section, the evidence supporting the connection between mastery-focused instruction and teachers' efficacy beliefs is discussed.

Connecting mastery-focused instruction and teachers' efficacy beliefs. Researchers have shown that teachers' efficacy beliefs are associated with mastery-focused instructional practices, such as the effort they exhibit in their planning (Allinder, 1994); level of openness to trying new instructional strategies to better meet the needs of individual students in their classroom (Berman, McLaughlin, Bass, Pauly, & Zellman, 1977; Guskey, 1988), and their level of persistence during setbacks (Ross, 1998). When compared to teachers who report low efficacy beliefs, teachers who report high efficacy beliefs tend to be less critical of their students when mistakes are made, believing that mistakes are a part of the learning process (Ashton & Webb, 1986), are more willing to persist when working with students who are struggling (Gibson & Dembo, 1994); and are less inclined to refer difficult students to special education programs (Podell & Soodak, 1993). Specific to the focus of this study and discussed in the next section is the link between teachers' efficacy beliefs and instructional practices in science classrooms.

Research specific to science education. In comparison to research conducted with preservice teachers, fewer studies have examined the connection between science teachers' sense of efficacy and instructional practices of inservice teachers. Furthermore, studies that have investigated teachers' efficacy beliefs and instruction have examined a variety of instructional practices. Therefore, this section provides a summary of the literature examining the connection between teachers' efficacy beliefs and various instructional practices that align with what could be considered mastery-focused instruction in motivation literature.

Riggs and Jesunathadas (1993) reported that teachers with a higher sense of personal science teaching efficacy were more likely to spend more time teaching science and more time developing the science concepts they were asked to teach than were teachers with a low sense of efficacy. Furthermore, Watters and Ginns (1995) reported personal science teaching efficacy to be associated with teacher ratings of the relevance of science and enjoyment of science activities. Specifically, more highly efficacious teachers rated science as more relevant and science activities as more enjoyable than teachers with a low sense of personal teaching efficacy. Evidence also suggests teachers with a high sense of personal teaching efficacy tend to engage their students in more student-centered science lessons (Loughran, 1994) and believe that all students are capable of learning science through classroom experiences and cooperation with peers (Scharmann, & Hampton, 1995). Other studies (Enochs, Scharmann, & Riggs, 1995; Gibson & Dembo, 1984) reported that science teachers with a low sense of efficacy tend to rely heavily on the use of more authoritative, teacher-directed instruction, such as text-based instruction or lecturing, and these teachers avoid using inquiry experiences in the classroom.

Consistent with this research, Marshall, Horton, Igo, and Switzer (2009) recently compared elementary school and high school teachers' efficacy beliefs for using inquiry-based practices and recorded the time they spent engaged in student-centered instruction based on inquiry and problem-solving. Using a situation-specific measure of teachers' sense of efficacy, they found that (a) elementary science teachers reported using inquiry-based instructional practices more often than middle or high school teachers, (b) science teachers who possessed higher efficacy beliefs for teaching inquiry showed a higher percentage of time devoted to inquiry during a typical lesson, and (c) the correlation between teachers' sense of efficacy and time spent using inquiry dropped slightly when they controlled for grade level and content area. These studies indicated that science teachers feel less efficacious for using instruction that is effective for overcoming barriers to student learning in science. Although progress has been made, additional research is needed to connect teachers' sense of efficacy and mastery-focused instruction to student-level outcomes. This study contributes to the extant body of literature in science education by investigating how these constructs relate to one another within the context of high school science classrooms.

Summary. Researchers have examined the connection between inservice science teachers' efficacy beliefs and various instructional practices that align with aspects of mastery-focused instruction. However, researchers have not yet investigated the potential mediating relation of mastery-focused instruction between teacher and student efficacy beliefs in high school science classrooms in the United States. Therefore, in the next few sections, a mediation model is presented. Drawing on existing research, teachers' efficacy beliefs are hypothesized to be associated with teachers' use of mastery-focused instruction in the classroom. In turn, mastery-focused instruction is hypothesized to be associated with students' efficacy beliefs.

Mastery-Focused Instruction as a Mediator between Teacher and Student Efficacy Beliefs

In psychological and educational research, mediation is concerned with understanding the mechanism by which constructs are related (Baron & Kenny, 1986). The potential mechanism by which teacher and student efficacy beliefs are related may lie in teachers' use of mastery-focused instruction. As described in previous sections, predictors of students' efficacy beliefs have been shown to include classroom emphasis on mastery-focused instruction (Meece et al., 2003) and teachers' sense of efficacy (Midgley et al., 1989; Ross et al., 2001). However, to date, only one study (Thoonen, Sleegers, Peetsma, & Ooart, 2011) was found that examined the relative importance of teachers' instruction and efficacy beliefs to explain variation in students' efficacy beliefs.

Thoonen and colleagues administered scales of teachers' efficacy beliefs (van Woerkom, 2003), student efficacy beliefs (Midgley et al., 1997), and teaching practices (Roelofs & Houtveen, 1999). When completing the instructional questionnaire, teachers indicated the extent to which the item referred to four teaching practices: process-oriented instruction, connection to students' world, cooperative learning, and differentiation. Thoonen and colleagues characterized process-oriented instruction as the gradual shift of control of the learning process from the teacher to the student, focusing on knowledge building, fostering independent learning, and supporting students to become lifelong learners. Using multilevel regression analyses, they reported, "the effect of teachers' sense of self-efficacy on students' well-being in school was fully mediated by process-oriented instruction and cooperative learning" (p. 356). In other words, teacher and student efficacy beliefs were related through the mediation of teachers' instructional practices, as measured by the four teaching practices. However, Thoonen and colleagues recognized the limitations of their study and recommended additional research be conducted. Therefore, this dissertation study attempts to address the limitations of Thoonen and colleagues' study and expand teachers' instructional practices to include mastery-focused instruction (Meece et al., 2003).

Purpose of the Study

Although evidence to support a mediation model exists, gaps in the literature suggest additional research is needed. The only published study found (Thoonen et al., 2011) that included all three proximal processes within a single mediation model has limitations with respect to generalizability. First, the researchers surveyed only elementary school teachers and students in a particular area of the Netherlands. Second, the researchers used an unpublished scale of teachers' efficacy beliefs, citing a dissertation as the only source for additional information. Third, the researchers did not collect certain demographic information from students (e.g., socioeconomic status, prior performance, ethnicity), which have been shown to be associated with students' motivation to learn (Desimone et al., 2010; Vedder, Boekaerts, & Seegers, 2003). To their credit, Thoonen and colleagues recognized some of these limitations by noting that their findings are restricted by a relatively small class-level and school-level variance. As a result of these limitations, the researchers recommended future studies use larger and more heterogeneous samples and utilize multilevel structural equation modeling to analyze the data.

This dissertation study responded to Thoonen and colleagues' (2011) call for additional research by addressing their limitations and extending the scope of investigation to high school classrooms. Furthermore, this dissertation study expanded this body of literature to high school science classrooms. Thus, the purpose of this dissertation was to use Self Efficacy Theory (Bandura, 1977) to examine the relationships among science teachers' efficacy beliefs, both student and teacher perceptions of science teachers' emphasis on mastery-focused instruction, and students' efficacy beliefs for science. In addition, this study used teacher and student reports of mastery-focused instruction in an effort to examine alignment between perceptions and if and how each partially mediates the relation between teacher and student efficacy beliefs.

Building on research reviewed in this chapter, this study relied on items from the High School Longitudinal Study of 2009 (Ingels et al., 2011) to measure the relation among four latent constructs: science teachers' sense of efficacy, science teachers' perceptions of mastery-focused instruction, students' perceptions of their science teachers' use of mastery-focused instruction, and science students' sense of efficacy. Specifically, a mediation model of mastery-focused instruction was examined to explore whether or not students' and teachers' perceptions of mastery-focused instruction partially mediate the relation between teachers' and students' efficacy beliefs in science. Because students are nested within classrooms, hierarchical structural equation modeling was used for analyses (Muthen & Muthen, 2007). This study contributes to and bridges a gap between bodies of literature in educational psychology and science education. The next section presents all research questions and hypotheses.

Research Questions and Hypotheses

1. Does the hypothesized model (see Figure 2.2, p. 39) provide a satisfactory fit to the sample data? I hypothesized that the model would produce satisfactory goodness-of-fit indices using the following goodness-of-fit indices used for multi-level structural equation modeling in Mplus (Muthen & Muthen, 2007): Akaike (AIC) and Bayesian (BIC).

2.1. Are science teachers' efficacy beliefs related to students' efficacy beliefs for science learning? I hypothesized science teachers' efficacy beliefs would be related positively to students' efficacy beliefs for science learning with statistical significance ($p < .05$) being the determining factor. In other words, teachers who report higher efficacy beliefs for science teaching would have students who report higher efficacy beliefs for science learning.

2.2. Are students' efficacy beliefs for science learning related to science teachers' efficacy beliefs? I hypothesized students' efficacy beliefs for science learning would be related positively to science teachers' efficacy beliefs with statistical significance ($p < .05$) being the determining factor. In other words, students who report higher efficacy beliefs for science learning would have teachers who report higher efficacy beliefs for science teaching.

3. Are science teachers' efficacy beliefs related to science teachers' perceptions of mastery-focused instruction? I hypothesized science teachers' efficacy beliefs would be related positively to science teachers' perceptions of mastery-focused instruction with statistical significance ($p < .05$) being the determining factor. In other words, teachers who report higher efficacy beliefs for science teaching would also report higher levels of mastery-focused instruction in the classroom.

4. Are science teachers' efficacy beliefs related to students' perceptions of mastery-focused instruction? I hypothesized science teachers' efficacy beliefs would be related positively to students' perceptions of mastery-focused instruction with statistical significance ($p < .05$) being the determining factor. In other words, science teachers who report higher efficacy beliefs would have students who report higher levels of mastery-focused instruction in the classroom.

5. Are science teachers' perceptions of mastery-focused instruction related to their students' perceptions of their mastery-focused instruction? I hypothesized science teachers' perceptions of mastery-focused instruction would be related positively to science students' perceptions of mastery-focused instruction with statistical significance ($p < .05$) being the determining factor. In addition, I hypothesized science teachers would report higher perceptions of mastery-focused instruction in the classroom than their students.

6. Are science teachers' perceptions of mastery-focused instruction related to students' efficacy beliefs for science learning? I hypothesized science teachers' perceptions of mastery-focused instruction would be related positively to students' efficacy beliefs for science learning with statistical significance ($p < .05$) being the determining factor. In other words, teachers who report higher levels of mastery-focused instruction in the classroom would have students who report higher efficacy beliefs for science learning.

7. Are students' perceptions of mastery-focused instruction related to students' efficacy beliefs for science learning? I hypothesized students' perceptions of mastery-focused instruction would be related positively to students' efficacy beliefs for science learning with statistical significance ($p < .05$) being the determining factor. In other words, students who report higher levels of mastery-focused instruction in the classroom would report higher efficacy beliefs for science learning.

8. What relation exists among science teachers' efficacy beliefs, science teachers' perceptions of mastery-focused instruction, students' perceptions of mastery-focused instruction, and students' efficacy for science learning? I hypothesized both teachers' and students' perceptions of mastery-focused instruction would partially mediate the relation between science teachers' efficacy beliefs and students' efficacy beliefs for science learning with statistical significance ($p < .05$) being the determining factor.

Teacher level variables (gender, race/ethnicity, highest degree earning, and years of high school teaching experience) and student level variables (gender, race/ethnicity, mathematics achievement, parent education, and type of school) were used as controls in this study. The conceptual model is displayed in *Figure 2.2* (p. 19). The structural model (*Figure 3.1, p. 59)* is discussed in the next chapter.

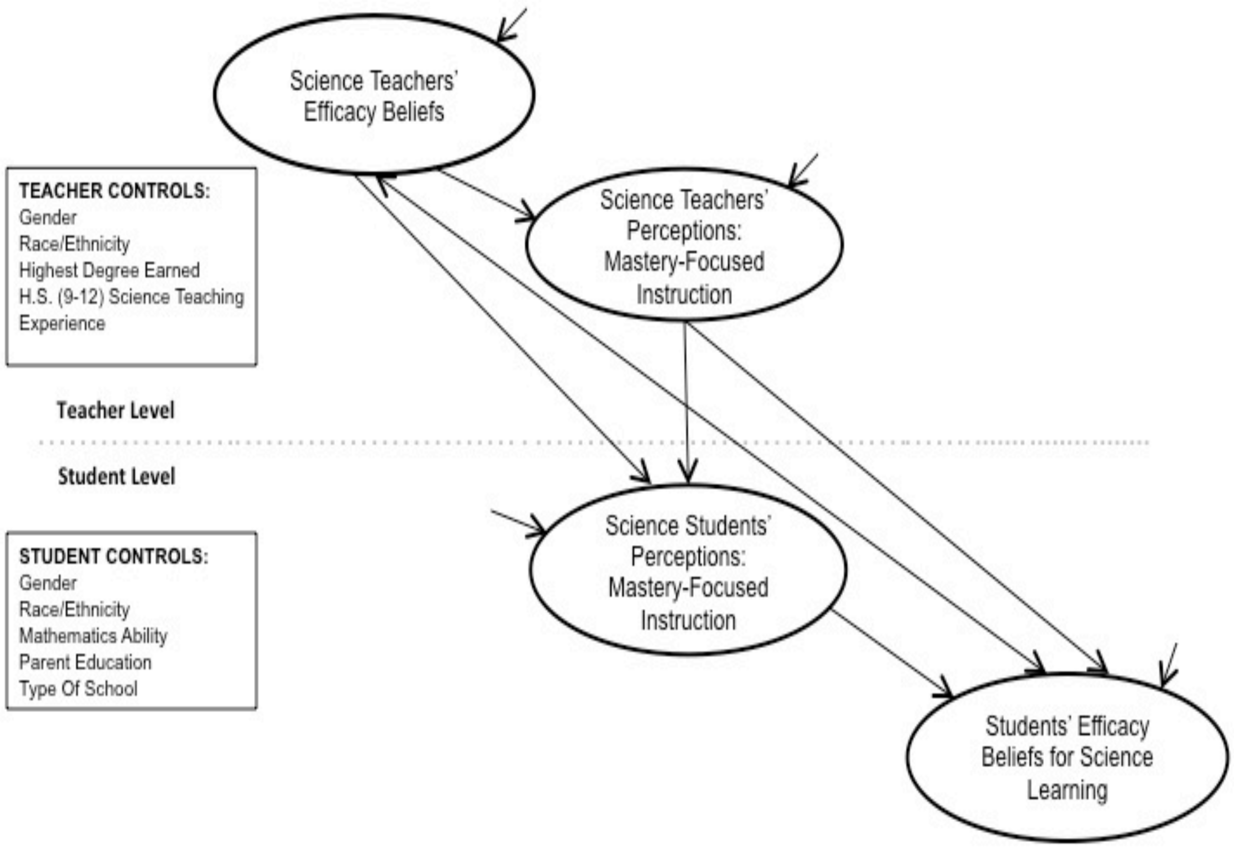

Figure 2.2 Conceptual Model of Science Student's Efficacy Beliefs for Science Learning

CHAPTER THREE

METHOD

In this chapter, a description of the High School Longitudinal Study 2009 (HSLS: 09) design, study procedures, and participants is provided. Next, descriptions of the instruments used for the proposed study are described, and an explanation of how the data were prepared for analysis is presented. This chapter concludes with a summary of the methods used to investigate each research question.

High School Longitudinal Study 2009

This study used data from HSLS: 09, which is a nationally representative, longitudinal study of ninth graders across the United States who will be followed through high school and into postsecondary education and the workforce (Ingels et al., 2011). HSLS: 09 is the fifth in a series of longitudinal studies conducted by the National Institute for Educational Statistics (IES), and the major focus of the study is to map student trajectories from the start of the high school experience into postsecondary education, the job market, and beyond.

HSLS: 09 Sample Design

HSLS:09 is a stratified, two-stage random sample design with schools defined as primary sampling units and students randomly selected from these schools defined as secondary sampling units (Ingels et al., 2011). First, high schools were randomly selected from strata that were generated based on geography and population densities. This target population was defined as regular public schools, public charter schools, and private schools in all 50 U.S. states and the District of Columbia providing instruction to ninth and 11th graders. This stratified process identified 1,889 eligible schools. A total of 944 schools participated in the study, which resulted in a 50.0% (unweighted) response rate. Second, 25,206 eligible students were randomly selected from ninth grade schools' enrollment lists, with approximately 27 students per school. Students unable to complete the questionnaire due to language barriers or severe disabilities were retained in the sample and reassessed in the first follow-up. Consequently, only contextual data were collected for 548 students during the base year, resulting in 24,658 questionnaire-capable students. During the base year, the selected students' parents, counselors, administrators, and science and/or mathematics teachers also were asked to complete a questionnaire. Based on the nature of the design, HSLS: 09 is nationally representative of schools with ninth and 11th grades and ninth graders in the United States during the 2009-2010 school year. Because the unit of analysis is the student, the study is not nationally representative of parents, teachers, counselors, or administrators (Ingels et al., 2011).

HSLS: 09 Procedure and Participants

Because this dissertation used data collected only from science teachers and science students, only those questionnaire procedures and participants are described. Data collection was conducted between September 8, 2009, and February 26, 2010, with telephone follow-up continuing until April 18, 2010, by 230 trained session administrators. A total of 21,444 students (85.7% weighted) randomly selected from 944 schools across the United States participated in the study (Ingels et al., 2011). The student participants completed a web-based, self-administered survey during an in-school session. Approximately 98% of the students completed the questionnaire during an in-school session, which was 90 minutes in length with 15 minutes for instruction and setup, 35 minutes for the student questionnaire, and 40 minutes for an algebraic reasoning assessment. Each participant inserted a disk into a computer, and data were sent directly to IES. The remaining 2% of the students completed the assessments during an out-of-school session. Because data collection began during the fall of 2009, some students were not enrolled in mathematics and/or science due to scheduling. A total of 4,804 science teachers participated in the study. The teacher participants also completed a web-based, self-administered survey if they had an HSLS student enrolled in their mathematics or science course, using the same procedures as described for the students (Ingels et al., 2011).

HSLS: 09 Imputation

As with any large-scale questionnaire, some questions are not answered by respondents. Imputation can address the issue of missing data due to nonresponse (Allison, 2010). Imputation allows researchers to use all of the respondent's data in the analysis, which allows for more power in statistical tests. Moreover, if the imputed value is equal to or close to the true value, and therefore the imputation procedure is effective, then the results from the analysis are less biased than are results generated from an incomplete data file (Allison, 2010). This study used only the following imputed variables, which are described in more detail later in this chapter: student ability estimates (*theta*) and the standard error of measurement (*sem*) for *theta,* which were replaced with values using imputation procedures by IES. A total of 22,108 students (96.9%) completed a sufficient number of questions to calculate *theta* and *sem.* For the remaining 663 students (less than 5% missing), multiple imputation procedures (i.e., Markov Chain Monte Carlo, [MCMC]) were used to estimate the probability distribution of the variables (Ingels et al., 2011). The use of MCMC assumes data are missing at random (MAR) and are normally distributed (Allison, 2010). Missing values were filled in by random draws from this distribution, and simultaneous imputation was used to best capture the association of *theta* with *sem* (Ingels et al., 2011).

Current Study

IRB and Restricted Data Access

Most of the variables in the HSLS: 09 data set could be accessed by the public. However, the variables needed to link the teachers to the students were suppressed and could be accessed only through an application process. After receiving UNC Institutional Review Board (IRB) approval, an application was sent to IES requesting access to the restricted data set. Access to the restricted data set was granted by IES, and all data analyses were conducted under the advisement of Judith Meece, Ph.D., Professor of Education, UNC-Chapel Hill, Catherine Zimmer, Ph.D., Senior Statistical Consultant and Adjunct Professor of Sociology, UNC-Chapel Hill, and Adam Holland, Ph.D., Research Investigator at UNC- Chapel Hill's Frank Porter Graham Child Development Center in a secure data room located in Peabody Hall at the University of North Carolina at Chapel Hill.

Participants

For the purposes of this dissertation study, data from only ninth grade Biology students and their Biology teachers were used for analyses. Because multiple students were enrolled in the same Biology class in some cases, the number of unique Biology teachers (N = 2,055) was fewer than the number of unique Biology students (N = 3,557). Demographic information on the students and teachers is presented in the next chapter.

Instrumentation

This dissertation study used items from the student and teacher questionnaires described below.

Student questionnaire. The student survey consisted of eight sections including (a) demographic information; (b) science and mathematics activities, eighth grade science and mathematics courses, and self-reported grades; (c) self-efficacy in mathematics; (d) self-efficacy in science; (e) attitudes about school, mathematics, and science; (f) career plans, friends' attitudes about school, program participation, and comparison of male and female abilities in science, mathematics, and English; (g) high school, college, and career plans and intentions to take advanced mathematics and science courses; and (h) educational expectations and estimates of college plans and careers. To reduce item nonresponse bias, students were assigned randomly to one of two groups that determined the order in which each section was administered (Ingels et al., 2011).

Teacher questionnaire. The teacher survey consisted of four sections about their science department and instruction: (a) professional and personal background information; (b) class and department climate, such as perceptions of how teaching assignments are made; (c) achievement level and preparedness of students for coursework, course objectives, and teaching approaches; and (d) school climate, such as evaluations of the school principal and faculty, barriers to teaching, and beliefs about influences on students' home life, and teachers' sense of efficacy (Ingels et al., 2011).

Measurement: Latent Variables

The conceptual model was presented in the previous chapter (see *Figure 2.2*, p. 19). The structural equation model is presented in *Figure 3.1*, p. 59, which includes the empirical relations among the constructs in the conceptual model. In the next few sections, the four latent variables used in the analysis are described.

Students' efficacy beliefs for science learning. The latent variable, students' efficacy beliefs for science learning, was measured using CFA of the student's science self-efficacy using a model generated by IES researchers. IES researchers reported Cronbach's alpha of 0.88 for the four-item scale using all science students' responses (see Table 3.1 for a list of items). The items on the four-point Likert scale were reverse coded for this study so higher scores reflected higher efficacy: *strongly agree* = 4; *agree* = 3; *disagree* = 2; and *strongly disagree* = 1. For the purposes of this study, exploratory factor analysis (EFA) was conducted to examine how these items empirically load on this factor (Students' Efficacy Beliefs) and reliability coefficients were calculated with a random sample of Biology students (n = 1,000). Results from these analyses are reported in Chapter 4.

Table 3.1
Students' Efficacy Beliefs for Science Learning Items

Item	
1	You are confident that you can do an excellent job on tests in this course.
2	You are certain you can understand the most difficult material presented in the textbook used in this course.
3	You are certain you can master the skills being taught in this course.
4	You are confident that you can do an excellent job on assignments in this course.

Mastery-focused instruction. Because this study used data from a large-scale assessment created by mathematics and science educators to assess variables of motivation, an investigation of the theoretical alignment of items with motivational constructs was conducted prior to this study. A class project was conducted to examine the construct validity of items within the HSLS under the advisement of Dr. Judith Meece, an expert in the field of motivational research. To do so, a survey was created on the website Survey Monkey and knowledgeable motivation faculty and graduate student researchers at the University of North Carolina at Chapel Hill, Duke University, Ohio State University, and North Carolina State University were invited to evaluate the theoretical alignment between selected items on the HSLS: 09 questionnaire, and the established motivational constructs. Ten people volunteered to participate and anonymously evaluated the theoretical alignment of 20 HSLS items to the following motivational constructs: *students' perceptions of mastery-focused instruction* and *teachers' perceptions of mastery-*

focused instruction. For the first nine items, participants were asked "*How well (or poorly) do you think the following item maps onto the construct: Students' perception of their science teacher's emphasis on mastery-focused instruction? (a) Does the item tap into motivation? (b) If so, academic or social motivation? Mastery?*" For the last 11 items, participants were asked the same questions but for the construct: *Teachers' perceptions of mastery-focused instruction.*

Students' perception of mastery-focused instruction. See Table 3.2 for a list of potential items for which motivation researchers were asked to provide feedback.

Table 3.2
Potential Items for Students' Perceptions of Mastery-Focused Instruction

"How much do you agree or disagree with the following statements about [your science teacher]? Remember, none of your teachers or your principal will see any of the answers you provide. Your science teacher…"

Item	
1	Values and listens to students' ideas.
2	Treats students with respect.
3	Treats every student fairly.
4	Thinks every student can be successful.
5	Your science teacher thinks mistakes are okay as long as all students learn.
6	Your science teacher treats some kids better than other kids.
7	Your science teacher makes science interesting.
8	Your science teacher treats males and females differently.
9	Your science teacher makes science easy to understand.

Results from the class project revealed that survey respondents agreed that four of nine items align with academic mastery (see Appendix A for a detailed table of all respondent feedback). Specifically, all 10 respondents agreed that items 4, 5, and 7 align with academic, mastery learning. However, one respondent cautioned that Item 4 could tap into student beliefs about ability. Eight of the 10 respondents reported that Item 1 aligns with academic mastery; one of the 10 thought it aligns better with social motivation, and one was unsure.

Furthermore, four of the nine items had a majority of respondents suggest the item does not align with academic but rather with social motivation and suggested not using the items.

Specifically, all 10 respondents agreed that Items 2, 3, 6, and 8 align better with social motivation than they do academic motivation. However, one respondent suggested using Item 6 but reverse-coding it. The feedback for Item 9 was split, with half of the respondents reporting it aligns with academic motivation and half reporting it aligns with social motivation. Based on the results of the project, a large majority (80% or higher) of motivational researchers agreed that four items theoretically aligned with the motivational construct and therefore were used to generate a composite variable. See Table 3.3 for a list of retained items reflecting students' perceptions of mastery-focused instruction and item reliability. The items on the four-point Likert scale were reverse coded so higher scores reflected higher emphasis on mastery-focused instruction: *strongly agree* = 4; *agree* = 3; *disagree* = 2; and *strongly disagree* = 1. For the purposes of this study, EFA was conducted to examine how these items empirically load on this factor (Student's Perceptions of Mastery-Focused Instruction) and reliability coefficients were calculated with a random sample of Biology students (n = 1000). Results from these analyses are reported in the next chapter.

Table 3.3
Retained Items for Students' Perceptions of Mastery-Focused Instruction

"How much do you agree or disagree with the following statements about [your science teacher]? Remember, none of your teachers or your principal will see any of the answers you provide. Your science teacher…"	
Item	
1	Values and listens to students' ideas.
2	Thinks every student can be successful.
3	Your science teacher thinks mistakes are okay as long as all students learn.
4	Your science teacher makes science interesting.

Teachers' perception of mastery-focused instruction. See Table 3.4 for a list of potential items for which the motivation researchers were asked to provide feedback.

Table 3.4
Potential Items for Teachers' Perceptions of Mastery-Focused Instruction

"Think about the full duration of this [fall 2009 science] course. How much emphasis are you placing on each of the following objectives?"	
Item	
1	Increasing students' interest in science.
2	Teaching students basic science concepts.
3	Teaching students important terms and facts of science.
4	Teaching students science process or inquiry skills.
5	Preparing students for further study in science.
6	Teaching students to evaluate arguments based on scientific evidence.
7	Teaching students how to communicate ideas in science effectively.
8	Teaching students about the applications of science in business and industry.
9	Teaching students about the relationship between science, technology, and society.
10	Teaching students about the history and nature of science.
11	Preparing students for standardized tests.

Results from the class project revealed that survey respondents agreed seven of 11 items align with academic mastery (see Appendix B for a detailed table of all respondent feedback). Specifically, nine of 10 respondents thought Items 4 and 5 align well with mastery instruction while one respondent thought Item 4 taps more into course objectives, and one respondent thought Item 5 was just "not a good item." Eight of 10 respondents thought the first item aligns with academic mastery while two of 10 thought it aligns better with generating situational interest. Eight of 10 respondents thought Items 6, 7, 9, and 10 align well with academic mastery as well. However, two respondents thought Items 6 and 7 align better with course objectives; one respondent thought Item 9 and 10 aligned better with course objectives, and one thought they align better with situational interest.

Furthermore, one of the 11 items had a large majority of respondents suggest that the item does not align with mastery instruction. Specifically, six of 10 respondents thought Item 11 aligns better with an emphasis on performance rather than mastery; one respondent did not know, and two respondents thought the item should be included but reverse-coded.

Three of the 11 items generated debate over whether they should be included to measure emphasis on mastery-focused instruction. Specifically, six of 10 respondents believed Item 8 aligns with mastery instruction, while two thought it aligns better with course objectives or situational interest, and two had reservations about including it. Four of 10 respondents thought Item 2 aligns with mastery instruction, while three respondents thought it aligns better with lower level thinking skills or performance, and three respondents thought it was not a good item. Finally, two of 10 respondents thought Item 3 aligns with mastery instruction, while three thought it aligns better with performance, five were either unsure or had reservations about including it, and one thought it should be included but weighted much lower.

Based on the results of the project, a large majority (80% or higher) of motivational researchers agreed seven items theoretically align with the motivational construct and therefore were used to generate a composite variable. See Table 3.5 for the list of retained items reflecting teachers' perceptions of mastery-focused instruction and item reliability. The items on the four-point Likert scale were coded so higher scores reflected higher emphasis on mastery-focused instruction: *heavy emphasis* = 4; *moderate emphasis* = 3; *minimal emphasis* = 2; and *strongly disagree* = 1. For the purposes of this study, EFA was conducted to examine how these items empirically load on this factor (Teacher's Perceptions of Mastery-Focused Instruction) and reliability coefficients were calculated with a random sample of Biology students (n = 1000) and their teachers. Results from these analyses are reported in the next chapter.

Table 3.5
Retained Items for Teachers' Perceptions of Mastery-Focused Instruction

"Think about the full duration of this [fall 2009 science] course. How much emphasis are you placing on each of the following objectives?"	
Item	
1	Increasing students' interest in science.
2	Teaching students science process or inquiry skills.
3	Preparing students for further study in science.
4	Teaching students to evaluate arguments based on scientific evidence.
5	Teaching students how to communicate ideas in science effectively.
6	Teaching students about the relationship between science, technology, and society.
7	Teaching students about the history and nature of science.

Science teachers' efficacy beliefs. IES researchers generated a seven-item composite scale using responses from all science teachers ("science teacher efficacy"), which yielded a Cronbach's alpha of 0.68 (Ingels et al., 2011). See Table 3.6 for the list of retained items reflecting science teachers' efficacy beliefs and item reliability. The items on the four-point Likert scale were reverse coded so higher scores reflected higher efficacy: *strongly agree* = 4; *agree* = 3; *disagree* = 2; and *strongly disagree* = 1. Due to relative low reliability, an EFA was conducted to assess individual item factor loadings using a random sample of Biology students' (*n* = 1000) teachers. EFA results for all latent constructs are reported in the next chapter.

Table 3.6
Science Teachers' Efficacy Beliefs Items

Item	
1	The amount a student can learn is primarily related to family background.
2	If students are not disciplined at home, they are not likely to accept any discipline at school.
3	You are very limited in what you can achieve because a student's home environment is a large influence on their achievement.
4	If parents would do more for their children, you could do more for your students.
5	If a student did not remember information you gave in a previous lesson, you would know how to increase their retention in the next lesson.
6	If a student in your class becomes disruptive and noisy, you feel assured that you know some techniques to redirect them quickly.
7	If you really try hard, you can get through to even the most difficult or unmotivated students.

Measurement: Covariates

Controlling for pre-existing student differences (e.g., gender, race/ethnicity, etc.) allows for a more precise analysis of the contribution of science teachers' efficacy beliefs and mastery-focused instruction on students' efficacy beliefs for science learning. In order to account for within-student and within-teacher factors, this study included both student and teacher level controls, which are briefly described below.

Student Level Covariates.

Gender. Students' gender is among the individual differences that are well documented to predict motivation and achievement. For example, girls are often found to report lower self-efficacy than boys do, despite equivalent performance (Denissen, Zarrett, & Eccles, 2007; Fredricks, Blumenfeld, Friedel, & Paris, 2005). Gender has been shown to predict students' efficacy beliefs in a variety of academic domains, such as science (Britner & Pajares, 2006; Gwilliams & Betz, 2001) and mathematics (Hackett & Betz, 1989; Joet, Usher, & Bressoux, 2011; Pajares, 2005). For example, Britner (2008) found gender-differences in self-efficacy favored girls in Earth Science courses but favored boys in Life Science courses (e.g., Biology). Because gender differences are not a main focus of this study, student's gender was used as a control variable. The composite variable of student's gender generated by IES researchers was taken from the base-year student survey, parent survey, and/or enrollment rosters provided by the school. If there was a discrepancy between surveys, then the variable was coded based on a manual review of the student's first name by IES researchers. The variable for gender in the model is categorical with two response options, which was recoded in STATA to numeric values (Male = 1; Female = 2). Dummy variables were created for analyses with male as the reference category.

Race/ethnicity. Students' race and/or ethnicity have also been shown to predict students' efficacy beliefs in a variety of academic domains, such as science (Hackett, Betz, Casas, & Rocha-Singh, 1992; Pajares, Britner, & Valiante, 2000), mathematics (Pajares & Kranzler, 1995), and writing (Pajares & Johnson, 1996). For example, Britner and Pajares (2001) found that among middle school students, White students had higher science grades and reported stronger self-efficacy than did African American students. Because race and ethnicity are not a main focus of this particular investigation, student's race/ethnicity was used as a control variable. The composite variable of race/ethnicity characterizes the student's race/ethnicity by summarizing six dichotomous composites (Hispanic, White, Black, Asian, Pacific Islander, and American Indian), which are based on data from the student survey, if available. If the data were not available from the student survey, then the data were based on enrollment rosters provided by the school or from the parent questionnaire. The variable for race/ethnicity in the model is categorical with eight responses, which was recoded to numeric values using STATA as: 1 = American Indian/Alaska Native, non-Hispanic; 2 = Asian, non-Hispanic; 3 = Black/African-American, non-Hispanic; 4 = Hispanic, no race specified; 5 = Hispanic, race specified; 6 = more than one race specified, non-Hispanic; 7 = Native Hawaiian/Pacific Islander, non-Hispanic; and 8 = White, non-Hispanic. Dummy variables were created for analyses with White, non-Hispanic as the reference category.

Parent education. Educational research also presents a link between academic development and learning and family characteristics, such as parent education and socioeconomic status (e.g., Bradley & Corwyn, 2002; McLoyd, 1990). These researchers reason that parents with less education or those who experience economic difficulty cannot provide the resources that stimulate cognitive development through forms such as traveling, games, computers, and books. Parent education has been shown to be highly correlated with socioeconomic status, and in many cases is considered a component of composite variables of "socioeconomic status" (see Sirin, 2005 for a meta-analysis). The HSLS:09 does provide both parent education and socioeconomic status as variables for analysis. However, socioeconomic status required imputation due to missing data. In an effort to reduce the variables requiring imputation due to missing data, only parent education was used in this investigation.

Parent education has been linked to students' efficacy beliefs for subject areas, including science (e.g., Uçak & Bağ, 2012) and computer literacy (e.g., Yan & Qianziang, 2013). These studies support the notion that parent education relates to children's academic efficacy beliefs. Specifically, students who report high academic efficacy tend to have parents with a higher level of education when compared to students who report low academic efficacy. Further, parent education has been shown to relate to students' choice to pursue science and mathematics fields as potential careers (Gruca, Ethington, & Pascarella, 1988). Because family characteristics are not a primary focus of this study, parent education was controlled. The composite variable parent education characterizes the highest level of education reached by either parent living in the student's home. The variable is categorical with seven responses, which was recoded to numeric values using STATA: 1 = Less than high school; 2 = High school diploma; 3 = Associates degree; 4 = Bachelor's degree; 5 = Master's degree; 7 = Ph.D., M.D., law, or other high-level professional degree. Dummy variables were created for analyses with bachelor's degree as the reference category.

Type of School. The type of school (i.e. public, private, or Catholic) has also been shown to relate to student motivation and achievement (e.g., Snyder, 2013). Some researchers reason that the quality of the school facilities, availability of resources, and socioeconomic status of the surrounding community and student population may be factors underlying this relation. In addition, the type of school and factors mentioned above (i.e., family characteristics) may also play a role in teachers' assessment of how successful they can be in the classroom (Lee, Dedrick, & Smith, 1991; Tschannen-Moran, Woolfolk Hoy, & Hoy, 1998). Dummy variables were created for analyses with public school as the reference category.

Mathematics ability. HSLS: 09 did include a measure of prior achievement in science. However, the science achievement measure was based on students' self-reported grades in their previous science class, which researchers have suggested is less valid than actual measures of ability due to students' overestimating or even underestimating their own achievement. For example, Kuncel, Crede, and Thomas (2005) conducted a meta-analysis of self-reported grade point average, class rank, and test scores and found self-reported grade validity was strongly moderated by actual levels of cognitive ability and school performance. They suggest using self-reported grades with caution. Students' mathematics ability has also been shown to relate to students' efficacy beliefs in mathematics (e.g., Carmichael, Callingham, Hay, & Watson, 2010; Pajares, 1996; Yildirim, 2012) and science, mathematics, engineering, and technology (STEM) (Smith & Fouad, 1999), as well as their pursuit toward college majors and careers in science and mathematics (Crisp, Nora, & Taggart, 2009). Across studies, students who earned higher scores on mathematics problem-solving tasks or ability tests also reported higher efficacy beliefs for mathematics, science, or the desire to pursue STEM majors and careers in the future.

Therefore, students' mathematics ability, an observed variable, was used as a control for this study. Students' mathematics standardized *theta* score characterizes a norm-referenced measure of achievement, meaning it is an estimate of achievement relative to the fall 2009 ninth grade population as a whole (Ingels et al., 2011). This ability variable provides information on the student's status in relation to peers rather than to an estimated percent-correct score, which would represent a student's achievement status in relation to a particular criterion set of test items. It is a continuous variable, scaled to a mean of 50 with a standard deviation of 10. The benefit of using a standardized score versus the raw score is that comparisons can be made using standard deviation units. Theta scores were used as a measure of ability in this study for the following reasons: (a) they estimate ability in a particular domain; (b) are more normally distributed than estimated number of correct scores because they do not depend on item-difficulty parameters of the items within a set of scale scores; (c) the standard error of measurement of theta represents the precision of the IRT theta and the smaller the standard error of measurement, the greater the precision of the measurement; (d) they provide a summary measure of achievement useful for correlational analysis and multivariate models; and (e) when the HSLS concludes and longitudinal data is available after the first follow-up, they can be used to measure growth over time in student achievement. Descriptive statistics about *theta* scores and *sem* and are presented in the next chapter.

Teacher Level Covariates.

To control for pre-existing teacher differences, the study includes variables for gender, race/ethnicity, education, and science teaching experience. Each of the teacher variables is briefly described below.

Gender. Although there are some discrepancies in the literature, gender has been shown to act as a predictor of teacher efficacy beliefs in some studies. With respect to science and mathematics, research suggests males report higher levels of teaching efficacy than do females (Raudenbush, Rowan, and Choeng, 1992; Riggs, 1995). With respect to language arts and social studies, females report higher levels of teaching efficacy than do males (Anderson, Greene

Lowen, 1988; Evans & Tribble, 1986; Lee, Buck & Midgley, 1992; Raudenbush et al., 1992; Ross, Cousins, & Gadalla, 1996). Yet, others have found no relation between teachers' gender and efficacy beliefs (e.g., Tschannen-Moran & Hoy, 2007). Additional research should be conducted to provide some clarity. Gender differences however, are not a main focus of this particular investigation, and therefore teacher's gender is used as a control. The composite variable of science teacher's gender was taken from the base-year teacher survey responses. The variable for gender in the model is categorical with two response options, which was recoded in STATA to numeric values (Male = 1; Female = 2). Dummy variables were created for analyses with male as the reference category.

Race/ethnicity. Tschannen-Moran and Hoy (2007) found no relation between teachers' race/ethnicity and their efficacy beliefs, but postulated that if the two were related, it might be through the availability of vicarious experiences with similar models in their area of teaching. Although this area of research needs more investigation, it is not a primary focus for this dissertation, so it is used as a control as well. The composite variable of science teacher's race/ethnicity characterizes the teacher's race/ethnicity by summarizing six dichotomous composite variables (Hispanic, White, Black, Asian, Pacific Islander, and American Indian), which are based on data from the teacher survey. The variable for race/ethnicity in the model is categorical with eight responses, which I recoded to numeric form using STATA as: 1 = Asian, non-Hispanic; 2 = Black/African-American, non-Hispanic; 3 = Hispanic, no race specified; 4 = Hispanic, race specified; 5 = More than one race specified, non-Hispanic; 6 = White, non-Hispanic; 7 = Other, non-Hispanic. Dummy variables were created for analyses with White, non-Hispanic as the reference group. Some racial group categories may be combined if there are too few teachers.

Highest degree earned. There is also some debate in the literature as to whether or not teachers' level of education predicts efficacy beliefs due in part to how education is defined (i.e., highest degree earned, number of disciplinary courses taken, etc.). In general, higher levels of education are more often associated with higher levels of efficacy beliefs (Benz, Bradley, Alderman, & Flowers, 1992; Campbell, 1996; Hoy & Woolfolk, 1993). However, Enochs and colleagues' (1995) highlighted the possible presence of other variables embedded within educational levels that may have influenced efficacy beliefs, such as content or pedagogical knowledge. Henson (2002) cautioned that one must be careful when interpreting findings when education level has been viewed as a proxy for teacher knowledge as it relies on the assumption that higher education levels equate to higher levels of knowledge. Because teacher education is not a main focus of this investigation, it is also used as a control. The composite variable highest degree earned characterizes the highest level of education reached by the student's science teacher. The variable is categorical with five responses, which I recoded to numeric values using STATA as: 1 = Bachelor's degree; 2 = Master's degree; 3 = Educational Specialist Degree; 4 = Ph.D., M.D., law, or other high-level professional degree. Dummy variables were created for analyses with bachelor's degree as the reference group.

Years of high school science teaching experience. There are also discrepancies in the literature in regard to whether teaching experience acts as a predictor of teacher efficacy beliefs (Plourde, 2002; Woolfolk Hoy & Burke-Spero, 2005). In general, studies comparing teachers with varied amounts of experience have found that teachers with more experience report higher teaching efficacy than do novice teachers (Tschannen-Moran, Hoy, & Woolfolk, 2001; Ross, 1996). However, when teaching efficacy is differentiated into three factors, experienced teachers are only more highly efficacious than novice teachers with respect to classroom management and instructional strategies, but not for student engagement (Fives & Buehl, 2009; Tschannen-Moran & Hoy, 2007; Wolters & Daugherty, 2007). Tschannen-Moran and Hoy (2007) reason that the emphasis on student engagement is new to education and it may take time to develop strategies to impact this facet of efficacy beliefs. The disparity could exist because more experienced teachers have had more mastery experiences, more exposure to experienced models, and more feedback on their performance, which all contribute the development of their efficacy beliefs (Bandura, 1997). Nevertheless, because teaching experience is not a main focus of this particular investigation, it is used as a control too. The continuous variable years of teaching experience characterizes the number of years the science teacher has taught high school science.

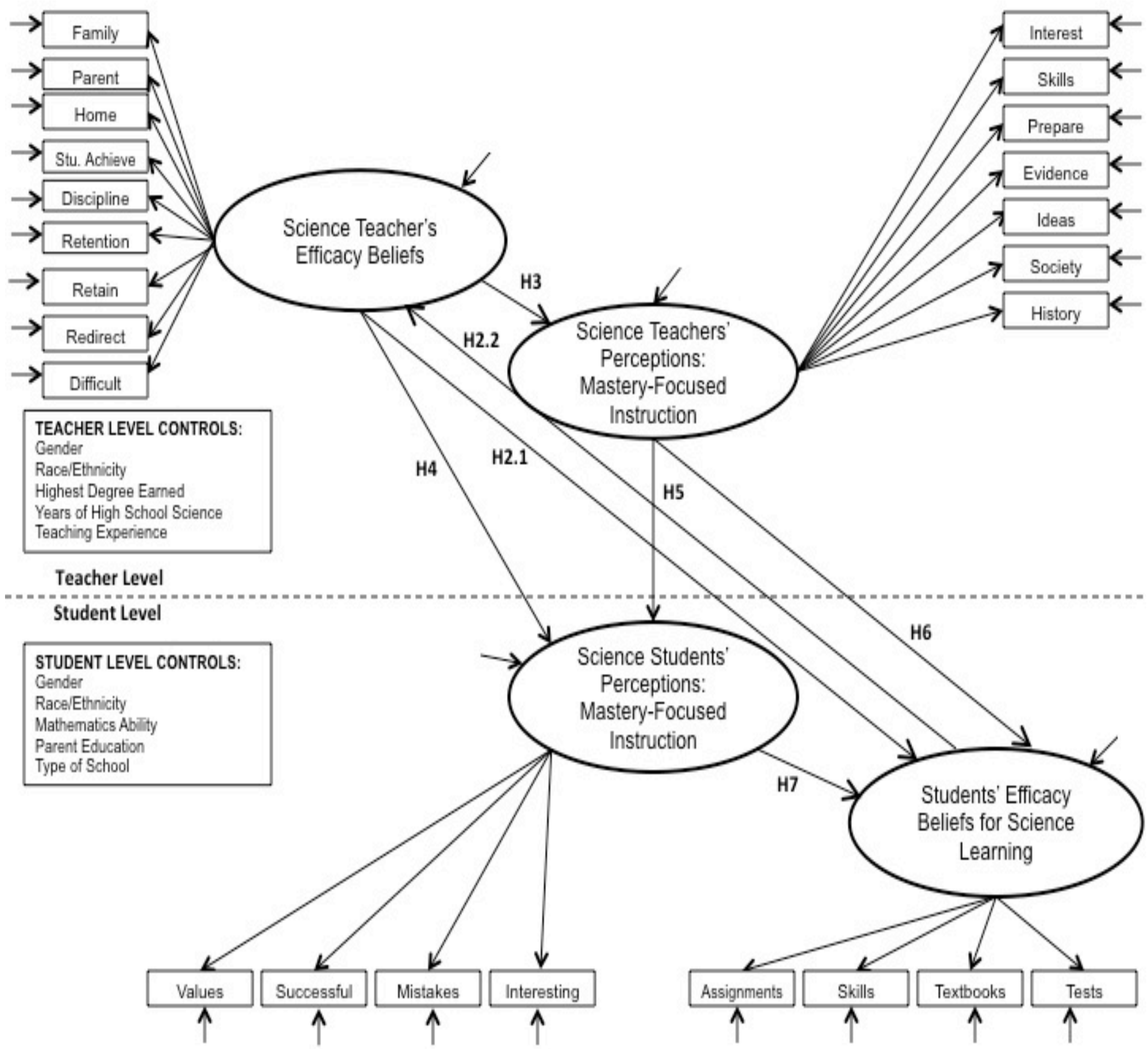

Figure 3.1 Full Structural Model of Students' Efficacy Beliefs for Science Learning

Construction of the Dataset and Software

The data set for this study was constructed by extracting appropriate variables and weights from the large restricted data file using the Education Data Analysis Tool (EDAT) (Ingels et al., 2011), which allows for download to computers and selection of survey, population, and variables relevant to particular analyses. For statistical analyses, the software packages STATA (Version 12), SPSS (Version 22) and Mplus (Version 7.0) were used. The descriptive statistics, EFA, and reliability coefficients were generated using STATA, missing data analysis was conducted using SPSS, and structural equation modeling analyses was conducted using Mplus. The EDAT system was used in conjunction with STATA to generate appropriate syntax, which took into account information from the sampling design (i.e., weights) during the computation of statistics and standard error values. The extracted dataset contained 38 variables and sample weights.

Applying sample weights and design variables. Analytic weights are necessary when attempts are made to estimate characteristics of the population even though the entire population did not provide data. According to Kline (2005), weights can be used to adjust for differential selection probabilities, such as oversampling for minorities or private-school students to obtain enough information from reliable estimates. Weights are also used to adjust for bias associated with nonresponse by adjusting for differential nonresponse by finding similar cases with survey responses and weighting them higher. Since the HSLS: 09 is a sample survey, the entire population of 4 million students was not surveyed. IES generated weights allow for national estimates to be made using the HSLS: 09 data set. Furthermore, because the data was derived from randomly selected schools and then randomly selected students within these schools and their science teachers, it is necessary to take into account this nested sampling design prior to analysis. Students had different probabilities of selection, and not all selected students chose to participate in the study, but the weights help correct for this differential nonresponse. Because the unit of analysis is at the student level, IES generated a series of weights reflecting the total number of study-eligible ninth graders enrolled in science in 2009 (Ingels et al., 2011). In other words, a sample weight was assigned to each student respondent and teacher respondent in the sample. These sample weights were used during all STATA, SPSS, and Mplus analyses to take into account the sampling design, stratification, differential sampling of subgroups, and non-response biases. The sampling weight WISCITCH was used for all students' science teacher analyses and was calculated by multiplying the school by the student and then by the science teacher (School * Student * Science Teacher) (Ingels et al., 2011). Due to the two-stage stratified random sample design, there are variables that were included in the analyses that described and accounted for the complex sample design. These variables were STRAT_ID for the stratum and PSU for the primary sampling units (i.e., school).

Missing data. There are different types of missing data (i.e., systematic and item-non-response), and IES researchers coded these differently in the data set. The data that were missing systematically included items that where "legitimately skipped" because they were either non-applicable or did not appear on the online survey because of the way in which the participant responded to a previous question. For example, if a teacher responded that she had not earned a Masters degree, then a follow-up question regarding the university of attendance would not appear, and would be coded as "systematic missing" in the data set. If the teacher did not respond to the item at all, then the item was coded as missing, non-response. IES conducted their own investigation of item nonresponse missingness, which lead to imputation for some variables. However, the mathematics achievement score and standard error of measure were the only imputed variables used in this dissertation analysis.

Although there is no theoretical basis that completion of this study is tied to the outcome variable (i.e., students' efficacy beliefs in science; Allison, 2002), it is important to empirically examine potential percentages and patterns of missingness for the subset of only Biology students (with Biology teacher data) used for this dissertation study. Therefore, the data coded as "missing due to item non-response" for the variables under investigation were isolated from those "missing systematically", and the data set was transferred from STATA to SPSS so that an empirical analysis of missingness could be conducted. Table 3.7 shows the univariate statistics for all quantitative and categorical variables with missing values greater than 1%. The percentage of missing values was under 5% for all variables. Little's MCAR test was also conducted, which empirically tests the assumption of missing completely at random (MCAR) over several variables with missing values simultaneously (Little, 1988). The results of Little's MCAR test [χ^2 (3)= 0.692, $p > .05$] indicated the data were indeed missing at random (i.e., no identifiable patterns of missingness). The data set was then transferred into Mplus for multi-level analysis where further precautions were taken. According to Allison (2010), procedures for handling missing data can yield biased parameter estimates or standard error estimates that are too low. Allison recommends using robust maximum likelihood (MLR) in Mplus because it uses all available information to estimate parameters and yields unbiased estimates. The MLR method assumes data are missing at random (MAR) while listwise deletion does not always do so (Muthen & Muthen, 2007). Thus, all multi-level structural equation modeling was conducted using MLR.

Table 3.7
Univariate Statistics for Missing Data Analysis

	Mean	Std. Deviation	Missing		No. of Extremes	
			Count	Percent	Low	High
Student Gender			0	.0		
Student Race/Ethnicity			0	.0		
Student's Parent Education			0	.0		
Student Math Ability	54.635	9.627	0	.0	17	7
Student Math Ability SEM	0.256	0.033	0	.0	12	147
Type of School			0	.0		
Student Efficacy: Skills			32	1.2		
Student Efficacy: Assignments			38	1.4		
Student Efficacy: Textbooks			25	.9		
Student Efficacy: Tests			21	.8		
Student Perceptions MFI: Interesting			36	1.3		
Student Perceptions MFI: Mistakes			45	1.6		
Student Perceptions MFI: Successful			42	1.5		
Student Perceptions MFI: Values			27	1.0		
Teacher Years High School Teaching Experience	11.21	9.412	0	.0	0	147
Teacher Race/Ethnicity			0	.0		
Teacher Gender			0	.0		
Teacher Highest Degree Earned			0	.0		
Teacher Efficacy: Family			10	.4		
Teacher Efficacy: Parent			47	1.7		
Teacher Efficacy: Home			39	1.4		
Teacher Efficacy: Student Achieve			26	.9		
Teacher Efficacy: Discipline			22	.8		
Teacher Perceptions MFI: Interest			15	.5		
Teacher Perceptions MFI: Skills			37	1.3		
Teacher Perceptions MFI: Prepare			25	.9		
Teacher Perceptions MFI: Evidence			20	.7		
Teacher Perceptions MFI: History			55	2.0		
Teacher Perceptions MFI: Society			45	1.6		
Teacher Perceptions MFI: Ideas			41	1.5		

*Little's MCAR: χ^2 (3) = 0.692, $p > .05$

Plan for Analyses

Initially, descriptive analyses were conducted to describe the characteristics of the sample. Variables were assessed through univariate statistics, including means, standard deviations, skewness, and kurtosis; bivariate statistics included correlations. Scatterplots of bivariate distributions were visually inspected. Second, a random sample without replacement (approximately 50% of the sample) was drawn, and EFA was completed to examine the possible underlying factor structure of each set of variables without imposing a preconceived structure on the outcome. Third, reliability coefficients were calculated for each latent factor. Fourth, MSEM was used to assess the potential relationships between the latent and observed variables, similarly to running multiple regression equations successively (Muthen & Muthen, 2007). The indicator variables were specified as ordered categorical. The commands for accounting for the sampling design and weights (i.e., stratification, oversampling, etc.) were used by specifying the variable name for each, which is the common procedure for Mplus (Muthen & Muthen, 2007).

The MSEM was chosen because multiple indicators are used to measure the latent variables of science teachers' efficacy beliefs, students' efficacy beliefs for science learning, and both teacher and student perceptions of mastery-focused instruction. The MSEM was completed in three steps. In step one, the links between students' efficacy beliefs for science learning and teachers' efficacy beliefs were modeled. In step two, teachers' gender, race/ethnicity, years of teaching high school science, and highest degree earned as well as students' gender, mathematics ability, parent education, and type of school were entered as covariates. In step three, teacher and student perceptions of the teachers' emphasis on mastery instruction were entered into the model as mediators for the relation between teacher and students' efficacy beliefs. According to Preacher, Zyphur, and Zhang (2010), teachers' perceptions of their instruction should be considered an *upper mediator* because it is on the second level (teacher or class level) of the model while students' perceptions of instruction will be considered a *lower mediator* because it is on the first level (student level) of the model. The use of MSEM allows for the investigation of multiple types of linkages simultaneously (e.g., 2-2 linkages, such as teachers' efficacy beliefs and teachers' perceptions of mastery-focused instruction and 2-1 linkages, such as teachers' efficacy beliefs, and students' perceptions of mastery-focused instruction, (Preacher et al., 2010). Parameter estimates and their standard errors were calculated for each path coefficient, and a 90% confidence interval (CI) was examined for the indirect effect (Preacher et al., 2010). The maximum likelihood estimator (MLR) in Mplus was used to provide more accurate standard errors for data; the robustness primarily protects against non-normality and model mis-specification while remaining asymptotically unbiased (Yuan & Bentler, 2000). Limitations with the study, subsequent adjustments to the analysis, and hypotheses are presented in the next two sections.

Limitations and Analytic Adjustments

As with any study, there were some limitations during analysis that should be mentioned. First, scales for two of the four latent constructs (student and teacher perceptions of mastery instruction) were constructed by the researcher. Although an examination of construct validity was conducted, these scales have not been used in this manner prior to this investigation and therefore do not have pre-existing psychometric properties. Therefore, additional validation is needed, regardless of the study findings.

Second, the restricted data set did not include a unique teacher identification number as expected, so one was generated by creating a composite variable using the following values for the science teacher: weight, gender, race/ethnicity, years of science teaching experience, and year they earned their Bachelor's degree. This composite variable was needed for the "class" or "cluster" value for MSEM analyses. Once the composite variable, named "Cluster" was created, the data were sorted by cluster and a visual inspection was performed to be sure there was no variation within a cluster on gender, race, highest degree earned, etc. After visual inspection and only three corrections to the cluster number, the data were transferred to Mplus.

Third and most importantly, the full model with both mediators would not converge using the computer in the restricted data room due to the lack of memory space to run the input file. The analysis required 6 dimensions of integration resulting in a total of 1.1391×10^7 integration points, which was most likely the cause of the memory shortage. The number of integration points was reduced to 5,000 using MonteCarlo integration rather than Gaussian. However, the full model still did not converge after many attempts, suggesting the need for a simpler model. Therefore, two models were run in Mplus, each with a different mediator (teachers' perceptions of mastery-focused instruction and student perceptions of mastery-focused instruction) and fit indices were compared between the models. In addition, existing methods for determining model fit in MSEM have not been verified using ordered categorical indicators, such as those used in this study (Muthen & Muthen, 2007). Therefore, rather than comparing model fit indices with baseline models, relative fit indices (described in Hypothesis 1) were used to compare the fit between mediation Model 1 (teachers' perceptions of mastery-focused instruction) and mediation Model 2 (students' perceptions of mastery-focused instruction). Additional issues arose with convergence for each MSEM model. The models would not converge due to issues with the latent variable describing science teachers' efficacy beliefs. To alleviate this problem, a composite was generated for teachers' efficacy beliefs (average score on 5 items), and the models were rerun and converged within two hours each.

Finally, testing the bidirectional link between teacher and student efficacy beliefs was intended as research supports this relation (H2.2 in *Figure 3.1*, p. 59) (e.g., Tschannen-Moran & Woolfolk Hoy, 1998; 2001). However, regressing student efficacy beliefs on teachers' efficacy beliefs would require adding another path to an already complex model. Given the circumstances, the choice was made not to add the additional path at this time as model convergence was already an issue. The revised hypotheses are discussed in the next section. The revised path diagrams and results of both mediation models are discussed in the next chapter.

Hypotheses

Hypothesis 1. The revised hypothesis specified that Model 2 (student perceptions of mastery-focused instruction) would produce relatively better fit indices than Model 1 (teacher perceptions of mastery-focused instruction). In other words, the model that included students' perceptions of mastery-focused instruction would fit the data better than the model with teachers' perceptions of mastery-focused instruction. Both models were evaluated using the following relative fit indices specifically used for multi-level SEM models with ordered categorical indicators: Akaike Information Criterion (AIC) (Akaike, 1969) and Baysian Information Criterion (BIC) (Schwarz, 1978). These indices provide relative estimates of the information lost when models are used to represent the process that generates the data. In general, when comparing models using these fit indices, lower values represent better model fit (Akaike, 1969; Muthen & Muthen, 2007; Schwarz, 1978).

Hypothesis 2.1. This hypothesis specified that science teachers' efficacy beliefs would be positively related to students' efficacy beliefs for science learning. The path coefficient between these two variables was evaluated for statistical significance ($p < .05$).

Hypothesis 2.2. This hypothesis specified that students' efficacy beliefs for science learning would be positively related to science teachers' efficacy beliefs. As discussed above, the bidirectional relation between teacher and student efficacy beliefs was not examined in the revised models due to issues regarding computer memory and convergence.

Hypothesis 3. This hypothesis specified that science teachers' efficacy beliefs would be positively related to science teachers' perceptions of mastery-focused instruction. The path coefficient between these two variables was evaluated for statistical significance ($p < .05$).

Hypothesis 4. This hypothesis specified that science teachers' efficacy beliefs would be positively related to science students' perceptions of mastery-focused instruction. The path coefficients between these two variables were evaluated for statistical significance ($p <.05$).

Hypothesis 5. This hypothesis specified that science teachers' perceptions of mastery-focused instruction would be positively related to students' perceptions of mastery-focused instruction. However, this hypothesis could not be tested due to issues regarding computer memory and convergence.

Hypothesis 6. This hypothesis specified that science teachers' perceptions of mastery-focused instruction would be positively related to students' efficacy beliefs for science learning. The path coefficient between these two variables was evaluated for statistical significance ($p <.05$).

Hypothesis 7. This hypothesis specified that students' perceptions of mastery-focused instruction would be positively related to students' efficacy beliefs for science learning. The path coefficients between these two variables were evaluated for statistical significance ($p < .05$).

Hypothesis 8. The original hypothesis specified both teacher and student perceptions of mastery-focused instruction would mediate the relationship between teacher and student efficacy beliefs. Due to analytic adjustments, the original model and subsequent hypotheses were divided into two parts. The original Hypothesis 8 became Hypothesis 8 and 9 described below.

Hypothesis 8 specified that science teachers' perceptions of mastery-focused instruction (Model 1) would partially mediate the relation between science teachers' efficacy beliefs and students' efficacy beliefs for science learning. Teachers' perceptions of mastery-focused instruction were entered into the model as an *upper-level mediator* (Preacher et al., 2010) for the relation between teacher and students' efficacy beliefs (Model 1). Mediation was assessed by evaluating the size and statistical significance ($p < .05$) of the direct effect of teachers' efficacy beliefs on students' efficacy beliefs for science learning after the introduction of the mediator (teachers' perceptions of mastery-focused instruction) and by testing the statistical significance ($p < .05$) of the indirect effect mediated by teachers' perceptions of mastery-focused instruction (Bauer, Preacher & Gil, 2006; Muthen & Muthen, 2007).

Hypothesis 9. This revised hypothesis specified that students' perceptions of mastery-focused instruction (Model 2) would partially mediate the relation between science teachers' efficacy beliefs and students' efficacy beliefs for science learning. Students' perceptions of mastery-focused instruction were entered into the model as a *lower-level mediator* (Preacher et al., 2010) for the relation between teacher and students' efficacy beliefs (Model 2). Mediation was assessed by evaluating the size and statistical significance ($p < .05$) of the direct effect of teachers' efficacy beliefs on students' efficacy beliefs after the introduction of the mediator (students' perceptions of mastery-focused instruction) and by testing the statistical significance ($p < .05$) of the indirect effect mediated by students' perceptions of mastery-focused instruction (Bauer, Preacher & Gil, 2006; Muthen & Muthen, 2007).

CHAPTER FOUR

RESULTS

This study examined the associations among students' efficacy beliefs for learning science, mastery-focused instruction (both teacher and student perceptions), and teachers' efficacy beliefs for teaching science. This chapter provides the results of the investigation in three parts. First, descriptive and demographic information is presented. Next, results from exploratory factor analyses of items measuring students' efficacy beliefs, students' perceptions of mastery-focused instruction, teachers' perceptions of mastery-focused instruction, and teachers' efficacy beliefs are presented. Third, results from multilevel structural equation modeling are discussed, and findings are organized by hypothesis. Final model tables and figures are included.

Analysis

Descriptive statistics. The data were examined with histograms and descriptive statistics in an effort to be sure decisions regarding the analytic approach followed recommended practices. Histograms revealed that few of the variables included in the full conditioned multi-level models approximated a normal distribution. Descriptive statistics (skewness and kurtosis) are presented in Table 4.1 and show that two of the continuous variables used in the model (student's math ability and teacher's years of high school science teaching experience) fall outside the range of ±2 when skewness and kurtosis coefficients are divided by their standard errors. Although the ratios are not ideal, concerns regarding the effects of these non-normal variables are reduced due to the exceptionally large sample size and use of the robust maximum likelihood estimator (MLR), which provides more accurate standard errors and chi-square statistics for data that are non-normal (Curran, West, & Finch, 1996; Yuan & Bentler, 2000). Demographic information, including means and standard deviations for the continuous variables are presented for students (Table 4.2) and for teachers (Table 4.3) separately in the next section.

Table 4.1
Descriptive Statistics: Skewness and Kurtosis

	Skewness		Kurtosis	
	Statistic	Std. Error	Statistic	Std. Error
Students' Math Ability	-.182	.046	-.060	.093
Teacher Years H.S. Science Teach Experience	1.268	.046	1.020	.093

Demographic information for biology students. Survey responses from 3,557 ninth grade Biology students were used for analyses. The majority of students were white females who attended public school and reported their parents' highest level of education to be a Bachelor's degree. Students' mathematics ability (standardized *theta* scores) ranged from 25.0 to 82.0 standardized units (M = 53.79, SD = 9.68). See Table 4.2 for student demographic information.

Table 4.2
Biology Student Demographics

	N (Sample)	% Sample	Mean	Standard Deviation
Sex				
Male	1,729	48.6%		
Female	1,828	51.4%		
Race				
American Indian/ Alaskan Native	16	0.4%		
Asian	357	10.0%		
Black/African American	316	8.9%		
Hispanic, no race specified	28	0.8%		
Hispanic, race specified	556	15.6%		
More than one race	271	7.6%		
Native Hawaiian/Pacific Islander	19	0.5%		
White	1,994	56.1%		
Parents'/Guardians' Highest Level of Education				
Less than High School	150	4.2%		
High School Diploma/GED	764	21.5%		
Associate's degree	401	11.3%		
Bachelor's degree	813	22.9%		
Master's degree	456	12.8%		
Educational Specialist diploma	18	0.5%		
Professional degree (Ph.D./M.D./Law/Other)	251	7.1%		
Math Ability				
Math Score (Standardized Theta)			53.790	9.682
Standard Error of Measure			0.260	0.034
Type of School				
Public	2,656	74.7%		
Private	580	16.3%		
Catholic	321	9.0%		

Demographic information for biology teachers. Survey responses from 2,055 individual Biology teachers were used for analyses. The majority of the Biology teachers were white females with Master's degrees. These teachers ranged in teaching experience (9^{th} through 12^{th} grade science teaching) from 1 to 48 years (M = 11.16, SD = 9.30). See Table 4.3 for teacher demographic information.

Table 4.3
Biology Teacher Demographics

	N (Sample)	% Sample	Mean	Standard Deviation
Sex				
Male	808	39.3%		
Female	1,247	60.7%		
Race				
American Indian/ Alaskan Native	0	0.0%		
Asian	44	2.1%		
Black/African American	85	4.1%		
Hispanic, no race specified	3	0.1%		
Hispanic, race specified	82	4.0%		
More than one race	49	2.4%		
Native Hawaiian/Pacific Islander	4	0.2%		
White	1,788	87.0%		
Highest Level of Education				
Bachelor's degree	831	40.4%		
Master's degree	1,046	50.9%		
Educational Specialist diploma	88	4.3%		
Professional degree (Ph.D./M.D./Law/Other)	90	4.4%		
Years of 9^{th}–12^{th} Grade Science Teaching Experience			11.16	9.30

Multiple students in classrooms. In many cases there were more than one HSLS student enrolled in a particular biology class. Specifically, there were 728 instances where multiple students were enrolled in the same class, ranging from 1 to 18 students. Table 4.4 shows the frequency of instances where multiple students were enrolled in the same biology classroom and the total number of students enrolled. For example, there were 401 instances in which 2 students were enrolled in the same biology class (with the same biology teacher) while there was only one instance in which 12 students were enrolled in the same biology class. As discussed previously, in an effort to account for this type of hierarchical data, multi-level SEM was used over single-level SEM. The use of MSEM accounts for the nested structure (i.e. students nested within classrooms with different teachers) of the data.

Table 4.4
Frequency of Students Per Biology Classroom

Number of Students Per Biology Classroom	Frequency
1	1,327
2	401
3	159
4	65
5	45
6	22
7	9
8	10
9	7
10	2
11	3
12	1
13	0
14	1
15	1
16	1
17	0
18	1

Exploratory Factor Analysis. Exploratory factor analysis (EFA) with promax rotation was used to determine the factor structure of several measures and to examine their internal reliability. EFA is a statistical method used to identify a set of latent constructs underlying a set of measured variables. It assumes that any indicator (measured variable) may be associated with any factor, and EFA should be conducted prior to further analyses (Ware, 2010). Although there are different factor extraction methods that can be employed, maximum likelihood (ML) was used for these EFAs because "it allows for the computation of a wide range of indices of the goodness of fit of the model [and] permits statistical significance testing of factor loadings and correlations among factors and the computation of confidence intervals" (Fabrigar, Wegener, MacCallum, Strahan, 1999, p. 277).

A random sample of approximately half of the total sample of Biology students and their teachers was drawn using STATA, and a series of EFAs using maximum likelihood estimation were conducted to assess how well individual items on the four constructed scales measured the latent variables of interest: students' efficacy beliefs for learning science, students' perceptions of mastery-focused instruction, teachers' perceptions of mastery-focused instruction, and science teachers' efficacy beliefs.   All potential items were included in each analysis and the number of extracted factors was based on the following criteria (Fabrigar et al., 1999; Ware, 2010):

- Eigenvalues 1.0 or higher
- Visual inspection of each scree plot of eigenvalues plotted against the factor numbers
- Supported by theory/previous literature

Goodness of fit was assessed with both Chi-square (χ^2) and Tucker Lewis Index (TLI). Chi-square assesses the difference between the sample covariance matrix and the restricted covariance matrix assuming the residual discrepancy between them is equal to zero. Therefore, statistically non-significant results ($p > .05$) indicate excellent fit. However, Chi-square tests are known to be sensitive to sample size and with a large sample such as this one, the solution is likely to be rejected regardless of the quality of fit (Miles and Shevlin, 2007). Therefore, an additional fit index (TLI) was calculated for all solutions. The TLI was chosen because it better accounts for all parameters in the model by balancing the effect of model complexity (Miles and Shevlin, 2007). TLI values close to or above .95 are considered acceptable with large sample sizes (Hu & Bentler, 1999).

Students' efficacy beliefs. The results from the EFA for students' efficacy beliefs (see Tables 4.5, 4.6) indicated a single factor solution to be most appropriate as all four items loaded on one factor. Although Chi-square results indicated less than accep fit [χ^2 (2) = 37.04, $p <$ 0.01)], the TLF index for a single factor solution indicated good fit (TLI= 0.97; Hu & Bentler, 1999). The generated scree plot also supported single factor extraction. Based on the EFA findings, the reliability coefficients were recalculated (α = 0.88) and indicated good reliability. See Table 4.7 for the list of items reflecting students' efficacy beliefs for science learning and item reliability.

Table 4.5
EFA Factor Loadings for Students' Efficacy Beliefs Using Maximum Likelihood Estimation

Item	Factor 1	Unique Variance
You are confident that you can do an excellent job on tests in this course.	0.80	0.37
You are certain you can understand the most difficult material presented in the textbook used in this course.	0.76	0.42
You are certain you can master the skills being taught in this course.	0.84	0.30
You are confident that you can do an excellent job on assignments in this course.	0.81	0.34

Table 4.6
Summary of EFA for Students' Efficacy Beliefs

Factor	Eigen Value
Factor 1	2.582

Note. χ^2 (2) = 37.04, $p < 0.01$; TLI = 0.97.

Table 4.7
Reliability Analysis for Students' Efficacy Beliefs

Item	Item-test correlation	Average interitem covariance	Alpha*
You are confident that you can do an excellent job on tests in this course.	0.87	0.35	0.85
You are certain you can understand the most difficult material presented in the textbook used in this course.	0.85	0.35	0.86
You are certain you can master the skills being taught in this course.	0.87	0.35	0.84
You are confident that you can do an excellent job on assignments in this course.	0.86	0.37	0.85
Test Scale		0.36	0.88

*Alpha value if item were removed with the exception of Test Scale.

Students' perceptions of mastery-focused instruction. The results from the EFA for students' perceptions of mastery-focused instruction (see Tables 4.8, 4.9) also indicated a single factor solution to be most appropriate as all four items loaded on one factor. Although Chi-square results indicated less than acceptable fit [χ^2 (2) = 60.49, p < 0.01], the TLI for a single factor solution indicated good fit (TFI= 0.95; Hu & Bentler, 1999). The generated scree plot also supported single factor extraction. Based on the EFA findings, the reliability coefficients were calculated (α = 0.82) and indicated good reliability. See Table 4.10 for the list of items reflecting student's perceptions of mastery-focused instruction and item reliability.

Table 4.8
EFA Factor Loadings for Students' Perceptions of Mastery-Focused Instruction Using Maximum Likelihood Estimation

Item	Factor Loading 1	Unique Variance
Your science teacher values and listens to students' ideas.	0.79	0.40
Your science teacher thinks every student can be successful.	0.76	0.41
Your science teacher thinks mistakes are okay as long as all students learn.	0.71	0.49
Your science teacher makes science interesting.	0.65	0.57

Table 4.9
Summary of EFA for Students' Perception of Mastery-Focused Instruction

Factor	Eigen Value
Factor 1	2.149

Note. χ^2 (2) = 60.49, p < 0.01; TLI = 0.95.

Table 4.10
Reliability Analysis for Students' Perceptions of Mastery-Focused Instruction

Item	Item-test correlation	Average interitem covariance	Alpha*
Your science teacher values and listens to students' ideas.	0.84	0.29	0.75
Your science teacher things every student can be successful.	0.81	0.32	0.77
Your science teacher thinks mistakes are okay as long as all students learn.	0.79	0.32	0.79
Your science teacher makes science interesting.	0.82	0.29	0.81
Test Scale		0.28	0.82

*Alpha value if item were removed with the exception of Test Scale.

Teachers' perceptions of mastery-focused instruction. The results from the EFA for teachers' perceptions of mastery-focused instruction (see Tables 4.11, 4.12) indicated two factors could be possible. Closer examination of factor loadings revealed each item loaded more strongly on the first factor than the second. In fact, only one item loaded strongly onto the second factor, suggesting that this factor was more an indication of the score on this item than a general factor. Also, the first factor's eigenvalue was greater than one, while the second eigenvalue was not. Although Chi-square results indicated less than accep fit [χ^2 (8) = 19.17, p < 0.01], the TLI index for a single factor solution indicated good fit (TLI= 0.99; Hu & Bentler, 1999). The generated scree plot also supported single factor extraction. Taken together, these observations indicated a single factor solution to be most parsimonious. Based on the EFA findings, the reliability coefficients were recalculated (α = 0.82) and indicated good reliability. Also, important to note are the factor loadings for Item 6 ("Teaching students about the relationship between science, technology, and society.") that had relatively high loadings on both factors. These high loadings on two factors could be due to the wording of the question. In this case, Factor 2 could be related to the degree to which teachers focus on only science while the other focuses on the relationship between science and other domains (i.e. technology and society). The item was retained for reliability analysis, but should be more closely examined in future studies. See Table 4.13 for the list of items reflecting teachers' perceptions of mastery-focused instruction and item reliability.

Table 4.11
EFA Factor Loadings for Teachers' Perceptions of Mastery-Focused Instruction Using Maximum Likelihood Estimation

Item	Factor Loading 1	Factor Loading 2	Unique Variance
Increasing students' interest in science.	0.5537	-0.0712	0.6883
Teaching students science process or inquiry skills.	0.6271	0.2939	0.5204
Preparing students for further study in science.	0.6253	0.2753	0.5332
Teaching students to evaluate arguments based on scientific evidence.	0.6946	0.2156	0.4711
Teaching students how to communicate ideas in science effectively.	0.6720	0.1487	0.5264
Teaching students about the relationship between science, technology, and society.	0.6707	-0.4817	0.3180
Teaching students about the history and nature of science.	0.5463	-0.1393	0.6822

Table 4.12
Summary of EFA for Teacher's Perceptions of Mastery-Focused Instruction

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor 1	2.77	2.29	0.85	0.85
Factor 2	0.49	.	0.15	1.00

Note. χ^2 (8) = 19.17, p < 0.01; TLI = .99.

Table 4.13
Reliability Analysis for Teachers' Perceptions of Mastery-Focused Instruction

Item	Item-test correlation	Average interitem covariance	Alpha*
Increasing students' interest in science.	0.63	0.17	0.79
Teaching students science process or inquiry skills.	0.68	0.17	0.76
Preparing students for further study in science.	0.70	0.16	0.78
Teaching students to evaluate arguments based on scientific evidence.	0.75	0.15	0.77
Teaching students how to communicate ideas in science effectively.	0.64	0.17	0.80
Teaching students about the relationship between science, technology, and society.	0.66	0.16	0.80
Teaching students about the history and nature of science.	0.73	0.16	0.77
Test Scale		0.16	0.81

*Alpha value if item were removed with the exception of Test Scale.

Teachers' efficacy beliefs. The results from the EFA for teachers' efficacy beliefs (see Tables 4.14, 4.15) indicated two factors could be possible. The first factor's eigenvalue was greater than one, but the second eigenvalue was also very close, which could mean a two-factor solution could be best. Closer examination of individual factor loadings revealed the first four items loaded more strongly on the first factor than on the second, and the last three item loadings were split between factors. Although Chi-square results indicated less than acceptable fit [χ^2 (1) = 2.80, $p < 0.01$], the TLF index for a two-factor solution indicated acceptable fit (TLI= 0.99; Hu & Bentler, 1999). The generated scree plot also supported a two-factor extraction.

Furthermore, a two factor solution aligned with previous theoretical findings discussed in the second chapter, which suggests a differentiation between *general teaching efficacy (GTE)*, defined as the belief that any teachers' capability to impact student learning can be significantly limited by factors external to the teacher and *personal teaching efficacy (PTE)*, defined as the belief that one possesses the skills and capabilities to bring about student learning (Gibson & Dembo, 1984; Tschannen-Moran, Woolfolk Hoy, & Hoy, 1998). Based on both empirical and theoretical support, a two-factor solution was most appropriate.

Table 4.14

EFA Loadings for Teachers' Efficacy Beliefs Using Maximum Likelihood Estimation

Item	Factor 1 (GTE)	Factor 2 (PTE)	Unique Variance
The amount a student can learn is primarily related to family background.	0.52	-0.13	0.71
You are very limited in what you can achieve because a student's home.	0.78	-0.22	0.34
If parents would do more for their children, you could do more for your students.	0.56	-0.19	0.64
When it comes right down to it, you really cannot do much because most of a student's motivation and performance depends on their home environment.	0.60	0.21	0.60
If students are not disciplined at home, they are not likely to accept any discipline at school.	0.60	-0.07	0.66
If a student did not remember information you gave in a previous lesson, you would know how to increase their retention in the next lesson.	0.23	0.36	0.82
If a student in your class becomes disruptive and noisy, you feel assured that you know some techniques to redirect them quickly.	0.24	0.51	0.68
If you really try hard, you can get through to even the most difficult or unmotivated students.	0.42	0.48	0.59

Table 4.15

Summary of EFA for Teacher's Sense of Efficacy

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor 1	1.57	0.58	0.61	0.61
Factor 2	0.99	.	0.39	1.00

Note. χ^2 (1) = 2.80, p < 0.01; TLI = .99.

Based on the EFA findings, the reliability coefficients were recalculated as separate factors, GTE (Table 4.16, α = 0.75) and PTE (Table 4.17, α = 0.53). Because the alpha coefficient for PTE was below 0.6, indicating low reliability, the decision was made to use only GTE items for further investigation in the Mplus.

Table 4.16
Reliability Analysis for Teachers' Efficacy Beliefs: General Teaching Efficacy (GTE)

Item	Item-test correlation	Average interitem covariance	Alpha*
The amount a student can learn is primarily related to family background.	0.68	0.19	0.72
You are very limited in what you can achieve because a student's home.	0.80	0.15	0.65
If parents would do more for their children, you could do more for your students.	0.69	0.18	0.71
When it comes right down to it, you really cannot do much because most of a student's motivation and performance depends on their home environment.	0.62	0.21	0.73
If students are not disciplined at home, they are not likely to accept any discipline at school.	0.72	0.17	0.70
Test Scale		0.18	0.75

*Alpha value if item were removed with the exception of the Test Scale.

Table 4.17
Reliability Analysis for Teachers' Efficacy Beliefs: Personal Teaching Efficacy (PTE)

Item	Item-test correlation	Average interitem covariance	Alpha*
If a student did not remember information you gave in a previous lesson, you would know how to increase their retention in the next lesson.	0.65	0.12	0.48
If a student in your class becomes disruptive and noisy, you feel assured that you know some techniques to redirect them quickly.	0.73	0.08	0.37
If you really try hard, you can get through to even the most difficult or unmotivated students.	0.78	0.08	0.43
Test Scale		0.10	0.53

*Alpha value if item were removed with the exception of the Test Scale.

Multi-level Mediation

Testing mediational hypotheses has become increasingly important in psychological science (Baron & Kenny, 1986; Shrout & Bolger, 2002), and many mediational questions are relevant to multi-level data. Kenny, Kashy, and Bolger (1998) first introduced this concept and have since explained the differences between upper and lower level mediation. The following two models each test a different level mediator. The first model examines teachers' perceptions of mastery-focused instruction (level 2) as a potential *upper level* mediator between teachers' efficacy beliefs (level 2) and students' efficacy beliefs (level 1). The second model examines students' perceptions of mastery-focused instruction (level 1) as a potential *lower level* mediator between teachers' efficacy beliefs (level 2) and students' efficacy beliefs (level 1).

To account for the nested structure of the data, each mediation model consisted of two levels: a within level which addressed effects at the student level and a between level, which addressed effects between teachers (Model 1) or between student (Model 2). Effects at the two levels were estimated simultaneously. In accordance with my hypotheses, the MSEM was performed in three steps for each model tested. In Step 1, the links between students' efficacy beliefs and teachers' efficacy beliefs were modeled. In Step 2, student level covariates were added. In step three, teachers' perceptions of mastery-focused instruction was entered into the model as a mediator for the relation between teacher and student efficacy beliefs. Mediation was assessed by inspecting the size and statistical significance of the direct effect of teachers' efficacy beliefs on students' efficacy beliefs after the introduction of the mediator, and by testing the statistical significance of the indirect effect mediated by teachers' perceptions of mastery-focused instruction (Kenny, Kashy, & Bolger, 1998; MacKinnon, Fairchild, & Fritz, 2007; Muthen & Muthen, 2007). Tables 4.18 and 4.19 show the results of the MSEM analyses, which include parameter estimates (PE), and their standard errors (SE), and *p*-values. The path diagrams (Figure 4.1 and 4.2) are included at the end of the chapter.

Table 4.18

Parameter Estimates for Model 1: Teachers' Perceptions of Mastery-Focused Instruction

Parameter	PE	SE	*p*-value
Full Indirect Effect (Mediation)	-0.048	0.025	0.061
Between Student Efficacy Beliefs on			
Teachers' Perceptions Mastery-Focused Instruction	-0.103	0.056	0.126
Teachers' Efficacy Beliefs	**0.699**	**0.091**	**<0.001**
Between Teachers' Percept. Mastery-Focused Instruction on			
Teachers' Efficacy Beliefs	**0.462**	**0.044**	**<0.001**
Between Teachers' Efficacy Beliefs on			
Race/Ethnicity	0.002	0.009	0.827
Sex (Female = 1)	**0.192**	**0.023**	**<0.001**
Highest Degree Earned	-0.002	0.016	0.913
Years of 9-12 Science Teaching Experience	**0.002**	**0.001**	**0.035**
Within Students' Efficacy Beliefs on			
Gender (Male =1)	**-0.767**	**0.133**	**<0.001**
Race/Ethnicity	-0.041	0.028	0.147
Mathematics Ability Score	**0.086**	**0.007**	**<0.001**
Parent Education Level	**-0.177**	**0.045**	**<0.001**
Type of School	-0.138	0.102	0.089
Residual Variances			
Between Teachers' Efficacy Beliefs	0.249	0.009	<0.001
Between Teachers' Percept. Mastery-Focused Instruction	1.538	0.160	<0.001
Between Student Efficacy Beliefs	1.092	0.165	<0.001
Within Students' Efficacy Beliefs	9.035	0.069	<0.001

Note. Bold indicates path is statistically significant.

Table 4.19

Parameter Estimates for Model 2: Students' Perceptions of Mastery-Focused Instruction

Parameter	PE	SE	*p*-value
Full Indirect Effect (Mediation)	-0.001	0.003	0.751
Between Students' Efficacy Beliefs on			
Between Students' Percept. Mastery-Focused Instruction	-0.079	0.061	0.384
Teachers' Efficacy Beliefs	**0.068**	**0.029**	**0.010**
Between Students' Percept. Mastery-Focused Instruction on			
Between Teachers' Efficacy Beliefs	0.011	0.029	0.356
Between Teachers' Efficacy Beliefs on			
Teacher Race/ethnicity	-0.089	0.051	0.080
Teachers' Gender (Male = 1)	**0.717**	**0.140**	**<0.001**
Teacher's Highest Degree Earned	-0.168	0.084	0.094
Years of 9-12 Science Teaching Experience	**0.015**	**0.006**	**0.009**
Within Students' Efficacy Beliefs on			
Within Students' Mastery-Focused Instruction	**1.062**	**0.155**	**<0.001**
Within Students' Percept. Mastery-Focused Instruction on			
Gender (Female =1)	-0.059	0.115	0.303
Race/ethnicity	0.009	0.017	0.597
Mathematics Ability Score	**0.026**	**0.005**	**<0.001**
Parent Education Level	-0.003	0.024	0.911
Type of School	**0.159**	**0.063**	**0.006**
Residual Variance			
Between Teachers' Efficacy Beliefs	5.165	0.571	<0.001
Between Student Efficacy Beliefs	0.273	0.045	<0.001
Between Teachers' Percept. Mastery-Focused Instruction	1.254	0.176	<0.001
Within Students' Efficacy Beliefs	7.563	1.226	<0.001
Within Students' Percept. Mastery-Focused Instruction	2.017	0.268	<0.001

Note. Bold indicates path is statistically significant.

Hypothesis 1. This hypothesis specified that the final MSEM Model 2 (students' perceptions of mastery-focused instruction) would produce relatively better fit indices than Model 1 (teachers' perceptions of mastery-focused instruction). When running the original mediation models, the model featuring teachers' perceptions of mastery focused instruction failed to converge. Therefore, an iterative process was used to determine which variable or variables were causing issues. After beginning with a basic model and building to the more complex model, it was determined that the issue lay in the teachers' efficacy beliefs latent variable. Therefore, a composite was created from this variable's indicators, and this composite was used in the model rather than using a latent variable. In order to accurately compare this model with the model featuring students' perceptions of mastery focused instruction, that model was also re-run using the composite for teachers' efficacy beliefs.

Results indicated that Model 2 (students' perceptions of mastery-focused instruction as the mediator) more accurately described the relations among variables in the data than did Model 1 (teachers' perceptions of mastery-focused instruction as the mediator). Specifically, Model 2 produced a considerably lower AIC value (42281.93) than did Model 1 (56790.28), suggesting that Model 2 is more likely to accurately portray the relationships within the data. Model 2 also produced lower BIC value (42616.612) than did Model 1 (57167.772). Although Model 2 was run in this comparison featuring a composite variable, using such a variable ignores error in the measurement of that construct. Therefore, for the rest of the hypotheses that were tested using this model, the full model including teachers' efficacy beliefs as a latent variable was used.

Hypothesis 2. This hypothesis specified that science teachers' efficacy beliefs would be positively related to students' efficacy beliefs for science learning. In Models 1 and 2, the results supported this hypothesis. In Model 2, for every one unit increase on teachers' latent efficacy beliefs, a 0.07 unit increase in students' latent sense of efficacy was predicted. The path coefficient was statistically significant ($p = .01$).

Hypothesis 3. This hypothesis specified that science teachers' efficacy beliefs would be positively related to science teachers' perceptions of mastery-focused instruction. In Model 1, the results supported this hypothesis. Specifically, for every one unit increase on teachers' efficacy beliefs, a 0.46 unit increase on teachers' perceptions of mastery-focused instruction was predicted. The path coefficient was statistically significant ($p < 0.001$).

Hypothesis 4: This hypothesis specified that science teachers' efficacy beliefs would be positively related to science students' perceptions of mastery-focused instruction. The results from Model 2 did not support this hypothesis ($p = .356$).

Hypothesis 5. This hypothesis specified that science teachers' perceptions of mastery-focused instruction would be positively related to science students' perceptions of mastery-focused instruction. As mentioned in the previous chapter, this hypothesis could not be tested due to issues regarding computer memory and convergence.

Hypothesis 6: This hypothesis specified that science teachers' perceptions of mastery-focused instruction would be positively related to students' efficacy beliefs for science learning. The results from Model 1 did not support this hypothesis ($p = .126$).

Hypothesis 7: This hypothesis specified that students' perceptions of mastery-focused instruction would be positively related to students' efficacy beliefs for science learning. The results from Model 2 supported this hypothesis at the within level but not the between level. In other words, within classrooms, students' perceptions of mastery-focused instruction were positively related to their efficacy beliefs ($p < .001$). For every one unit increase in students' perceptions of mastery-focused instruction within the classroom, a 1.062 unit increase in students' efficacy beliefs was predicted. However, between classrooms, students' perceptions of mastery-focused instruction did not have a statistically significant relationship with science students' efficacy beliefs ($p = .384$). This suggests that differences between students within a classroom regarding their perceptions of mastery focused instruction are related to differences between peers in the same classroom regarding their efficacy beliefs, but that differences between classrooms with regard to these constructs are not related.

Hypothesis 8: This hypothesis specified that science teachers' perceptions of mastery-focused instruction would partially mediate the relationship between science teachers' efficacy beliefs and students' efficacy for science learning. The results of Model 1 did not support this hypothesis. The indirect effect was not statistically significant (p = .12) for the full model. This result, combined with the fact that the relationship between science teachers' efficacy beliefs and students' efficacy beliefs for science learning was significant, suggesting a direct effect rather than mediation.

Hypothesis 9: This hypothesis specified that students' perceptions of mastery-focused instruction would partially mediate the relation between science teachers' efficacy beliefs and students' efficacy beliefs for science learning. The results of Model 2 did not support this hypothesis. The indirect effect was again not statistically significant (p = .75) for the full model. As before, this result, combined with the fact that the relationship between science teachers' efficacy beliefs and students' efficacy beliefs for science learning was significant, suggesting a direct effect rather than mediation.

Final path diagrams (*Figure 4.1* and *Figure 4.2*) presented on the next few pages.

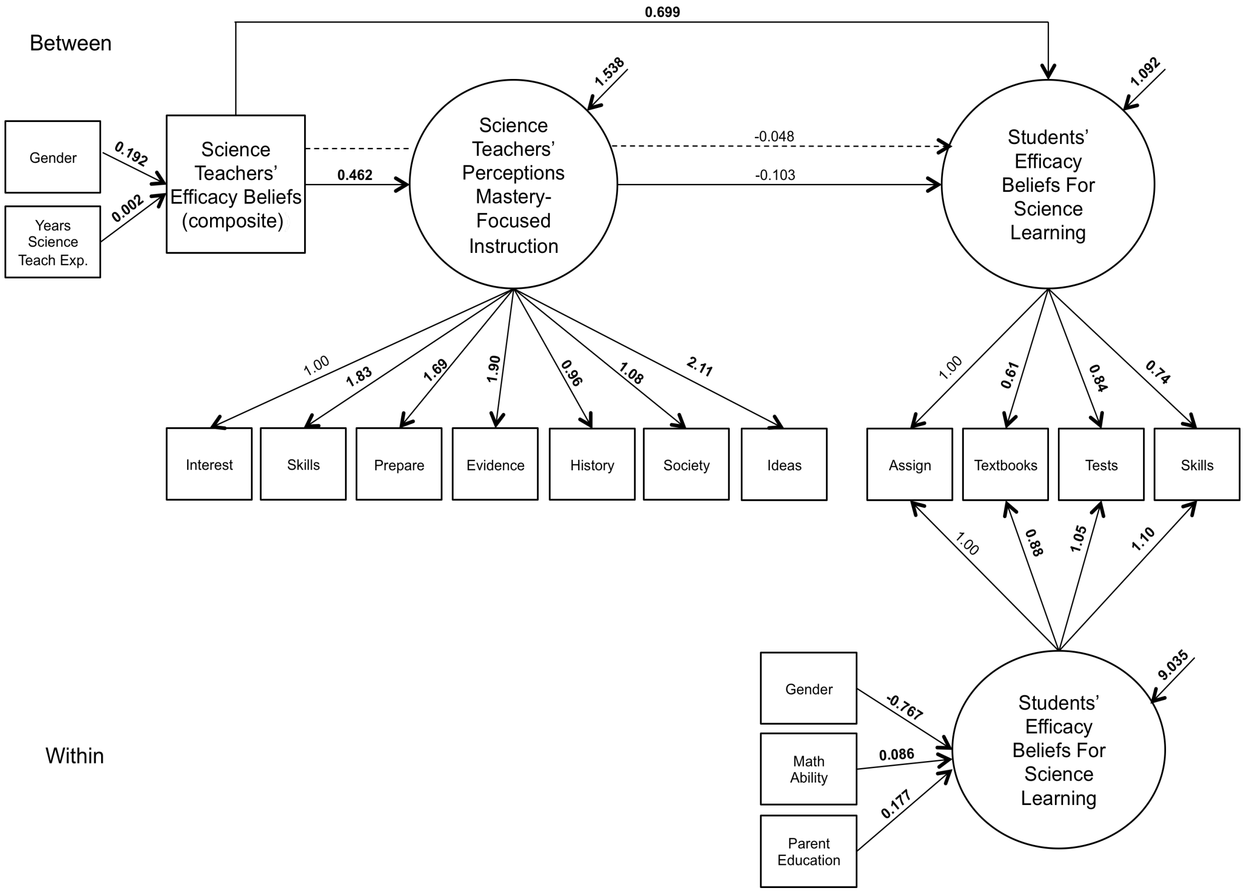

Figure 4.1. Model 1: Path Diagram of Teachers' and Students' Efficacy Beliefs as Mediated by Teachers' Perceptions of Mastery-Focused Instruction. For readability, only covariates yielding *p*-values < 0.05 are shown; statistically significant paths are bolded.

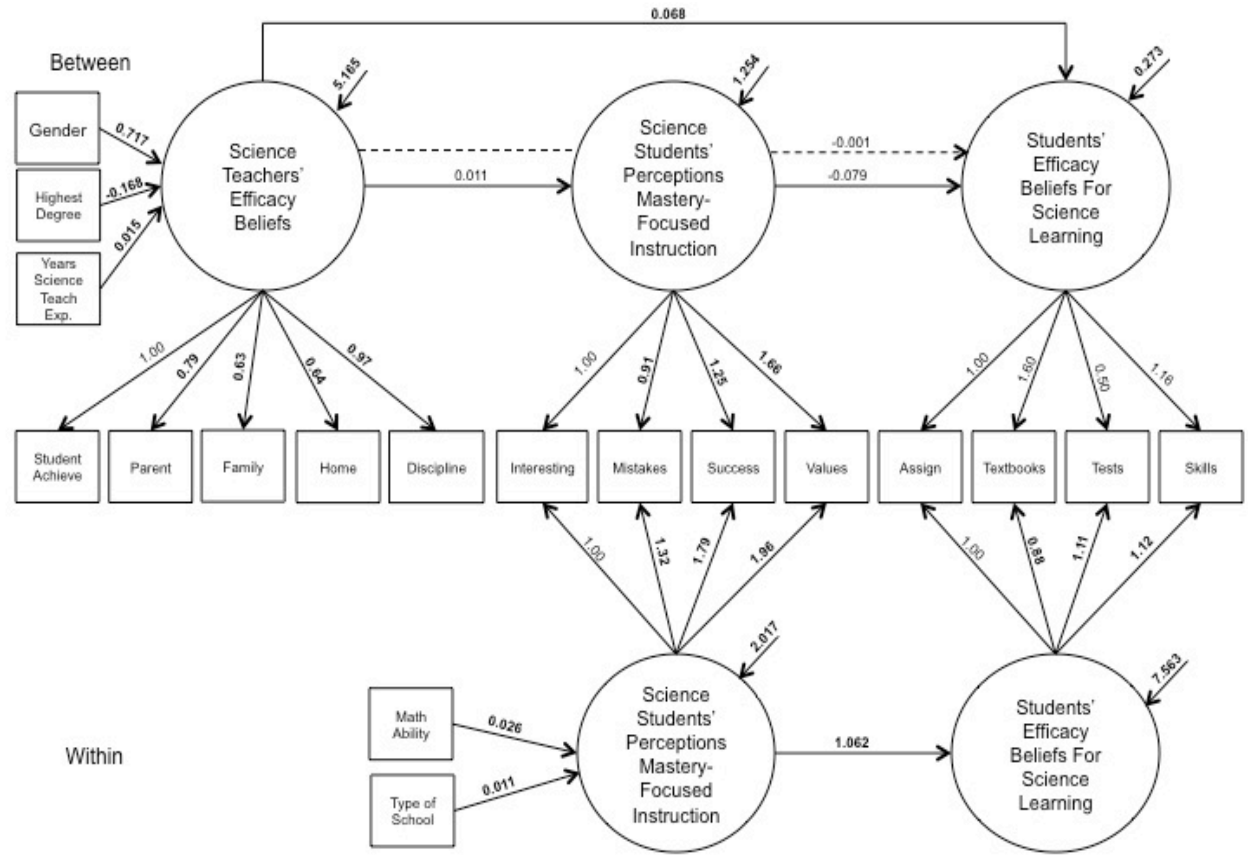

Figure 4.2. Model 2: Path Diagram of Teachers' and Students' Efficacy Beliefs as Mediated by Students' Perceptions of Mastery-Focused Instruction. For readability, only covariates yielding *p*-values < 0.05 are shown; statistically significant paths are bolded.

CHAPTER FIVE

DISCUSSION

Using a lens of self-efficacy theory (Bandura, 1977), the overall purpose of this research study was to investigate classroom factors that may contribute to students' motivation for learning science. Specifically, this study centered on examining the relation among high school students' and teachers' motivational efficacy beliefs for science learning and their perceptions of the classroom instructional environment established by the teacher. In this chapter, the importance of the classroom environment is discussed. Next, a summary of major findings is provided, including how these findings did or did not support the hypotheses. Finally, implications for science education and educational psychology, future directions, limitations of the study, and a brief conclusion are presented.

Classroom Instructional Environment is Key

How both students and teachers perceive the structure of the classroom environment is critical to the overall classroom experience. There is a large body of literature in educational psychology focused on the processes and mechanisms through which students experiences in classrooms contributes to their academic development (e.g., Eccles & Midgley, 1989; Eccles & Roeser, 1999; 2011; Hamre & Pianta, 2010; Pressley et al., 2003). Classroom proximal processes include teacher and student beliefs, teacher beliefs and practices, and student beliefs and teacher practices (Hamre & Pianta, 2010). Some motivation researchers have turned their attention to these processes in an attempt to understand how the classroom instructional environment helps shape students' academic motivation and achievement, and how this environment is perceived by students within and between classrooms (e.g., Meece et al., 2006; Pintrich & Schunk, 2002). Specifically, research suggests that when students perceive their teachers to be stimulating interest and curiosity, promoting the use of higher-order thinking skills, accepting that mistakes are a part of the learning process, and believing all students can learn, they are using mastery-focused instruction (Meece et al., 2003). Consistent with this motivation research, new reforms in science education, such as the framework for the Next Generation Science Standards (NRC, 2013), echo the need for further examination of teachers' classroom instructional practices as a means for producing academic gains for all students in science. Therefore, this investigation brings both science education and educational psychology literatures together to examine how these proximal processes operate within the context of the high school science classroom and how the instructional environment is perceived by both students and teachers. The results from the MSEM analysis provided mixed support for the proposed models.

Summary of Major Findings

Four hypotheses were supported by the results. First, when compared to teachers' perceptions, the inclusion of students' perceptions of mastery-focused instruction provided a more accurate representation of the relationships among constructs in the model. Second, findings indicated science teachers' efficacy beliefs predicted teachers' perceptions of their use of mastery-focused instructional practices in the science classroom. Third, science teachers' efficacy beliefs predicted students' efficacy beliefs for science learning. Fourth, within classrooms, students' perceptions of their teacher's use of mastery-focused instruction predicted students' efficacy beliefs for science learning. These findings are discussed further in the following sections.

Teachers' efficacy beliefs and classroom instruction. Findings from this study indicate science teachers' efficacy beliefs directly relate to their classroom instruction. Specifically, if there is a one unit increase in the science teacher's latent efficacy beliefs, a teacher's emphasis on classroom practices aligned with mastery-focused instruction can also be expected to rise by 0.46 units. These findings are consistent with previous research suggesting teachers' efficacy beliefs predict the frequency and duration of particular instructional practices (Klassen, Tze, Betz & Gordon, 2011; Tschannen-Moran & Woolfolk Hoy, 2001). Within the domain of science education, highly efficacious teachers spend more time teaching science and developing science content (Riggs & Jesunathadus, 1993), believe all students are capable of learning science through cooperation with peers (Scharmann & Hampton, 1995), engage in more student-centered science lessons (Loughran, 1994), and show science is relevant to students' lives (Watters & Ginns, 1995). Finally, science teachers who assume responsibility for student learning rather than shifting the responsibility onto students or parents report higher general teaching efficacy (Riggs & Enochs, 1990), and when they assume this responsibility, they demonstrate classroom instructional behaviors that foster student motivation and learning (Angle & Moseley, 2009; Tschannen-Moran & Hoy, 2001).

Teachers' efficacy beliefs and students' efficacy beliefs. Findings from this study indicate science teachers' efficacy beliefs are directly related to students' efficacy beliefs for science learning. In other words, if teachers' latent efficacy beliefs rise by one unit, students' latent efficacy beliefs will likely rise by 0.70 units. These findings align with prior research in other domains such as language arts, social studies (Anderson et al., 1988) and computer science (Ross et al., 2001). Highly efficacious teachers believe their students are not limited in what they can learn due to environmental factors outside the classroom (Klassen, Tze, Betts, &

Gordon, 2011), and may be modeling this high confidence to their students. These students may perceive their science teachers to believe in their capacity to learn science, which in turn may promote the development of students' efficacy beliefs. Further, highly efficacious teachers may be providing continuous and constructive feedback to students on their performance on assignments and activities, which has been shown to provide students with a realistic evaluation of their performance and suggest strategies for improvement (Schunk & Swartz, 1993). When students receive this type of constructive feedback regarding their progress, it fosters the belief that they are improving their science skills and promoting growth in their efficacy beliefs (Schunk & Meece, 2006).

Students' perceptions of mastery-focused instruction and students' efficacy beliefs. Findings from this study indicate a direct relationship between students' perceptions of their teacher's emphasis on mastery-focused instruction and students' efficacy beliefs for science learning within classrooms. This relation was observed at the classroom level only. When compared to their peers in the same classroom, students who perceived their teacher to be emphasizing mastery-focused instruction more often reported higher efficacy beliefs for science learning. For every one unit increase in a student's report of mastery-focused instruction within the classroom, a 1.06 increase in that student's report of their efficacy beliefs can be expected.

Non-significant findings. Some hypotheses were not supported by study findings. First, although students' perceptions of mastery-focused instruction were directly related to students' efficacy beliefs for science learning within the classroom ($\beta = 1.06$), this relationship was not significant between classrooms ($p = .19$). In other words, teachers on average who have students who report higher levels of mastery-focused instruction do not report higher average levels of efficacy beliefs for learning science. This finding does not align with prior research on the subject (e.g., Meece et al., 2003; Meece, 1991), which suggests that when students between classrooms report high levels of mastery-focused instruction, they also report high levels of efficacy beliefs. There are a number of possible reasons for the conflicting findings. First, this study has operationalized its latent variables using different indicators. Although great care was taken in selecting these items, it is possible that the latent variable under consideration here is significantly different from those constructs under investigation in prior studies. Such differences might have led to difference in the relations between the constructs. Although this study drew from a large, nationally representative sample, past studies have done so as well (e.g., Meece et al., 2003). Second, idiosyncrasies within the samples might have caused disparate findings (e.g., survey administration, student affect during completion). Third, although the relationships within the population may be as described by past studies, the findings of this investigation should not be overlooked due to the sophisticated methodology employed in this study. For example, past studies have utilized hierarchical linear modeling (HLM) analyses, which has been the standard for analysis of hierarchically nested data for many years. However, creating level two variables from aggregations of level one responses (e.g., creating a classroom average of student perceptions of mastery focused instruction) has been shown to create biased estimates of contextual effects, which underestimates the related standard errors (Lüdtke et al., 2008). Because the MSEM approach accounts for error in estimation of group means from individual responses, the associated parameter estimates are more reliable (Muthen & Muthen, 2007). Further investigation is needed to explore these discrepant findings.

Additionally, teachers' efficacy beliefs were not related to students' perceptions of mastery-focused instruction. In other words, even though science teachers who report high efficacy also report high emphasis on mastery-focused instructional practices, students may not perceive their teachers to be using instructional practices aligned with mastery. Further, teachers' perceptions of their own emphasis on mastery-focused instruction in the classroom did not relate to students' efficacy beliefs for science learning. In other words, even though teachers may report using instructional practices aligned with mastery, these experiences may not be perceived by the students as contributing to their own efficacy for science learning. Thus, the notion that the mechanism by which teacher and student efficacy beliefs are related lies in teachers' perceptions of mastery-focused instruction was not supported in this particular study. This result is contrary to the findings of Thoonen, Sleegers, Peetsma, and Ooart (2011), where teachers' perceptions of classroom practices (i.e., use of process-oriented instruction, connection to student world, cooperation, and differentiation) fully mediated the relation between teacher and student efficacy beliefs.

Taken together, these non-significant findings highlight the importance of understanding how students perceive the classroom instructional climate. As previously discussed in the second chapter, there is much debate regarding whether the classroom instructional climate should be measured through teacher or student reports (Desimone, Smith, & Frisvold, 2010). Findings from this study support the claim that discrepancies may exist between teacher and student reports of the classroom instructional environment (Fisher & Fraser, 1983). This discrepancy could be attributed to teachers reporting something that students are not picking up on. For example, teachers may in fact be using mastery-focused instruction often, such as trying to increase students' interest in science, but students may not perceive their teachers' classroom practices to promote their interest. This mismatch in perceptions could make it more difficult for teachers to gain or maintain their students' interest in science.

Another possibility is that teachers may be overrating their use of mastery-focused instructional practices. Although teachers sometimes view their own instruction to be closely aligned with standard-based reforms, they may overestimate their emphasis on particular aspects of instruction (Fisher & Fisher, 1983). For example, Appleton and Lawrenz (2011) examined the alignment of perceptions of student cognitive engagement by students, teachers, and outside observers across middle and high school science and mathematics classrooms. They found significant differences between student and teacher perceptions of cognitive engagement across science and mathematics classrooms with teachers consistently reporting higher perceptions than students. Therefore, students' reports can provide a unique perspective on the degree to which they perceive their teachers to be focused on instructional strategies that promote mastery in the classroom. This notion, coupled with the significant links found in this study between (a) teacher and student efficacy beliefs and (b) student perceptions of mastery-focused instruction and student efficacy beliefs within the classroom may suggest the mechanism by which teacher and student efficacy beliefs are related may lie in students' perceptions of mastery-focused instruction. However, partial mediation for this was non-significant. Additional research is needed to further examine the role of student perceptions of the classroom instructional climate as a possible mechanism for the link between teacher and student efficacy beliefs.

Contributions to Science Education and Educational Psychology

With the new Next Generation Science Standards (NRC, 2013) reforms, there is a heightened need for creating classroom instructional environments that motivate and properly prepare high school students for careers in science. This study's findings provide four major contributions to the fields of science education and educational psychology. First, it extends the literature in the field of educational psychology regarding the development of students' efficacy beliefs to high school science classrooms. Evidence from this investigation supports some previous findings concerning the relation among these constructs within the context of elementary and middle school science classrooms while disputing others (e.g., Anderman & Young, 1994; Meece, 1991). With over four million ninth graders enrolled in high schools in the United States in 2009 (Ingels et al., 2011), it is particularly critical for educators and researchers to better understand the complex nature of high school student motivational beliefs and how the classroom environment contributes to their development. Therefore, additional investigation is needed to clarify discrepancies among study findings and further explore how these proximal processes operate within high school science classrooms.

Second, findings from this investigation highlight the idea that individual student differences are linked to their developmental trajectories (Hamre & Pianta, 2010). In other words, relative to their peers, some students develop more positive developmental trajectories than others. Specifically, findings reinforce the notion that individual student perceptions of the classroom instructional climate are related to their efficacy beliefs for science learning. Particularly during times of new instructional reforms, such as those that accompany the Next Generation Science Standards, students need to perceive their science teacher in ways that promote high engagement in science learning. Such behaviors include valuing and listening to students' ideas, thinking every student can be successful, and thinking mistakes are okay as long as all students are learning. However, the relationship between individual student perceptions of their teacher and their own efficacy beliefs is not understood well enough yet to hypothesize a causal direction or mechanism or make changes to teaching practices or policy, and further investigation is needed.

Third, findings extend both bodies of literature regarding the connection between the motivational beliefs of students and their teachers. When science teachers believe all students can learn science regardless of conditions outside the classroom, they may be modeling high efficacy beliefs and a sense of agency to students in their class. In turn, these students may perceive themselves to be capable of learning science and report higher efficacy beliefs. This has important implications for how students approach science tasks and even future course and career paths. Students who report higher efficacy beliefs for learning science tend to perform better on science achievement tests (Andrew, 1998; Angle & Moseley, 2009), continue with science courses (Zeldin & Pajares, 2000); pursue undergraduate degrees in science (Dalgety & Coll, 2006), and express interest in science-related careers (Gwilliam & Betz, 2001). Taken together, this information is particularly critical for science educators and administrators during new science reform as it may become even more challenging to find ways to motivate students and teachers. Recognizing that learning is contextualized and this proximal process (i.e., relation between teacher and student efficacy beliefs) is constantly occurring within the classroom may help guide the development and delivery of teacher education programs and professional developments aligned with the Next Generation Science Standards (NRC, 2013).

Finally, this study addresses Thoonen and colleagues' (2011) call for the use of a large-scale heterogeneous sample and advanced statistical procedures, such as multi-level structural equation modeling, to examine the relation among these constructs. This study also addressed Thoonen and colleagues' suggestion of including student background variables (e.g., gender, race/ethnicity, math ability) as controls since research has shown that background information can contribute to students' efficacy beliefs for science learning (e.g., Denissen, Zarrett, & Eccles, 2007; Pajares, Britner, & Valiante, 2000). This investigation further extended Thoonen et al.'s work by including teacher background variables (e.g., gender, race/ethnicity, years of teaching high school science) as controls since research has shown that teacher-level background information can contribute to their efficacy beliefs (e.g., Smith & Fouad, 1999; Woolfolk Hoy & Burke-Spero, 2005).

Future Directions

The findings from this investigation have the potential to stimulate future research in the fields of educational psychology, science education, and methodology regarding student and teacher motivational beliefs and perceptions of the classroom instructional climate.

Educational Psychology. First, this dissertation study could be replicated on a smaller scale using the same items from the Patterns of Adaptive Learning Scale (PALS, Midgely et al., 1997) to better assess the degree of alignment between teacher and student reports of the classroom instructional environment. Second, although this study only used general teaching efficacy (GTE), previous research has shown a direct relation between personal teaching efficacy (PTE) and student achievement outcomes in science (e.g., Angle & Moseley, 2009). Therefore, future studies could use the HSLS:09 to reexamine reliability coefficients for PTE using a larger sample of science teachers (not just Biology) to see if the reliability coefficients remain low. If not, then researchers could examine the direct relation between teachers' personal teaching efficacy and students' efficacy beliefs and the indirect relation between these two constructs through students' perceptions of mastery-focused instruction. In other words, do teachers' with high PTE also have students' with high efficacy beliefs for science learning?

Third, researchers could investigate the relation among these constructs using Tschannen-Moran, Woolkfolk Hoy, and Hoy's (1998) scale to measure teachers' efficacy beliefs in three dimensions (efficacy for classroom management, student engagement, and instructional practices) within the science classroom. Over the last decade, the use of this scale in educational psychology has increased due to its strong factor loadings (Henson, 2001; Klassen et al., 2011; Tschannen-Moran et al., 2001) and theoretical link to Bandura's (2006) *Guide for Constructing Self-Efficacy Scales*. Yet, few studies have used this measure in high school science classes (Klassen et al., 2011). Those researchers who have used this scale have found that teachers tend to report higher efficacy for classroom management than instructional strategies and increasing student engagement, which are two critical component of mastery-focused instruction (Fives & Buehl, 2009; Tschannen-Moran & Woolfolk Hoy, 2001).

Science Education. This study used a sample of only Biology students and their teachers, but future studies could use the entire sample of science students and their teachers and disaggregate by course type to see if teachers' efficacy beliefs, student efficacy beliefs, and perceptions of the instructional climate vary as a function of discipline. In other words, could teacher and student efficacy beliefs differ by content area, such as Biology, Chemistry, Earth Science, and Physics? Could student perceptions of the instructional environment vary by discipline? If students perceive an instructional environment that fosters mastery in Biology but does not in Chemistry or Physics, what implications might that have on students' willingness to continue on with science courses, majors in college, or future careers in science? Further, do teachers' efficacy beliefs (PTE and/or GTE) and perceptions of their own instruction differ between science courses; and if so, do those differences relate to the efficacy beliefs of students enrolled in these courses? The same questions could be extended to mathematics disciplines (e.g., Algebra, Geometry, Calculus, etc.) using the HSLS:09.

Methodology. First, the full hypothesized model could be rerun using a computer with more memory. Second, given that paths between some covariates and latent students' efficacy beliefs were not statistically significant: race/ethnicity (*p* = 0.60) and parent education level (*p* = 0.91), these controls could be dropped from the model to reduce complexity. The same could be done at the teacher level with teachers' race/ethnicity (*p* = 0.08) and teachers' highest degree earned (*p* = 0.09). Third, given the statistically significant outcomes of this study and direction of estimates of non-significant findings, perhaps an examination of students' efficacy beliefs as the mechanism that underlies the relation between teachers' efficacy beliefs and students' perceptions of instruction is warranted. In other words, perhaps students filter their perceptions of the instructional climate through their own efficacy beliefs for learning science prior to making judgment about the classroom instructional environment. Therefore, future studies could examine the possibility of an indirect effect of students' efficacy beliefs between the relation of teachers' efficacy beliefs and students' perceptions of mastery-focused instruction.

Limitations of the Study

Although this study contributes to existent bodies of literature, there are a few limitations that need to be addressed when conducting secondary data analyses. First, this investigation used existing items on the HSLS:09 teacher questionnaire to assess teachers' efficacy beliefs. Due to a low reliability coefficient for personal teaching efficacy beliefs, only general teaching efficacy beliefs were used for MSEM analysis. Second, different items were used to create latent teacher and student perceptions of mastery-focused instruction. While the items used for generating latent students' perceptions of mastery-focused instruction aligned more with items used on a previously validated scale measuring students' perceptions of mastery-focused instruction (e.g., PALS, Midgely et al., 1997), the items used to generate latent teachers' perceptions of mastery-focused instruction were constructed by the investigator. Although some examination of validity was performed to examine how each item aligned theoretically, they have not been previously validated to measure the construct. Thus, further examination and validation of these items is needed. Fourth, as mentioned in the analysis plan in the third chapter, the full model with both latent variables (teacher and student perceptions of mastery-focused instruction) would not converge due to lack of computer memory space. The analysis required too many integration points to be able to run the complex model. As a result, two separate mediation models were run. Finally, due to additional issues with convergence, a composite of teachers' efficacy beliefs was generated from the variable's indicators rather than a latent variable (see Model 1). Because composite variables do not partial out measurement error associated with the construct, the relationships in the model including the composite could be attenuated.

Conclusion

This study investigated classroom instructional factors that may contribute to students' motivation to learn science using a lens of Self-Efficacy theory (Bandura, 1977). Although the research on efficacy beliefs is rich in many academic domains, less information is available regarding how the classroom instructional environment relates to the development of students' efficacy beliefs within the domain of high school science. This study used reports from 3,557 high school Biology students and their Biology teachers (N = 2,055) who participated in the High School Longitudinal Study of 2009 (Ingels et al., 2011). Multi-level structural equation modeling was used to explore the relation among science teachers' efficacy beliefs, students' and teachers' perceptions of mastery-focused instruction, and students' efficacy beliefs for science learning. This study found that teachers' efficacy beliefs positively relate to their own perceptions of their emphasis on mastery-focused instruction; teachers' efficacy beliefs positively relate to students' efficacy beliefs for learning science; and within classes, students' perceptions of their teachers' emphasis on mastery-focused instruction positively relate to their efficacy beliefs for science learning. Although findings need further confirmation, this study provides some insight into how students' confidence in their capability to learn science develops within the context of the classroom instructional environment, and understanding student perceptions of the instructional climate of the classroom is important for nurturing student motivation for science learning.

APPENDIX A: RESULTS OF ITEM ALIGNMENT QUESTIONNAIRE: STUDENT PERCEPTIONS OF MASTER-FOCUSED INSTRUCTION

"How much do you agree or disagree with the following statements about [your science teacher]? Remember, none of your teachers or your principal will see any of the answers you provide. Your science teacher…"

Items 1-3

Respondent	*Item 1* *Values and listens to students' ideas.*	*Item 2:* *Treats students with respect.*	*Item 3:* *Treats every student fairly.*
1	This is definitely tapping into social motivation. The statement focuses on values and listening and deals with the relatedness component of a teacher-student relationship. Definitely not mastery/academic motivation, but social motivation.	Again, this is social motivation. Not academic motivation.	Asking a student if his/her science teacher treats them fairly is a social motivation question and not an academic motivation question in my opinion.
2	Academic Motivation	Social Motivation	Social Motivation
3	Academic, could tap mastery or relatedness	This sounds like it taps into a perception of relatedness, as in self-determination theory.	This sounds like it taps into a perception of relatedness, as in self-determination theory.
4	If you think about Epstein's TARGET framework, this trait in a teacher seems like it would help foster an environment where students feel comfortable contributing and making mistakes. This seems very in line with the idea of a mastery oriented environment.	This seems more social to me. It could be interpreted by students as respecting many different aspects, not all necessarily related to academics.	Again, this isn't necessarily academic. What if the teacher favors certain students for non-academic reasons (e.g., giving the athletes more affordances than other students?). I'd say that, if this taps in to motivation, it's more social than academic.
5	Yes, mastery. Academic If the teacher is not willing to listen to student ideas, then the focus would be more on performance goals.	.Yes motivation, mastery not necessarily. Both, but this is murky I would keep this item out. It doesn't get at the heart of mastery motivation.	Yes, motivation. Mastery—maybe. Both Again, I'd keep this item out. It doesn't seem to differentiate mastery motivation from

			performance motivation in a clear manner.
6	This somewhat taps into mastery - in the sense that it gets at relatedness and perhaps autonomy.	Again - I think this is getting more at relatedness between students and teachers rather than mastery.	Again - I think this is getting more at relatedness between students and teachers rather than mastery.
7	Academic, mastery through valuing	I don't think that this taps into mastery academic motivation but may support mastery through social motivation.	I don't think that this taps into mastery academic motivation but may support mastery through social motivation.
8	At first glance, this item seems to represent more of a social relationship between teacher and student (e.g., Wentzel's work on social motivation). But, on closer inspection I can see that a teacher valuing a student's ideas about science can represent the teacher wanting students to master their own understanding of science phenomena. As someone who has worked in survey development, I'm disappointed that this item didn't specify "ideas about science". I can imagine students thinking this could be teachers valuing talking to students about their lives, problems, etc.	Again, this seems more like a social motivation variable. I don't think being performance-oriented necessarily precludes treating students with respect, although theoretically it might seem like that should be the case (?). Is there literature supporting a relationship between respectfulness and mastery-oriented teaching? If there is support for this in the literature, you could use it a mastery orientation type item, but on a personal level, I don't agree that respectfulness = mastery-oriented.	Again, just like with the item above, I would question if there is a reliable and valid relationship between fairness and mastery-orientation. If anything, I think you could make the argument that performance-oriented teachers are more fair because they would base grades, etc., on quatitatively measurable criteria, while mastery-oriented teachers might have to make subjective appraisals from general rubrics in order to give grades. Does that make sense? I guess it depends on how the students define "fair". Again, you could actually ask high school students what they think the word fair means in this item.
9	Mastery Academic	Social motivation	Social motivation
10	Mastery, academic	Motivation, social, seems to deal with student teacher relations.	Motivation, social, seems to deal with student teacher relations.

Items 4-6

Respondent	*Item 4:* *Thinks every student can be successful.*	*Item 5* *Your science teacher thinks mistakes are okay as long as all students learn.*	*Item 6* *Your science teacher treats some kids better than other kids.*
1	Now this question transitions to academic-mastery motivation. By focusing on whether the teacher things every student can be "successful" put this question in the academic motivation camp	Focuses on mastery motivation as opposed to performance motivation. It is trying to identify if the teacher is mastery vs. performance oriented. It is trying to identify if the teacher is more concerned about mastering the material as opposed to just getting the right answer (performance-oriented).	Oh yeah, this is purely social motivation.
2	Academic Motivation	Academic Motivation	Social
3	This sounds more in line with a mastery orientation question. This sounds like an academic motivation question.	This sounds in line with a mastery orientation question. This sounds like an academic motivation question.	This sounds like it taps into a perception of relatedness.
4	This seems very mastery oriented (academic).	This seems central to the idea of mastery orientation: a focus on truly developing competence.	I don't this is necessarily academic or related to motivation. I wouldn't use it as a measure.
5	Yes, mastery. Academic I would definitely include this item.	Yes, mastery. Academic I would definitely include this item.	Yes motivation, mastery maybe. Both I'd consider reverse coding this and adding it. It is a bit different than the question about "fairly" because I might think that treating the misbehaving student "fairly" is to frequently consequence him. A teacher who is providing mastery motivation would, in my opinion,

			treat all students the same. So I'd consider adding this item, but not be wedded to it.
6	This one is a little more mastery focused than the others- but to me seems to be tapping into an underlying incremental beliefs about ability.	Yes - this a mastery item from PALS and reflects the general evaluation/task components.	To me this probably mixes social relatedness and performance goal structure. Not really tapping into mastery though.
7	This item taps into more academic motivation and mastery components but is very general.	This item taps into more academic motivation and mastery components in that mistakes are okay. But still very general across domains	This may have to do with performance motivation or social motivation issues - hard to tell because it is vague. I would not use it for this study.
8	I think this can be seen as "mastery orientation". I think the literature would support performance-oriented as teachers thinking some kids will always do better than some other kids and mastery-oriented as teachers thinking everyone can learn and succeed.	I definitely think this is a mastery-oriented motivation item!!	To me, this survey question seems to be getting at more of a social component than an academic motivation type of construct. What is the thought here: that performance-oriented teachers are nicer to the smarter kids? Maybe there is a correlation there (?). I taught math very procedurally for two years and more conceptually for two more years. But, I don't think I favored the smarter kids in any way. In fact, I think I spent more time with and aimed my lessons at the middle-to-lower group when I was teaching more procedurally.
9	Mastery academic	Mastery academic	Social motivation
10	mastery, academic	Mastery, academic	Motivation, social, seems to deal with student teacher relations.

Items 7-9

Respondent	*Item 7* *Your science teacher makes science interesting.*	*Item 8* *Your science teacher treats males and females differently.*	*Item 9* *Your science teacher makes science easy to understand.*
1	This question taps into a student's intrinsic motivation; specifically if his/her teacher works to make science interesting which leads me to believe that the teacher is more interested in the student's motivation as opposed to the content matter.	This is social motivation.	This one points to academic motivation and to mastery goals. The focus here is on understanding (not completion for the sake of completion)...this facilitates mastery and competence in science.
2	Academic Motivation. Can also lead to mastery.	Social Motivation	Mastery, feeds into their confidence.
3	This sounds like an academic motivation question, but sounds like it's tapping situational interest.	This does not sound like a mastery orientation. Perhaps perceptions of stereotype threat or something like that.	Not sure about this one. It's not clearly a mastery orientation question to me. I'm not sure what this might be tapping.
4	I'm not sure how this would fit with mastery. It certainly isn't specific to the academic realm.	I'm not sure how this would fit with mastery. It certainly isn't specific to the academic realm.	This could work (it's certainly academic), but on the other hand a teacher may make the material easy to understand because they give students the specific answers or ask easy questions. I could see some potential concerns with this item.
5	Yes, mastery. Academic Seems pretty self-explanatory to me	Yes, motivation. Mastery, maybe. Both I'd probably not include. Although really similar to #6, this approaches gender more. I understand a teacher providing mastery motivation will treat students of different	Yes, mastery. Academic. Definitely include.

		genders the same, but I think this will add variance to the scale whereas #6 will already pick up on this difference.	
6	I don't think this measures mastery - seems to get more about gender stereotypes.	I don't think this measures mastery - seems to get more about gender stereotypes.	This seems more about the effectiveness of the instruction rather than mastery per se.
7	This may have to do with performance motivation or social motivation issues - hard to tell because it is vague. I would not use it for this study.	This may have to do with performance motivation or social motivation issues - hard to tell because it is vague. I would not use it for this study.	It taps into (possibly) academic motivation and maybe mastery issues.
8	Okay, so I think this can be a motivation item. But, I don't necessarily think treating males and females similarly is related to mastery-oriented teaching. For example, I had a math teacher in high school that was very procedural, but treated girls and boys similarly, which probably motivated me, a girl. But did it motivate the boys? I'm not sure. I also had a math teacher that was more mastery-oriented, but who was very biased in favor of the boys - definitely a motivation suppressant for me, a girl.	I think this can be a motivation item. But, I don't necessarily think treating males and females similarly is related to mastery-oriented teaching. For example, I had a math teacher in high school that was very procedural, but treated girls and boys similarly, which probably motivated me, a girl. But did it motivate the boys? I'm not sure. I also had a math teacher that was more mastery-oriented, but who was very biased in favor of the boys - definitely a motivation suppressant for me, a girl.	Sometimes I find that teaching procedures can actually be easier (for students and teachers) than teaching for conceptual understanding. However, from the student's point of view, I think it will matter in how well they define "understand" when they read this item. For example, you probably don't conceptually understand when learning rote procedures, but will the kids think of "to understand" in that way? Not sure. Something you could do (for your own sense of trusting your data) is to give these items to some teenagers and ask them to tell you what they are thinking when they answer the item. This will tell you if they

			consider "to understand" as understanding conceptually or not.
9	Social motivation	Social motivation	I don’t know.
10	Motivation, social, seems to deal with student teacher relations.	Motivation, social, seems to deal with student teacher relations	Mastery, academic.

APPENDIX B: RESULTS OF THE ITEM ALIGNMENT QUESTIONNAIRE: TEACHER PERCEPTIONS OF MASTERY-FOCUSTED INSTRUCTION

"Think about the full duration of this [fall 2009 science] course. How much emphasis are you placing on each of the following objectives?"

Items 1-3

Respondent	*Item 1* *Increasing students' interest in science*	*Item 2* *Teaching students basic science concepts*	*Item 3* *Teaching students important terms and facts of science*
1	I think this maps more on intrinsic motivation.	Does map onto mastery motivation...but lower level thinking skills...could lead to memorization and more performance oriented motivation.	Does map on mastery motivation...but lower level thinking skills...could lead to memorization and more performance oriented motivation.
2	Literature on interest and mastery....I can be interested but not have mastery…so I will go with the middle option.	Very well	Very well
3	This sounds like a situational interest question to me. This does not necessarily sound like mastery instruction.	This does not sound like a very good mastery instruction question. I would think most teachers would agree with this regardless of a mastery orientation orientation. It seems to tap course objectives more than a mastery orientation or not.	This does not sound like a very good mastery instruction question. It seems to tap course objectives. The other end of this might be learning concepts rather than learning facts, but not necessarily a mastery orientation.
4	Yes, I think this works.	Yes.	This could also be a focus of performance-oriented classrooms. If you think about high stakes testing, some teachers are focused on teaching their students facts and figures rather than the deeper meaning of a topic. I wouldn't call this an example of mastery orientation.

5	Yes, include	Yes, include	Yes, include. It doesn't say: get students to repeat them back to me. Maybe weight less than item 13, if that is possible.
6	Again - this could focus on the task component - but it seems more like supporting interest/value. If it were a mastery item, it should say "increasing students' understanding in science".	Hard to tell - basic science concepts may not really place an emphasis on learning - but more memorizing, which I would not characterize as mastery.	Hard to tell - basic science concepts may not really place an emphasis on learning - but more memorizing, which I would not characterize as mastery.
7	I think that interest is important to mastery goals, so I would include this.	Basic concepts and facts are important as well - so I would include this.	Basic concepts and facts are important as well - so I would include this.
8	I think this item could map onto the construct.	In my opinion, I think both procedural and mastery-oriented teachers think they do this. I think procedural teachers think providing a lecture on concepts is emphasizing "teaching basic science concepts". And I think a mastery-oriented teacher thinks that providing a hands-on activity can help students understand basic science concepts. Truly, what teacher wouldn't endorse an emphasis on teaching basic concepts? Sadly, I think this is a really bad item.	I can't even tell if this item is supposed to support mastery-orientation or not!! What teacher doesn't teach important terms and facts of science? There may be different ways of teaching these things (mastery vs. procedural), but who doesn't teach these things? The item doesn't say "memorizing facts of science" so I can only hope mastery-oriented teachers would strongly endorse this item because the whole point of mastery teaching is to help students conceptually understand factual science. Right? And any teacher would be remiss to not use appropriate terminology in their classrooms! I would recommend checking the distribution of this item. You don't want to use an

			item with a very restricted response range.
9	Mastery academic	I don't know.	I don't know.
10	Yes mastery	Performance	Performance

Items 4-6

Respondent	*Item 4* *Teaching students science process or inquiry skills.*	*Item 5* *Preparing students for further study in science.*	*Item 6* *Teaching students to evaluate arguments based on scientific evidence.*
1	Maps well on mastery motivation	Maps well on mastery motivation	Maps well on mastery motivation
2	Very well	Very well	Well (seems higher level)
3	This seems more about course objectives, rather than a focus on mastering material and improvement that I think of with a mastery orientation.	This seems a bit more mastery oriented as it seems to imply learning material for future use.	This seems more about course objectives, rather than a focus on mastering material and improvement that I think of with a mastery orientation.
4	This is teaching students science at a deeper level of processing, so seems more aligned with a mastery oriented environment.	This also seems mastery oriented.	Yes.
5	Yes, include	Yes, include	Yes, include
6	I think this gets more at mastery than the prior two items, but it also seems rather dependent on the curriculum.	Maybe? It's not a great item though.	Seems similar to item 13 - I think this is getting at more basic ideas about what aspects of science are being emphasized more than mastery.
7	I think that interest is important to mastery goals, so I would include this.	I think that interest is important to mastery goals, so I would include this.	I think that interest is important to mastery goals, so I would include this.
8	Great item!	Again, I don't know why procedural teaching	Great item!

		would preclude this. If you are a teacher and think you are teaching your students what they need to know, then aren't you trying to prepare them for futher study in science? Likewise for mastery-oriented teachers.	
9	Mastery academic	Mastery academic	Mastery academic
10	Mastery	Mastery	Mastery

Items 7-9

Respondent	*Item 7* *Teaching students how to communicate ideas in science effectively.*	*Item 8* *Teaching students about the applications of science in business and industry.*	*Item 9* *Teaching students about the relationship between science, technology, and society.*
1	Maps well on mastery motivation	Maps well on mastery motivation...speaks to relevance of what they are learning.	Maps well on mastery motivation
2	Well.	Well.	Very Well
3	This seems more about course objectives, rather than a focus on mastering material and improvement that I think of with a mastery orientation.	This seems more about course objectives, rather than a focus on mastering material and improvement that I think of with a mastery orientation.	This seems more about course objectives, rather than a focus on mastering material and improvement that I think of with a mastery orientation.
4	This is also important.	Making connections to the real world, so this is good (though this is probably more directly addressed in the interest development literature).	Again, making deeper connections. This is good.

5	Yes, include	Yes, include. Maybe weaker because it is providing students with non-mastery motivation for why, but I feel like a teacher who is promoting mastery motivation would do this as well.	Yes, include
6	Yes, sounds like mastery.	Seems more like a situational interest item.	More situational interest than mastery.
7	I think that interest is important to mastery goals, so I would include this.	This may or may not have to do with mastery goals - application might increase interest....	This may or may not have to do with mastery goals - application might increase interest....
8	Great item!	I think this could be a good item.	I think this could be a good item.
9	Mastery academic	Mastery academic	Mastery academic
10	Mastery	Mastery	Mastery

Items 10-11

Respondent	*Item 10* *Teaching students about the history and nature of science*	*Item 11* *Preparing students for standardized tests*
1	Maps on mastery motivation but not as well as previous items in my opinion.	Does not map well on mastery motivation.
2	Well	Boooo!!!! Not mastery, rote memory so poor.
3	This seems more about course objectives, rather than a focus on mastering material and improvement that I think of with a mastery orientation.	This seems more about course objectives, however does seem a bit more related to a performance orientation. So it may be a good reversed scored example of a mastery orientation.
4	This could work.	This does not seem in line with a mastery orientation.

5	Yes, include	Yes, include, but reverse score.
6	Sounds like mastery.	No, not mastery.
7	This may or may not have to do with mastery goals - history and context might increase interest.	This is a performance goal, not a mastery goal
8	I think this could be a good item.	Okay item. I don't necessarily think mastery teaching precludes "preparing students for standardized tests". In fact, I like to think the entirety of mastery teaching for conceptual understanding will aid students on any tests, including standardized tests.
9	Mastery academic	I don't know about this one.
10	Mastery	Performance

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