The Impact of Teacher Perception of Professional Learning Communities on Student Algebraic Achievement

Tyrone John
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THE IMPACT OF TEacher PerCEption OF Professional LEarning COMMunities ON Student ALGEBRAIC ACHIEVEMENT

by

Tyrone Ahson John

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

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

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THE CITY UNIVERSITY OF NEW YORK
Abstract
The Impact of Teacher Perception of Professional Learning Communities
on Student Algebraic Achievement

By

Tyrone Ahson John

Advisor: Professor Juan Battle

In this study, I investigate the impact of teachers’ perceptions of professional learning communities on student algebraic achievement. Furthermore, I also investigate whether these relationships manifest differently for males compared to females. Research indicates that teacher quality and professionalism are considered the most critical factors affecting academic achievement. In this dissertation, I interrogate this issue by employing multivariate analyses using data retrieved from the High School Longitudinal Study of 2009 (HSLS:09) and 2012 follow-up. HSLS:09 used a nationally representative sample of over 21,000 ninth-grade students, which incorporated teacher, parent, school administrator, and school counselor input to create a context for student achievement in algebra.

Vygotsky’s social constructivist theory and Eccles expectancy value theory serve as theoretical lenses through which to explore the impact of student and teacher characteristics as well as teacher perception of professional learning communities, as defined by HSLS:09, on students’ math educational outcomes. This study makes conceptual and methodological contributions to the field of teacher effectiveness by examining the effect perception of professional learning communities that involves teaching for mathematical proficiency has on student math achievement; by offering insight into the impact teacher perception of professional learning communities has on the algebraic scores of female and male students while controlling for student demographic and sociocultural factors and teacher sociocultural factors; and by
making recommendations for schools, districts, and policy entities focused on strategies for improving teacher quality.

This study has found that teachers’ perceptions of professional learning communities has a small impact on student algebraic achievement when all student characteristics are controlled for, however, perception is not significant in presence of other teacher sociocultural variables. The effect also manifests itself differently for male and female students.
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Chapter One: Introduction

In this age of high accountability and high-stakes testing, extensive stress has been placed on classroom teachers. School administrators under pressure from shrinking budgets and government demands for accountability need compelling data showing that school initiatives have a positive impact on student learning (Lange, Magee, & Montgomery, 2003). Under the reauthorized Elementary and Secondary Act, called the Every Student Succeeds Act (ESSA), all students are held academically accountable for their preparedness for college and careers (Every Student Succeeds Act, 2015). Under the Obama administration, the Race to the Top legislation called for more intensive and more structured teacher observations as well as higher student achievement mandates. As a result states, districts, and schools have been insistent on focusing on educator learning and development with current reform efforts (Caroll, 2009; Commissioner’s Task Force on Quality Teaching and Learning, 2005; Forum on Educational Accountability, 2010; Obama, 2010) as a way of enhancing student performance. This line of thinking is currently a part of most state education agendas. The National Research Council (NCR; 2011) suggested that “teacher quality is considered the most critical factor affecting academic achievement” yet goes on to say that although “there is no consensus on what defines teacher quality . . . the most common measures are content knowledge, experience, pedagogical skills, and academic skills and knowledge” (p. 79).

Teachers’ preservice training, prior academics, and professional experiences, in addition to their continuing professional development once they begin teaching, can affect teacher quality and the instructional climate of a school. Within most professional development initiatives teacher collaboration is an essential component. In this dissertation, I focus on the impact of teacher perception of professional learning communities on student algebraic achievement. The
collection of information from this research study provides implications for policymakers, schools districts, and administrators that wish to institute professional learning communities (PLCs) or better understand the effect teacher collaboration has on student achievement.

Within the context of this study, the student is the unit of analysis. Specific math-teacher characteristics and practices were included to link them to the student-learning contexts and educational outcomes. Teacher perception of professional learning communities is constructed as a composite variable established by the National Center for Educational Statistics (NCES) High School Longitudinal Survey of 2009 (HSLS:09) Study. Per the NCES (2015), teacher perception of PLCs is a product of teachers’ perceptions of critical discourse (discussion of workshops, student work, unsuccessful lessons, etc.), collaborative activities (exploration of approaches to teaching, sharing of research regarding specific groups of students), and supportive PLC leadership (support for new teachers, support provided by the math chair). Teacher perception of professional learning communities as well as the other pertinent variables used within this study are included and explained in detail in the Chapter 3: section on Methods.

This first chapter presents the specifics of the problem, rationale, and contribution of the study, along with a brief overview of relevant literature and the methodology used.

Statement of the Problem

With a plethora of education reforms implemented every academic year, school districts and administrators struggle with a myriad of choices centered on how to improve teacher quality within their schools. Creating PLCs is one option many elect to implement in order to change their school cultures. PLCs provide a good structure for schools to improve student achievement and are grounded in the idea that professional development for teachers should result in the greatest success for all students (DuFour, DuFour, & Eaker, 2008). PLCs are steadily becoming
the most popular school reform measures to increase student achievement (Hickman, Schrimpf, & Wedlock, 2009). Although there is no universal definition of a PLC, most descriptions include a group of people sharing and reflecting, promoting growth, and enhancing their effectiveness as professionals (Stoll et al., 2006). In a PLC, teachers share a vision, work and learn collaboratively, visit and review other classrooms, and participate in decision making (Hord et al., 2008). Hord (1997) also noted, “As an organizational arrangement, the professional learning community is seen as a powerful staff development approach and a potent strategy for school change and improvement.”

A PLC is distinguished and led by three core elements: a team of educators focused on learning, professional collaboration, and systemic reflection on accountable results (Dufour, 2004). In this dissertation, I focus on the impact of the teacher collaboration aspect of a PLC on student algebraic achievement. Dufour (2011) defined teacher collaboration as “a systematic process in which teachers work together interdependently to analyze and impact professional practice [and] improve results for [their] students, [their] teams, and [their] schools” (p. 10). Schmoker (2007b) proposed that collaboration enables teachers to deepen their understanding of teaching. “In collaborative working environments, teachers have the potential to create the collective capacity for initiating and sustaining ongoing improvement in their professional practice so each student they serve can receive the highest quality of education possible” (Pugach & Johnson, 2002, p. 6).

Assuming “that teachers can learn when given the opportunity to work together” (Brownell, Adams, Sindelar, & Waldron, 2006, p. 170), for most professional development initiatives to work, teacher collaboration is a vital component in promoting teacher learning (Brownell et al., 2006; Rogers & Babinski, 2002). Currently, there is a body of research that
suggests PLCs positively affect student learning (Dufour, Eaker, & DuFour, 2005; Fullan, 2001; Hannaford, 2010; Hord & Sommers, 2008; Ireland, 2010; Lujan & Day, 2010; Neuzil, 2010; Wood, 2007). However, there is a lack of math domain specific research focused on professional collaboration within a PLC and even less regarding teachers beliefs about collaboration within a PLC affecting student learning. As Fullan (2007) stated, “the question confronting most schools is not, ‘What do we need to know in order to improve?’” But rather, “How do we turn what we know already into action?” (p. 59). Thus, understanding the structures that comprise teacher collaboration helps make true action possible.

In addition, PLCs are founded on the premise that teachers benefit from critical discourse, which focuses on the examination of classroom instruction against current practices (Wood, 2007). Wood claimed that PLCs encourage the use of collaboration to construct practical solutions for problems in the classroom. A few studies have investigated the influence of teacher discourse patterns within teacher collaboration groups and have drawn links between them to instructional change and/or student achievement (Horn & Little, 2010; Wright et al., 1997). For this reason, investigating teacher perception of professional learning communities based on the critical discourse patterns that are used is an area in need of study.

Lastly, since PLCs are generally considered a form of organizational culture, teachers’ participation in that organizational arrangement has a unique affect of the instructional climate of a school. Else-Quest et al. (2010) and Ross et al. (2012) argued that more research needs to be conducted at the adolescent level to explore the effect of contextual and school environment factors that might cause differential effects in student achievement according to gender. In trying to understand current gender gaps, research still suggests that the teacher matters (Lender, Forgasz, & Jackson, 2014).
In this study, I investigate the impact of teacher perception of professional learning communities on student algebra achievement. This inquiry is based on the idea that teacher perception of professional learning communities has distinctive effects on the learning environment of a school, which can improve teacher quality and student achievement. Thus, if we better understand the impact teacher perception of professional learning communities has in fostering or hindering students’ academic outcomes, then we will be one step closer to improving the profession of teaching and helping students to reach their academic potential.

**Rationale**

Currently, one of the primary goals of our system of education is to produce students who are mathematically proficient and able to compete as part of the world economy. When compared to the mathematics scores of students in other countries, U.S. students’ mathematics scores fall from virtual equivalence in the early grades to being significantly behind by high school graduation. Moreover, the level of performance in the United States has failed to improve in international comparisons (PISA, 2012). The results of the latest administration of the National Assessment of Educational Progress—often referred to as the nation’s report card—indicated that since 1990, student math scale scores have increased by a statistically significant 27 points among fourth-graders (from 213 to 240) but has not varied much since 2007 and actually declined from 2013 to 2015 (from 242 to 240). Eighth-grader scores have shown a similar trend. The scores have risen 20 points (from 263 to 282), however, these scores have not varied much since 2007 and have also declined since 2013 (from 285 to 282). Moreover, only 40% of fourth-graders, 33% of eight-graders, and 25% of twelfth-graders are considered to be at or above proficient level in 2015 (National Center for Education Statistics [NCES], 2015).
Overall, indicators demonstrate that large proportions of U.S. students are not mathematically proficient (Darling-Hammond, 2010).

The poor mathematical outcomes of U.S. students continue into their adult lives. Currently, graduation rates are at an all-time high at 82%, an 8% increase from 1990 (NCES, 2016). Yet, the number of students who require remedial mathematics courses is staggering and increasing. For example, within the United States, colleges have reported that about 60% of new freshmen are unprepared for the rigor and content of college-level course work (Grubb et al., 2011), and this is most often due to mathematics courses (Attewell, Lavin, Domina, & Levey, 2006). Many community colleges have reported even higher statistics. For example, at the City University of New York (CUNY) in fall 2014, 76% of new community college freshmen were assessed as needing remedial mathematics (CUNY, 2015). Of those, 56% who were assigned to and enrolled in college-level statistics passed, whereas only 39% of those assigned to and enrolled in elementary algebra passed. In the United States, algebraic reasoning is an important focal point in mathematics education, and algebra is a content strand in grades K–12 in both the National Council of Teachers of Mathematics standards (NCTM, 2006) and the Common Core State Standards for Mathematics (National Governors Association, 2010). CUNY studies are even starting to show that those who elect to take college-level algebra unsuccessfully decrease their likelihood of graduating from college. In general, the completion of math remediation remains one of the greatest academic barriers to increasing college graduation rates. Ultimately, the aforementioned outcomes indicate that the U.S. educational system is not fulfilling its responsibility to prepare today’s mathematics students for the future despite that the United States has invested millions of dollars, more than most other industrial counties, in research and design efforts in math education.
Attaining a solid mathematics foundation in high school is seen as being a gateway to future science, technology, engineering, or mathematics (STEM) course taking and careers. A much smaller proportion of U.S. university and community college students choose STEM fields than do their peers in other developed countries. For example, in 2008 only 4% of bachelor’s degrees were earned in engineering, compared with 31% in other counties, such as China (National Science Board, 2012; OECD, 2012). STEM occupations are estimated to grow by 17% between 2009 and 2018, compared with 9.8% for non-STEM occupations, of which, the majority (92%) will require some postsecondary education (Carnevale et al., 2011; Langdon et al., 2011). The importance of high school preparation for future STEM career pursuit has been deemed pivotal. Studies have shown that advanced high school mathematics (i.e., algebra II, calculus) and science (i.e., physics, chemistry) courses are critical predictors of STEM major enrollment in college (Adelman, 2006; Maltese et al., 2011). High school preparation for STEM has also been linked to the high degree of attrition from STEM majors. For example, only 62% of students who enrolled in 4-year colleges as STEM majors between 2003 and 2009 graduated with a bachelor’s degree from a STEM domain. Researchers have noted insufficient STEM preparation in high school as having a role in the lack of persistence toward STEM careers (Carnevale et al., 2011; Maltese et al., 2011). Hence, the lack of high school preparation not only affects students’ future entry into STEM majors, but also their persistence towards those majors and entry into those careers.

Investigating the gender gaps in college course taking and STEM degree elections is hardly a new topic. Turner and Bowen (1999), Daymont and Andrisani (1984), Arcidiacono (2004), and Zafar (2013) have studied this issue, and the existence of large gender gaps, particularly in science, engineering, and humanities, is not controversial. However, Dickson
(2010) has shown that the gender gaps in major choice are still much larger than the racial gaps. High school STEM preparation affects student entry into STEM majors and persistence towards those majors, therefore, being mindful of the gender gaps and the future of STEM careers is important because currently women make up the majority of the student population in colleges and universities in the United States today (Hill, Corbett, & Rose, 2010). Moreover, community colleges have larger numbers of females enroll with the intention of pursuing advanced education in a variety of academic programs. From 1947 to 1960, the undergraduate male per undergraduate female ratio changed from 2.3 to 1.55, and currently the ratio has reversed to females outnumbering males by a ratio of 1.3 to 1.9 (Goldin, Katz, & Kuziemko, 2006).

Research has shown that men and women are graduating from high school with equal preparation and ability for science and math careers (Bharadwaj et al., 2012; Buchmann & DiPrete, 2006; Else-Quest et al., 2010). Additionally, at many postsecondary institutions women are being prepared equally, or even better, than their male counterparts (Hill, Corbett, & Rose, 2010), yet females are not equally represented in the STEM field or in the STEM workforce. Authors of recent studies are starting to show that the high school years are more important than college or elementary school years in determining the size of the gender gap in STEM degrees or studies (Else-Quest et al., 2010; Legewie & DiPrete, 2012). Researchers have shown that there is no easy way to investigate this complex topic.

Even if their preparation and ability are equivalent, their self-assessed ability and self-confidence towards STEM courses and careers are different. Bharadwaj, de Giorgi, Hansen, and Neilson (2012) provided evidence that (in developing countries) girls are more likely than boys to state that math is difficult and that girls report lower self-assessed ability than boys. Their finding suggested that this might be a result of girls internalizing societal expectations and
discrimination, resulting in lower self-confidence even when their ability is adequate. Speer (2017) also asserts that precollege academic factors account for a large portion of the gap as well. For example, precollege academic factors accounted for gaps in science (67%), engineering (45%), mathematics (26%), and in the humanities (50%). Precollege factors are the culmination of forces that shape one’s academic career (parental, schools, teachers, peers, environmental influences, and innate perception of ability) up until the time the test score is measured.

In considering population subgroups, one could consider investigating race/ethnicity versus gender. Savas (2016) states, “overall, school resistance and educational expectations are gendered and they matter in high school achievement. They matter because gender differences in school resistance and educational expectations are consistent whereas race/ethnic differences are not.” For example, studies have found negative school behavior and attitudes are most noticeable among males than females and this pattern is consistent across race/ethnicity. For this reason, in addition to ones listed above, this study investigates how the impact of teacher perceptions of PLCs may manifest differently for male and female students.

Additionally, research in psychology has shown STEM preparation and career pursuit is also linked to motivational problems not just for female students but also for all students. According to Hwang, Reyes, and Eccles (2016), expectancy value theory posits that individuals make achievement-related choices, such as how hard they will study for an assessment or course selection based on their expectations for success and their subjective task value (the importance of a task). Stinebrickner and Stinebrickner (2013a, 2013b), using longitudinal data from students at Berea College, found that students enter college over optimistic about their own abilities in math and science and about their chances of completing a degree in those fields. This is not a surprise because graduation rates are at an all time high (82%) due to the efforts of No Child Left
Behind (NCLB; Martin, Sargrad, & Batel, 2016) yet only 25% of twelfth-graders are considered to be mathematically proficient or better (NCES, 2015). Speer (2017) suggests that the best method of increasing the number of STEM majors and persistence in STEM pursuit is to undertake policies that improve precollege preparation in those subjects.

In part, under ESSA, schools, teachers, and students are held accountable for the academic preparedness of students for college and careers (ESSA, 2015). The ESSA also has a focus on increasing STEM preparation and preparedness. Under the Obama administration, the Race to the Top legislation, which added to the NCLB, called for more intensive structured teacher observations and evaluation, higher student achievement mandates, and competition among states on Common Core Standards attainment. As a result states, districts, and schools have been insistent on focusing on educator learning and development (Forum on Educational Accountability, 2010; Obama, 2010) as a way of enhancing student performance. The NCR (2011) has suggested, “Teacher quality is considered the most critical factor affecting academic achievement.”

As a means to an end, with a plethora of educational reforms that can be employed, many school districts and administrators implement some form of PLC in order to meet most of their needs (i.e., improving teacher quality, supporting data-driven instruction, and teacher preparation to meet standard based reforms). A PLC includes a group of people working collaboratively to share and reflect on practice, promoting growth, and enhancing their effectiveness as professionals (Stoll et al., 2006), thus, working together to change a school’s culture and the instructional environment. One of the core components of a PLC is professional collaboration, as it is with most professional development initiatives. Teacher collaboration battles isolation and perpetuation of the status quo with communication, the sharing of best practices, and alignment
of goals and visions for student learning for the teachers’ respective communities (Blankstein, 2004; Elmore, 2000; Little, 1987). It is also a structured system that supports the development of a culture of trust and interdependence through professional dialogue, which improves teacher efficacy (Supovitz, 2002). Within school environments where high levels of teacher collaboration are common place, there are also increased decision-making opportunities and shared leadership opportunities as well as open communication among staff members, creating a supportive environment in which teachers are unafraid to take risks and experiment with innovative curriculum and instructional strategies that transform student learning (Rosenholtz, 1985).

Gruenert (2005) investigated the correlation between collaborative culture and student achievement and found that more collaborative cultures had higher student achievement in mathematics and language arts as measured by the Indiana Statewide Testing for Educational Progress assessment. Gruenert emphasized that teacher collaboration seemed to provide the best setting for student achievement. Goddard, Goddard, and Tschannen-Moran (2007) also investigated the relationship between collaborative environments and achievement and found that student achievement in schools with teacher collaboration was higher than in schools without teacher collaboration. According to Rivkin, Hanushek, and Kain (2005), student performance differs more between classrooms than within classrooms, indicating that the quality of teaching matters in preparing students for the future. Thus, a better understanding of the nature of teacher collaboration has the ability to improve collective teacher quality and decrease the variation in student learning between classrooms.

In summary, as an educational system the United States is far from meeting the goal of achieving mathematical proficiency for all students. Although graduation rates are at an all-time
high, the mathematic aptitude of U.S. fourth-, eighth-, and twelfth-graders is still staggeringly low. In addition, because mathematics at the high school level is a gateway to future STEM course taking, persistence, and STEM fields and careers, American schools need to do more. Due to the efforts of NCLB and Race to the Top, districts and schools are being held more accountable for developing their educators and school leaders to better prepare students for future college and careers. Both NCLB and Race to the Top focus on teachers as a critical factor that has a significant impact on the instructional environment of a school, student achievement, and the educators’ development. Ball (2012) asserted that great teachers are not born, they are taught. My objective for the present study is to broaden the expanding body of knowledge pertaining to teachers’ perceptions of professional learning communities as barriers to or conduits for student algebraic achievement.

**Contribution to the Field**

This dissertation will contribute to the field of math education research in four distinct ways:

1. By making conceptual and methodological contributions to the field of math teacher effectiveness by examining professional learning communities that involves teaching for mathematical proficiency as measured by the HSLS:09 follow-up algebraic reasoning assessment.

2. Keeping in mind that PLCs are founded on the premise that teachers benefit from critical discourse (Wood, 2007), in this study I construct perception of professional learning communities as a product of teachers’ perceptions of the critical discourse patterns, actions, and activities that support math student learning and collaborative leadership support. In order to develop a firm understanding of how PLCs impacts student
achievement, it is important to incorporate aspects that an effect the quality of the collaborative experience (Chadbourne, 2004) and the discourse patterns teachers’ use within the collaborative experience (Horn & Little, 2010). Most studies lack the incorporation of both aspects of a collaborative experience in analyzing the impact it has on instruction change and student outcomes.

3. Perceptions of PLCs have an extreme impact on the instructional climate of a school. This study also offers insight into the impact teacher perception of PLCs has on the algebraic scores of female and male students while controlling for student demographic and sociocultural factors as well as teacher sociocultural factors. Speer (2017) asserts that precollege academic factors account for a large portion of the gender gap, precollege factors being the culmination of forces that shape one’s academic career (parents, schools, teachers, peers, environmental influences, and innate ability) up until the time the test score is measured.

4. Lastly, this research project makes recommendations for professional developments, teacher collaboration organization, teacher preparation programs, and education policies focused on improving teacher quality.

Overall this study gives insight into how teachers can be nurtured to be more effective. This study adds insight, suggestions, and information about how educators can work together to achieve the highest level of student academic performance, in turn, increasing the long-term projection for student success in STEM fields. When teachers are provided the opportunity to effectively work together, they can find solutions to instructional dilemmas and also work on ways to improve their teaching skills (Picard, 2005). Current research posits that teaching will
become more effective when educators recognize that true, effective, and efficient collaboration is a vital component in creating a positive learning environment (Souza, 2003).

The next section provides an overview of the background of this study. The background for this study is grounded within two fundamental theories and relevant literature regarding student math achievement, teacher collaboration, and how one understands the results of perception studies.

**Background**

In this study, I utilize two theoretical frameworks to ground my methodology and the interpretation of the results: social constructivism and expectancy value theory. Employing a single theoretical framework is insufficient to examine the complexities of teacher perception of PLCs on student algebraic achievement and variations in male and female academic outcomes. Vygotsky’s social constructivist theory highlights the critical importance of social interaction in the cognitive development (Chen, 2010) of children and adults. Participants’ interactions, past beliefs, cultural histories, experiences, perceptions, and worldviews are all part of the process of learning. All of these factors influence how teachers interact with one another and with their students, as well as effect how teachers and students make sense of the world. Expectancy value theory, viewed in conjunction with social constructivist approaches, suggests that gender-related behavior develops and occurs through social interactions (Deaux & Major, 1987). This section will explicate each theory and its relationship to this dissertation and its working hypotheses.

**Social Constructivism**

Vygotsky’s (1978) social constructivism theory plays a key role in understanding the process of teacher perception and cognition as well as student learning. When teachers participate in collaboration, communication, experimentation, and inquiry with their colleagues, social
constructivism suggests they are constructing meaning without de-emphasizing the importance of what each individual teacher is bringing to the shared interaction. Teachers who share problems, visions, and practices with their peers are more likely to invest more meaning in the process and thereby value such shared practices and invest greater energy in continuous improvement (Lieberman & Mace, 2010). Constructivism, particularly in its “social” forms, suggests that a learner is much more actively involved in a joint enterprise with a teacher in creating (constructing) new meanings (Chen, 2010). Gordon (2008) also pointed out that teachers bring their past beliefs, cultural histories, experiences, perceptions, and worldviews into the process of learning. All of these factors influence how teachers interact with one another and their students, as well as how they construct meaning within a cooperative structure. Within social constructivism, the role of discourse and negotiation in meaning making also becomes central to learning.

As teachers’ work and share experiences within their environment, they generate their own “rules” and “mental models,” which they use to make sense of their world. As teachers interact, they are also continually acquiring new informal rules, altering their assumptions, and creating new norms. Students are also extremely keen at perceiving conscious and unconscious changes in a teacher behavior through student–teacher interactions (Cvencek, Kapur, & Meltzoff, 2015). Social constructivist theory also considers the critical importance of the sociocultural aspects of cognitive development (Chen, 2010), blending aspects of the social environment with cognitive development. This theory posits that social interaction, past and present, leads to ongoing changes in a child’s thoughts and behavior.
Expectancy Value Theory

Expectancy value theory proposes that expectations of success at a given task and the degree to which the task is valued are determinants of achievement-related performance and choices (Eccles, 1994, 2009). Eccles and her colleagues (Eccles, 1994, 2009; Eccles & Wigfield, 2002; Eccles et al., 1983) elaborated multiple components of subjective task values and linked motivational beliefs to other psychological, social, and cultural factors leading to differential performance. Expectancy value theory posits expectations and values are assumed to directly influence performance, persistence, and task choices. Expectations and values are also assumed to be influenced by domain-specific and task-specific beliefs such as perceptions of competence, the difficulty of the tasks, and individuals’ goals and self-schemas. These social cognitive variables, in turn, are influenced by individual perceptions of other peoples’ attitudes and expectations for them, by their affective memories, and by their own interpretations of previous achievement outcomes.

Research has portrayed the gender dynamic in classrooms as an important source of the gender difference in educational outcomes (American Association of University Women [AAUW], 1992; Sommers, 2000). Studies also suggest that teachers are strong socializing agents within the learning environment and play pivotal roles in shaping boys’ and girls’ achievements. In actuality, that math gender gaps vary substantially depending on the context of a class indicates the key role that the environment and socialization play in the formation of these gaps (Else-Quest, Hyde, & Linn, 2010). Jones and Dindia (2004) suggested that teachers might subtly communicate different academic expectations of boys and girls. Indirectly, this bias becomes a self-fulfilling prophecy when students respond to them. The bias permeates the social context regardless of the belief systems of those directly involved. Researchers have mentioned that at
the high school level, explicit or implicit assumptions about gender beliefs and stereotypes within a sociocultural environment are widely shared (Legewie & DiPrete, 2014).

In general, especially in the social sciences, there is a conflict between the use of quantitative and qualitative methodologies. Within the confines of social constructivism and expectancy value theory, the same holds true. Weaver (1948) stated that quantitative analysis can be used to provide empirical evidence to make sense of the complexities of social reality. Quantitative analysis can be used to organize *disorganized complex systems*. In organized complex systems, the relationships among a large number of variables, and the organic whole they create, determine complexity (Baxter, 2014). Given these systems’ qualitative complexities, advanced quantitative methods are best suited for their exploration.

Byrne (2013) posited that in quantitative analysis, social reality is a form of disorganized complexity. The goal of such analysis is to explain aggregate behavior in terms of probability theory and the macroscopic laws of averages. In such analysis, variables are treated as rigorously real measures of social reality. Models are used to identify, measure, describe, and control for how certain independent variables impact one or more dependent variables in question. Byrne (2013) stated that if done right, these models can lead to reasonable linear explanations for why things happen the way they do, which, in turn, leads to relatively straightforward policy recommendations for what to do about the observed state of affairs.

In this study, I quantitatively investigate the impact that teacher perception of PLCs has on student math achievement outcomes. Figure 1 shows a general overview of how this study is situated within the two theoretical frameworks. Social constructivism is the overarching framework employed, followed by expectancy value theory. Social constructivist theory assists in understanding how collaborative interactions or the perception of them impact student
learning. Expectancy value theory looks a combination of sociocultural and psychological factors, which affect student achievement. I also argue that a teacher’s subtle beliefs can be perpetuated and become a self-fulfilling feature of student achievement creating possible differential effects in achievement. This makes a teacher and his or her perception of PLCs and expectations an important socializer within his or her students’ social world. For this reason, I also investigate the impact teacher perception of PLCs has on male and female student performance.

![Theoretical Framework Diagram]

*Figure 1. Overview of theoretical framework.*

The next section provides an overview of relevant literature that ground this study.
**Literature Review**

In this age of constant reform and new educational policies, research has shown that teachers are having challenges acclimating to curricula reforms even when well-designed implementation processes are in place. Fullan (2009) posited that reform efforts underestimate the complexities of the change process. Currently, with the implementation and widespread adoption of the Common Core State Standards for Mathematics (CCSSM) there has been a greater need than ever to develop educators to meet the new standards. The CCSSM offers more rigorous, focused, and coherent mathematics curricula, instruction, and assessments that promote conceptual understanding and reasoning as well as skill fluency (National Council of Teachers of Mathematics [NCTM], 2013). As part of the current reform efforts, the NCTM (2013) emphasized that critical factors to bring the tenets of CCSSM to fruition are the “substantial opportunities for ongoing professional development to ensure that all teachers understand and are prepared to implement the CCSSM. . . .” Stakeholders in the current effort in mathematics education reform (NCTM, 2009) see a need to change the culture of the mathematics classroom from one in which a teacher is the center of the classroom to one in which teachers and students interact as a community of learners in mathematical inquiry and discovery. Currently, there are many challenges in training teachers to embrace true student-centered teaching methodologies.

Teacher collaboration has the potential to support growth in mathematics instruction by energizing teams of teachers within schools to activate and guide teacher improvement, thereby sustaining the learning (Dallmer 2004). For this reason, researchers currently studying teacher collaboration seeks to broaden the fields knowledge of collaborative inquiry and show how teaching practice can be enhanced through collaborative efforts. Researchers have investigated efforts that move beyond mere collegial teamwork, and in this age of educational reform and
assessment they ask how teacher collaboration is linked to student achievement. This dissertation fits within this paradigm.

Teacher collaboration is defined in a variety of ways. Howland and Picciotto (2003) defined teacher collaboration as a process and opportunity for two or more teachers to regularly work with colleagues to engage in conversations regarding teaching and their own personal growth as teachers. Collaboration is a systematic process whereby educators work together to analyze and influence professional practice for the improvement of individual and collective student results (Dufour, 2003). Montiel-Overall (2005) also defined collaboration as the process of shared creation in which two or more individuals with complementary skills interact to create a shared understanding that none had previously possessed or could have formulated on their own. In essence, collaboration is a commitment to share resources, power, and talent (Ervin, 2011).

Researchers have overwhelming shown that the quality of a teacher matters in educating todays youths and that the quality of a teacher can have lasting impacts to student learning (Sanders & Rivers, 1996; Slater, Davies, & Burgess, 2012). Sanders and Rivers (1996) found that teacher effects on students were additive (adding from year to year but independent of the teacher effect from previous years) and cumulative across a student’s entire years of schooling. Slater and colleagues (2012) also found that having a high quality teacher had a significant effect on student test scores. When considering student performance, the quality of a teacher emerged as a significant factor.

Research suggests that the relationship between student achievement and teacher collaboration “is likely indirect” (Goddard et al., 2007; Loucks-Horsley & Matsumoto, 1999), meaning teacher collaboration may benefit teacher practice and improve teacher quality in many
ways, which in turn affect student achievement. For example, teacher collaboration affects teacher beliefs, content knowledge, and pedagogical knowledge, and also has been shown to cause changes in their instructional practices. Although these are important variables to examine indirectly, more research is needed to examine the direct relationship between teacher collaboration and student achievement.

In the last two decades, interest in investigating direct links between particular aspects of collaboration and student achievement has been growing among educational researchers. Whereas the focus previously had been on behavior in the classroom, at present the focus is more on contextual factors that affect teacher quality (Darling-Hammond, 2000; Ferguson, 1991; Goldhaber & Brewer, 2000; Laczko-Kerr & Berliner, 2002). Over that time, “growing research evidence suggests that teacher quality is not fixed and depends a great deal upon a school’s working environment and climate and the quality of colleagues” (Ronfeldt as quoted in Hart, 2015). Thus, the quality of a teacher can change over time and teacher perception of PLCs can give insight into the working environment, climate, culture, and quality of the collaborative interactions within the school. Ronfeldt (Hart, 2015) also adds that teacher collaboration has an impact on student learning, but differentiating between components of collaboration is at times difficult. For this reason, he suggests that it is better to use a range of components to measure the effects of teacher collaboration on student achievement.

Egodawatte, McDougall, and Stoiles cu (2011) investigated the types of collaboration teachers’ use in working together towards mathematics education reform. In a number of studies, especially in secondary schools, the most efficacious communities have been found to be located at the department level for each academic subject (McLaughlin & Talbert, 2001; Siskin & Little, 1995). Within departments, teachers interact to enact pedagogical norms of learning, grouping,
and school culture assessment, which in turn shape their work and student classroom experiences (Gutierrez, 1996). Egodawatte et al. (2011) linked improvements in teacher quality to discourse patterns used within groups, but they did not link student achievement to specific patterns that they used (discussion of English language learners, discussions of workshops and conferences, discussions of student work, etc.). Due to the qualitative nature of their study, improvements were not necessarily reflected in test scores. Egodawatte et al. (2011) found that teacher collaboration is an integral part of creating a positive work environment focused on student achievement. In this dissertation, I explore the links between multiple discourse patterns used within collaborative groups and their links to student achievement.

Horn and Little (2010) stated, “efforts to introduce or increase professional community at the school level or among within-school groups (grade level, subject) would therefore benefit from understanding what makes conversation in naturally occurring workplace groups generative for learning” (p. 13). Horn and Little (2010) found that although groups could be given a set of discourse cues with which to discuss problems of practice, groups used them differently. Thus the generative potential of their collaborative talk differed. One limitation of their work was that their analysis could not be interpreted in light of the background and sociocultural nature on which teachers draw. For this reason, in this dissertation I will add to their research by employing a large data set to analyze conversational routines within collaboration groups in the presence of sociocultural factors that affect student and teacher positions and their relative impact on secondary student algebraic achievement.

Based on the above ideas, I do not seek to make general claims about all teacher collaborative groups but rather to contribute to the existing literature on the contextual conditions conducive to instructional improvement. The principal aim of this study is to advance
understanding of the ways in which teacher perception of collaborative teacher interactions directly impacts student achievement.

**Methodology**

Utilizing data retrieved from the national survey, HSLS:09, and secondary assessment scores collected from the cohort of students in 2012 as a dataset, I investigate the impact of a teacher’s perception of professional learning communities on students’ algebraic achievement and whether the relationship manifests itself differently with male and female students.

**Procedure**

In this quantitative study, I conduct a secondary analysis of the public-use data file retrieved from the base year of the HSLS:09 (NCES, 2009). The HSLS:09 is a nationally representative longitudinal study of more than 21,000 ninth-graders in 944 schools across 10 states. The survey follows the students throughout their secondary and postsecondary years. Base-year data were collected in 2009 and focused on uncovering when, why, and how students make decisions, particularly with regard to choosing STEM courses, majors, and careers.

The data were collected using a variety of methods, including a survey and math assessment components. The survey component directly asked students for demographic information about school experience (attitudes about school and mathematics, science, college, and career plans) and educational and occupational expectations. The math assessment component gauged students’ algebraic skills by focusing on six algebraic content domains (language of algebra, proportional relationships, linear functions, nonlinear functions, systems of equations, and sequence and recursive relationships) and four algebraic reasoning processes (algebraic skills, using representations, algebraic reasoning, and algebraic problem solving).
Authors of the HSLS:09 also surveyed parents, teachers, school counselors, and school administrators to provide contextual information about the students. HSLS:09 authors investigated specific teacher characteristics and practices to be linked to the learning contexts and educational outcomes of the students in the study. The teacher component of the study involved collecting background information on specific teachers regarding demographics: educational and professional backgrounds; class, departmental, and school climates; and teachers’ perceptions of barriers to effective teaching.

The first follow-up of the HSLS:09 study was administered to students, parents, school counselors, and school administrators in the spring of the students’ 11th-grade year, 2012. Similar to the base survey, the follow-up consisted of a survey designed to elaborate, expand on, and capture evolving attitudes and plans, as well as a math assessment component. Both are currently available for review.

In this dissertation, I focus on the entire student sample and the corresponding math teacher population that participated in the study. Although the HSLS:09 contains several opportunities for important research relevant to students, parents, teachers, school counselors, and administrators, in this study I employ student- and teacher-level data from the 2009 base year survey, the 2012 junior year follow-up survey, and algebraic achievement data from 2012.

The dependent variable, students’ achievement, is operationalized in terms of theta ability scores on the algebraic assessment administered to the population of students during the 2012 HSLS:09 follow-up. For this study, the theta ability score provides a summary measure of achievement for an individual student that is useful for correlational analysis. This dissertation compares all models according to their effects on the students’ theta ability scores.
The unit of analysis in the HSLS:09 was designed to be the student. Ninth-grade students took a mathematics assessment and survey online. The design of the mathematics teacher survey does not provide a standalone analysis sample of teachers, but instead it permits specific teacher characteristics and aspects of a school environment to be related directly to the learning context and educational outcomes of the sampled students. The study involved several stages of analysis. The goal of the initial stage was to develop a deeper understanding of the constructs that make up the study. Descriptive statistics and correlation matrices were used to accomplish this goal. Next, the strength, direction, and significance of the associations among variables of interest were derived from their correlations. Subsequently, an OLS regression analysis was employed to determine the impact of teachers’ perception of PLCs, student demographics, and student and teacher sociocultural variables had on the dependent variable, student algebraic achievement. Four hierarchical models are used in the regression to explore relative impacts.

Model I, the baseline model, examines the impact of teacher perception of professional learning communities, a composite variable, which constructs collaboration as a product of teachers’ perceptions of the critical discourse patterns, actions, and activities that support math student learning, and collaboration leadership support within a PLC has on predicting students’ algebraic achievement is also examined by model I. In addition, this model determined the statistical significance (p value) and coefficient of determination (R²) for teachers’ perceptions of collaboration on the dependent variable, students’ algebraic achievement. To address the research question, control variables are introduced into the subsequent models.

Model II examines the effect teacher collaboration has on students’ algebraic achievement while controlling for student demographic variables. These variables included students’ sex, race/ethnicity, socio-economic status, whether the student attended public school,
and urbanicity. Model III, building on models I and II, further controls for student-level variables by incorporating sociocultural predictors. These sociocultural variables include whether a student took algebra prior to high school, a student’s prior achievement in a previous math course, math-class effort, math identity, math utility, math self-efficacy, math interest, a student’s sense of school belonging, and a student’s school engagement. Prior achievement has been shown to be the single largest predictor of student achievement, and when not controlled for studies are not considered valid or reliable (Goe, 2007). Some researchers posit that the inclusion of prior achievement in teacher-effectiveness models adequately accounts for other potentially confounding student characteristics and allows students to serve as their control (Ballou, Sanders, & Wright, 2004).

Finally, model IV was built on the previous models by controlling for teacher-level sociocultural variables. This model was used to determine the relative impact of teacher collaboration on students’ algebraic achievement when controlling for all other variables. Teacher sociocultural variables included teacher gender, race/ethnicity, degree level, years teaching high school math, whether a teacher held a prior math job, teacher self-efficacy, teacher certificate level, and a teacher’s perception of average class-achievement level.

To determine the overall effect across gender, using models I through IV I examined the effect the four variable domains had on students’ algebraic achievement for the entire sample. Regressions were split to show the relative impact for male students only (models V through VIII) and for female students only (models IX through XII). In summary, the dependent variable—student algebra achievement—is compared using multivariate regression models. The dependent variable is predicted over four domains of variables for all students and independently for males and females, resulting in a total of 12 multivariate regressions.
Dissertation Outline

This dissertation consists of six chapters. Chapter two outlines the literature that exists on teacher collaboration and student achievement within the domain of mathematics. Chapter two also describes the existing research on the student demographic, the student sociocultural variable, and teacher sociocultural (demographic and affective) variables. The use of the two theories in this study (social constructivism and expectancy value) will be explained and linked to the dependent variable of student algebraic achievement. Chapter three then outlines the methodology involved in this dissertation in detail, including a discussion of the HSLS:09 survey instrument, the dependent and independent variables, and the design of the four regression models. Chapter four will present the statistical findings generated by the described methodology. Following, chapter five provides an in-depth discussion of the relevant findings presented in chapter four and will relate them to the literature and theories discussed earlier in chapter two. Finally, chapter six discusses the ways in which the results of this study may inform educators and policymakers on ways to support educator learning and student achievement as well as the limitations of the study and ideas for future research.
Chapter Two: Literature Review

This study investigates the impact of teachers’ perceptions of collaboration on students’ algebraic achievement and furthermore whether these relationships manifest differently for males compared to females. Research indicates that teacher quality and professionalism are considered the most critical factors affecting academic achievement. In Chapter One: Background, a brief overview of the current situation with educators using professional learning communities and professional collaboration as a vehicle to impact student achievement was developed. This present chapter will expand on many of the ideas presented in the first chapter and further develop the theoretical frameworks employed. In addition, relevant literature related to school-, teacher-, and student-level variables, which affect math student achievement, are discussed.

Theoretical Framework

Two theoretical frameworks are used to ground the methodology and the interpretation of the results: social constructivism and expectancy value theory (EVT). Employing a single theoretical framework is insufficient to examine the complexities of teacher perception of professional learning communities on student algebraic achievement and variations in male and female academic outcomes. Vygotsky’s social constructivist theory highlights the critical importance of social interaction in children and adults’ cognitive development (Chen, 2010). Participants’ interactions, past beliefs, cultural histories, experiences, perceptions, and worldviews are all part of the process of learning. All of these factors influence how teachers interact with each other and their students and affect how teachers and students make sense of the world. Viewed in conjunction with social constructivist approaches, EVT suggests that gender-related behavior develops and occurs through social interactions (Deaux & Major, 1987).
This section will explicate each theory, its relationship to this dissertation, and its working hypotheses.

**Social Constructivism**

Social constructivist theory plays a key role in understanding the process of teacher collaboration and cognition and student learning. It helps one understand the need for collaboration and relationship between the participants (Bunker, 2008; Lave & Wenger, 1991; McMahon, 1997) and urges communities of practice to realize that by working together, common goals can be achieved. Each teacher is an amalgamation of his or her previously constructed knowledge. Social constructivism suggests that while working cooperatively, each teacher constructs new meaning without deemphasizing the importance of what each individual teacher brings to the shared interaction. Professional learning communities (PLCs) encourage the use of professional collaboration as a core tenet to have educators share previously constructed knowledge and construct new knowledge (Bertsch, 2012).

For the knowledge shared to be earnest, it must match the social consensus and be functional. This knowledge is only viable if it works (Teague, 2000). Social constructivist theory also considers the critical importance of the sociocultural aspects of cognitive development (Chen, 2010). Teachers bring their past beliefs, cultural histories, experiences, perceptions, and worldviews into the process of learning (Gordon, 2008). All of these factors influence how teachers interact with one another and their students and how they construct meaning in a cooperative structure. Teachers who share problems, visions, and practices with their peers are more likely to invest more meaning in the process and, thereby, values such as shared practices and invest greater energy in continuous improvement (Lieberman & Mace, 2010).
In social constructivism, the role of discourse, action, and negotiation in meaning making are central to learning. Vygotsky (1978) believed that cognitive development depends on the zone of proximal development (ZPD). Participants must interact with some knowledge of prior social experience. Interaction generally occurs through language or action, which are both context specific. The use of language can be very flexible depending on the exact meaning and interpretation of the participants’ actions. The participants’ actions are then influenced by the course of the interaction and the prior knowledge exchanged in a transaction. In the transaction, participants negotiate meaning and knowledge. As a result of this transaction, both parties leave the interaction having gained some form of knowledge (Teague, 2000). Figure 2.5 shows the general process of learning using the social constructivist framework, which can be applied to both adult and student learning. Vygotsky’s theory explains consciousness as the end product of socialization (Kearsley, 2001).
Current educational reforms ask teachers to stretch their thinking and examine their teaching methods in a new light to push teaching and learning to a new level. A collaborative view of knowledge generation shares authority for learning, understanding, and distributing experience with all participants rather than one person leading the group or monopolizing the knowledge (Peterson, 1994). Thus, the role of discourse, action, and negotiation in meaning making not only becomes central to adult learning but to student learning as well within the school environment. As teachers develop participating in professional collaboration, students are also keen at perceiving conscious and unconscious changes in their behavior, language, and actions (Cvencek, Kapur, & Meltzoff, 2015). As a result, teacher and instructional variations within the learning environment can be measured as a product of student outcomes.
Expectancy Value Theory

EVT proposes that the expectation of success for a given task and the degree to which this task is valued are determinants of achievement-related performance and choices (Eccles, 2015). Eccles and her colleagues (Eccles, 1994, 2009; Eccles & Wigfield, 2002; Eccles et al., 1983) elaborated multiple components of subjective task values and linked motivational beliefs to other psychological, social, and cultural factors leading to differential performances. Consequently, expectations and values, in a reciprocal relationship, are assumed to directly influence performance, persistence, and task choices. Figure 2.6 shows the general structure and connection between the students’ social world, motivational beliefs, and achievement behavior, which in turn affects their cognitive understanding of the world.

Figure 2.6. A social cognitive expectation-value model of achievement motivation. Material modified from Eccles et al. (2002).

Eccles (2014) comments that in creating this framework, she wanted to demonstrate that a balance can exist between psychological and sociocultural perspectives on human development.
in which the ideas of personal agency in picking one’s own path and socialization are integrated. The sociocultural aspect of the framework helps us understand how task-specific beliefs such as perception of competence, perception of the difficulty of the task, goals, and self-schema are developed. In turn, these variables are influenced by individuals’ perceptions of other peoples’ attitudes and expectations for them, their affective memories, and their own interpretations of their previous achievement outcomes. These perceptions and interpretations of their past outcomes are then assumed to be influenced by socializers’ behaviors (e.g., actions and beliefs of parents, teacher, peers), cultural milieu (e.g., race, ethnicity, nationality, gender), and past experiences (e.g., maturation experience, prior academic achievement, prior life experience).

The boundaries between these social-world components are porous. Eccles (2015) noted that parents are extremely strong socializers that influence children culturally and experientially. In childrearing, parents share several child- and domain-specific habits of mind, such as the importance of sports, reading, math, independence, and dependence. Research has shown that parental beliefs are also predictors of long-term success (Eccles, 2015). Often, children’s beliefs in their own achievement-related ability declines from age 5 through 17; however, the rate of this decline is buffered positively by the confidence parents have in their ability (Fredricks et al., 2005).

Parents’ beliefs and behaviors are also associated with their socioeconomic status (SES); families with higher SES are likely to produce more positive outcomes for children (Eccles, 2009). However, the majority of the literature on family SES has focused on the direct, positive effects of SES on children’s academic achievement, perceived competence, task beliefs (Eccles, 2007), and children’s expectations of how far they will go in school (Halle, Kurtz-Costes, & Mahoney, 1997). More recent research has started to investigate the mediation effects of
motivational beliefs, suggesting that the relationships of SES to academic achievement and educational aspirations are partially mediated by motivation variables (Grolnick, Friendly, & Bellas, 2009).

In addition to parents, teachers and peers are also strong socializers that are part of a child’s social world. EVT asserts that teachers’ expectations for students can be confirmed in reality (Babad, 2009; Jussim, Robustelli, & Cain, 2009; McKown, Gregory, & Weinstein, 2010; Weinstein, 2002). Changes in student academic performance are hypothesized to occur from differential interactions with teachers that provide different opportunities to learn (direct effects) and from social cues that communicate differential ability (indirect effects). These direct and indirect effects also act as mediators that influence students’ self-expectations, motivation, and learning (Babad, 2009; Jussim et al., 2009).

Research has examined the effects of teacher expectations and have shown striking differences in the magnitude of effects between teachers (McKown & Weinstein, 2008; Rubie-Davies, 2006). For example, McKown and Weinstein (2008), in their investigation of classroom differences, found that after controlling for prior achievement, teacher expectations explained more of the year-end achievement gap between stereotyped and non-stereotyped groups in high-bias rather than low-bias classrooms. Here, bias in classrooms was measured by children’s perceptions of the degree of differential treatment. Similarly, Rubie-Davies (2006) documented large effect-size differences in expectancy outcomes between teachers who had high versus low expectations for all of their students. These studies suggest that a contextual analysis of teacher expectancy processes is critical to advancing understanding of the classroom conditions under which such effects are most likely to occur.
Gender also influences achievement-related behaviors through its association with motivational beliefs. In other words, gender differences in achievement-related behaviors are mediated by gender differences in motivational beliefs (Eccles, Barber, & Jozefowicz, 1999; Nagy, Trautwein, Baumert, Kölle, & Garrett, 2006; Nagy et al. 2008; Simpkins, Davis-Kean, & Eccles, 2006). Multiple studies have reported more positive math self-concept, attitudes, and affect for males (Eccles & Wigfield, 2002; Marsh et al., 2013). However, in recent decades, growing evidence in cross-national meta-analyses (Else-Quest, Hyde, & Lynn, 2010) shows gender similarities in math achievement but substantial differences in math efficacy and self-evaluation of ability (Bharadwaj et al., 2012). Furthermore, females’ educational aspirations have dramatically increased, and particularly in secondary school, females tend to report higher educational aspirations than their male counterparts (Schoon & Polek, 2011) but not necessarily toward a STEM career due to perception of math or science ability.

As stated earlier, EVT is a framework that combines psychological and sociocultural perspectives on human development in which the ideas of personal agency in picking one’s own path and socialization are integrated. One’s expectancy and motivation are a product of their social world, past experience, perception, and socializers. The other aspect of EVT used to determine achievement behavior is domain-specific task-value perceptions. Eccles et al. (2002) outlined four components of task-value/perception: attainment value, intrinsic value, utility, and cost.

Attainment value is defined as the personal importance of doing well on a task. Drawing on the self-schema and identity theories, attainment value is linked to the relevance of engaging in a task for confirming or disconfirming salient aspects of one’s self-schema. Because tasks provide the opportunity to demonstrate aspects of one’s actual or ideal self-schema, such as
masculinity, femininity, or competence in various domains, tasks will have higher attainment value to the extent they allow an individual to confirm salient aspects of their self-schema.

Intrinsic value is the enjoyment an individual obtains from performing an activity or subjective interest he or she has in a subject. This component of value is similar to the construct of intrinsic motivation. Utility value is determined by how well a task relates to current and future goals, such as career and future academic goals. A task can have positive value because it facilitates important future goals, even if the individual is uninterested in the task for its own sake. For instance, students often take classes they do not particularly enjoy but that they need to take to pursue other interests, please their parents, or be with their friends. Finally, Eccles identified cost as a critical component of value (Eccles, 2002). Cost is conceptualized in terms of the negative aspects of engaging in a task, such as performance anxiety or fear of failure or success, the amount of effort needed to succeed, and the lost opportunities that result from making one choice rather than another. This current study focuses on all four aspects as they relate to academic outcomes.

Although the mediating role of motivation factors has been widely addressed in the literature, current research still seeks to deepen the understanding of contextual factors that create these changes in the gender gap and teachers’ role in that process. This study uses a series of control variables and teacher collaboration as an aspect of the social environment or a contextual factor that mediates the teacher role in affecting the educational outcomes of a student or differentiated student sample. This project hopes to further EVT and add to the math-education literature on these points.

Social constructivist theory and EVT both affirm that teacher beliefs or perceptions should have an interactional effect on student achievement. However, they both posit that
learning and achievement are not developed in isolation of a child’s social world. To determine
the extent to which teachers’ perception of PLCs impacts students’ algebraic achievement,
control variables are added to each model that are known to impact student math achievement
and that fall within the social constructivist and EVT paradigm.

The next section will review literature pertinent to understanding teacher collaboration,
teacher perception/ beliefs, and predictors of math student achievement as applicable to this
study.

Quantitative Methodologies

In general, especially in the social sciences, there is a conflict between the use of
quantitative and qualitative methodologies. Within the confines of social constructivism and
expectancy value theory, the same holds true. Weaver (1948) stated that quantitative analysis can
be used to provide empirical evidence to make sense of the complexities of social reality.
Quantitative analysis can be used to organize disorganized complex systems. In organized
complex systems, the relationships among a large number of variables, and the organic whole
they create, determine complexity (Baxter, 2014). Given these systems’ qualitative complexities,
advanced quantitative methods are best suited for their exploration.

Byrne (2013) posited that in quantitative analysis, social reality is a form of disorganized
complexity. The goal of such analysis is to explain aggregate behavior in terms of probability
theory and the macroscopic laws of averages. In such analysis, variables are treated as rigorously
real measures of social reality. Models are used to identify, measure, describe, and control for
how certain independent variables impact one or more dependent variables in question. Byrne
(2013) stated that if done right, these models can lead to reasonable linear explanations for why
things happen the way they do, which, in turn, leads to relatively straightforward policy recommendations for what to do about the observed state of affairs.

Theories are tools researchers employ to assist in understanding ways of viewing social reality. Quantitative analysis, in most cases, should begin with theory and is used to test theory. Theory assists with the development of concepts that create the overarching theme of a study and should support the selection of the indicators to measure. Baxter (2014) suggested that testing theories quantitatively can improve them but not to prove them. In the case of this dissertation, social constructivism and expectancy value theory are theoretical frameworks employed to assist in understanding how students and teachers share knowledge and learn. Indicators were selected for their influence on student achievement in mathematics as they fit within the frameworks of social constructivism and expectancy value theory. All variables have been operationalized and their influences tested. The goal of this study was to use these frameworks to determine and describe the impact of teachers’ perceptions of PLCs on students’ algebraic achievement. The relationship between the independent and dependent variables is developed more in the methodology section.

**Literature Review**

The remainder of this chapter will describe in detail the major scholarship used to inform the design of this dissertation and will draw connections between current math education research on professional collaboration and the contextual teacher- and student-level factors that influence student achievement. Teacher collaboration within a professional learning community is developed first and is the main focus of this dissertation. The following literature is reviewed related to student demographic and sociocultural variables and teacher attributes that affect students’ math achievement outcomes. Later, these variables are controlled for in each model
studied to determine the impact of teachers’ perception of PLCs on student algebraic achievement.

**Teacher Collaboration**

In this age of constant reform and new educational policies, research has shown that teachers struggle with acclimating to curricula reforms even when well-designed implementation processes are in place. Fullan (2009) posited that reform efforts underestimate the complexities of the change process. Currently, with the implementation and widespread adoption of the Common Core State Standards for Mathematics (CCSSM) there has been a greater need than ever to develop educators to meet the new standards. The CCSSM offers more rigorous, focused, and coherent mathematics curricula, instruction, and assessments that promote conceptual understanding and reasoning and skill fluency (National Council of Teachers of Mathematics [NCTM], 2013). As part of the current reform efforts, the NCTM (2013) emphasized that critical factors to bring the tenets of CCSSM to fruition are the “substantial opportunities for ongoing professional development to ensure that all teachers understand and are prepared to implement the CCSSM. . . .” Stakeholders in the current effort in mathematics-education reform (NCTM, 2009) see a need to change the culture of the mathematics classroom from one in which the teacher is the center of the classroom to one in which teachers and students interact as a community of learners in mathematical inquiry and discovery. Currently, many challenges exist in training teachers to embrace true student-centered teaching methodologies.

Mathematics reforms are expected to improve instructional quality. According to Schoenfeld (2002), four conditions are necessary for providing high-quality mathematics instruction for all students: (a) a high-quality curriculum; (b) a stable, knowledgeable, and professional teaching community; (c) a high-quality assessment aligned with curricular goals;
and (d) stability and mechanisms for the evolution of curriculums, assessment, and professional
development. To achieve these conditions, this research project posits that teachers should be
given opportunities to work together toward common goals. Schoenfeld (2002) mentioned that
when teachers are treated like professionals and are given the opportunity to develop their skills
and understanding over time, the results can improve students’ mathematical performance
significantly.

Teacher collaboration has the potential to support growth in mathematics instruction by
energizing teams of teachers in schools to activate and guide teacher improvement, thereby
sustaining learning (Dallmer, 2004). For this reason, current research into teacher collaboration
seeks to broaden its knowledge of collaborative inquiry to show how teaching practice can be
enhanced through collaborative efforts rather than mere collegial teamwork and how, in this age
of educational reform and assessment, teacher collaboration is linked to student achievement.
This dissertation fits within this paradigm.

Teacher collaboration is defined in a variety of ways. Howland and Picciotto (2003)
defined teacher collaboration as a process and opportunity for two or more teachers to regularly
work with colleagues to engage in conversations regarding teaching and their own personal
growth as teachers. Collaboration is a systematic process in which educators work together to
analyze and influence professional practice for the improvement of individual and collective
student results (Dufour, 2003). Montiel-Overall (2005) also defined collaboration as the process
of shared creation in which two or more individuals with complementary skills interact to create
a shared understanding that no one previously possessed or could have formulated on their own.
In essence, collaboration is a commitment to share resources, power, and talent (Ervin, 2011).

Researchers have overwhelmingly shown that the quality of a teacher matters in
educating today’s youth and that the quality of a teacher can have a lasting impact on student learning (Sanders & Rivers, 1996; Slater, Davies, & Burgess, 2012). Sanders and Rivers (1996) found that teacher effects on students were additive (adding from year to year but independent of teacher effects from previous years) and cumulative (develops from the beginning to the end of one school year). Slater and colleagues (2012) also found that having a high-quality teacher had a significant effect on students’ test scores. When considering student performance, the quality of the teacher emerged as a significant factor. These two studies described teacher effects as follows: a good teacher could have a greater impact on student learning than a poor teacher, and a series of poor teachers could set a student on a trajectory that would be challenging for future educational experiences to remedy. When considering student performance, the quality of the teacher emerged as a significant factor. However, these studies did not identify particular teacher characteristics, activities, or discourse patterns as being responsible for this teacher-quality effect.

Research suggests that the relationship between student achievement and teacher collaboration “is likely indirect” (Goddard et al., 2007; Loucks-Horsley & Matsumoto, 1999), meaning teacher collaboration may benefit teacher practice and improve teacher quality in many ways, which in turn affects student achievement. For example, teacher collaboration affects teacher beliefs, content knowledge, and pedagogical knowledge and has also been shown to cause changes in their instructional practices. Although these are important variables to examine indirectly, more research is needed to examine the direct relationship between teacher collaboration and student achievement.

In the last two decades, interest in investigating direct links between particular aspects of collaboration and student achievement has been growing among educational researchers.
Whereas the focus was previously on behavior in the classroom, at present, the focus is more on contextual factors that affect teacher quality (Darling-Hammond, 2000; Ferguson, 1991; Goldhaber & Brewer, 2000; Laczko-Kerr & Berliner, 2002). Over time, “growing research evidence suggests that teacher quality is not fixed and depends a great deal upon a school’s working environment and climate and the quality of colleagues” (Ronfeldt, as quoted in Hart, 2015). Thus, the quality of a teacher can change over time, and teachers’ perception of PLCs can give insight into the working environment, climate, culture, and quality of the collaborative interactions within the school. Ronfeldt (Hart, 2015) added that teacher collaboration has an impact on student learning, but differentiating between components of collaboration is difficult at times. For this reason, he suggested it is better to use a range of components to measure the effects of teacher collaboration on student achievement.

Several leading studies have disaggregated collaboration into its essential elements. Little (1982, 1990) identified four types of collegial relationships found in schools: storytelling and scanning for ideas, aid and assistance, sharing, and joint work, which is the optimal collaborative relationship for which schools should strive. Joint-work collaboration includes experiences such as researching or designing curricula materials and ideas, reviewing and discussing plans, persuading others to try an idea, inviting others to observe one’s teaching, analyzing and discussing practices and effects, and teaching others formally or informally (Little, 1990). Fullan and Hargreaves (1998) noted that joint-work collaboration “implies and creates stronger interdependence, shared responsibility, collective commitment and improvement, and greater readiness to participate in the difficult business of review and critique” (p. 47) of one’s own and other instructional practices.
Egodawatte, McDougall, and Stoilesescu (2011) investigated the types of collaboration teachers use when working together towards mathematics-education reform. In numerous studies, especially in secondary schools, the most efficacious communities were found at the departmental level for each academic subject (McLaughlin & Talbert, 2001; Siskin & Little, 1995). In departments, teachers interact to enact pedagogical norms of learning, grouping, and school culture assessment, which in turn shape their work and students’ classroom experiences (Gutierrez, 1996). Egodawatte et al. (2011) linked improvements in teacher quality to discourse patterns used within groups, but they did not link student achievement to specific patterns that they used (e.g., discussions of English language learners, workshops or conferences, or student work). They concluded that through these interactions, participants develop new skills, attitudes, and beliefs and, through these mediators, affect student learning. This is in accordance with Schmoker (2005) who stated, “Teachers learn best from other teachers, in settings where they literally teach each other the art of teaching” (p. 141). Due to the qualitative nature of their study, improvements were not necessarily reflected in test scores. Ultimately, Egodawatte et al. (2011) found that teacher collaboration is an integral part of creating a positive work environment focused on student achievement.

Horn and Little (2010) stated, “Efforts to introduce or increase professional community at the school level or among within-school groups (grade level, subject) would therefore benefit from understanding what makes conversation in naturally occurring workplace groups generative for learning” (p. 13). Horn and Little (2010) found that although groups could be given a set of discourse cues with which to discuss problems of practice, groups used them differently. Thus, the generative potential of their collaborative talk differed. One limitation of their work was that their analysis could not be interpreted in light of the background and sociocultural nature on
which teachers draw. In this dissertation, I will add to the research by quantitatively analyzing teachers’ perceptions of collaboration. The teacher-perception variable is constructed using a combination of factors, including teacher perception of the discourse pattern used within their professional collaboration groups, leadership support, pertinent activities aid at teacher in order to develop student math proficiency.

Other results of teacher collaboration include improved collective efficacy (Ervin, 2011; Pounder, 1999; Shachar & Shmuelevitz, 1997), improved attitudes towards teaching (Brownell, Yeger, Rennells, & Riley, 1997), and higher levels of trust in principals, colleagues, and clients (Tschannen-Moran, 2001). Furthermore, research has also connected teacher collaboration with improved student achievement (Goddard et al., 2007, 2015; Louis, Dretzke, & Wahlstrom, 2009). The next section explores professional collaboration with teacher efficacy, perceptions and beliefs, and student achievement.

**Teacher collaboration and collective efficacy**

Teacher efficacy can be defined as the extent to which the teacher believes he or she has the capacity to affect student performance (Berman, McLaughlin, Bass, Pauly, & Zellman, 1977) or the teachers’ belief or conviction that they can influence how well students learn, even those who may be difficult or unmotivated (Guskey & Passaro, 1994). Many scholars link professional collaboration to feelings of equally shared responsibility for positive outcomes (Brookhart & Loadman, 1990), alignment of expectations for students, increased feelings of effectiveness (Little, 1987), and an increased sense of efficacy (Ashton & Webb, 1986; Louis, 1992; Ross, Cousins, & Gadalla, 1996), both individual and collective. Collective efficacy is a concept that amalgamates these benefits, as it expresses shared perceptions of a group’s ability to achieve collective goals. Perceived collective efficacy is both associated with teacher collaboration.
(Ashton & Webb, 1986) and student achievement (Goddard, 2002; Goddard, Hoy, & Woolfolk-Hoy, 2000, 2007, 2015). Thus, collective efficacy may be a mechanism that can explain how teacher collaboration affects student achievement.

In her article discussing the relationship between teacher collaboration and student achievement, Ervin (2011) linked teacher improvements to the border social context in which individuals operate. Ervin suggested it is better to analyze teacher collaboration groups based on collective or group-based efficacy beliefs. She found that in schools with a strong commitment to teacher collaboration, the study of individual self-efficacy beliefs offers a limited frame of analysis. How a group perceives the school organization’s effectiveness may offer better insight into evaluating goal achievement at the institutional level (Ervin, 2011).

Shachar and Shmuelevitz (1997) argued that collaboration between teachers in the school context functions to strengthen teacher beliefs about the efficacy of school-based instruction. They indicated that teachers believe that staff and facility collaboration strengthens the general effectiveness of the instructional climate of the school. The context of the specific school environment affects individual teachers’ beliefs about self-efficacy, and teachers’ beliefs about individual efficacy is either enhanced or limited by teachers’ beliefs about the collective efficacy of the school organization (Goddard & Goddard, 2001), making the relationship between the individual and the collective reciprocal. By viewing collective efficacy and professional collaboration through this lens, an increasing amount of evidence has implied that a positive relationship exists between teacher collaboration and student achievement (McClure, 2008).

Goddard et al. (2007) surveyed 452 teachers at 47 elementary schools, controlling for student characteristics and school social context. Their research demonstrated that teacher collaboration was a significant positive predictor of differences among schools in student
achievement. They further explored the extent that collective efficacy and instructional leadership had on teacher collaboration affecting student achievement (Goddard et al., 2015). Their finding indicated that the degree to which teachers’ collaboration impacts achievement depends on the strength of instructional leadership and collective efficacy in the school. Teacher collaboration was a strong predictor of collective efficacy, and, in turn, perceived collective efficacy was a strong predictor of differences among schools in student achievement. However, Goddard et al. (2001, 2007, 2015) used a narrow view of teachers’ collaboration and was not domain specific. Although they investigated the parameters separately for math and reading, when they used the parameters to predict achievement, they combined the math and reading assessment scores. Thus, the impact that teacher perception had specifically on mathematics was not determined.

**Perception of Collaboration and Achievement**

A growing body of evidence supports the link between teachers’ perception of collaboration and student achievement, but more research is needed to explore the extent to which teachers’ collective work affects student outcomes. Research acknowledges collaborative impacts on instructional practices, school climate, and teachers’ perceptions, but is still unclear whether collaboration among colleagues affects the way students learn (Naughton, 2006). Research linking teacher perception of collaboration to student achievement within the domain of mathematics is limited and has mixed results (Bunker, 2008; Muñoz, 2008; Zito, 2011; Naughton, 2006).

Bunker (2008) conducted a mixed-methods study investigating teacher perceptions about collaboration. The qualitative portion of her study focused on teacher perceptions of collaborative value and perception of skill level developed during collaborative meetings.
Collaborative value was determined based on teachers’ feelings about collaborative practices and processes and the results of the collaborative process as linked to changes to instructional practice. Skill level was determined by measuring teacher perception at the end of each meeting regarding six traits, the setting of student goals, data collection, consensus on teaching strategies, implementation of common teaching strategies, and quality of instructional practices. Bunker (2008) found that teacher skill in the collaborative process had a significant link with math student achievement among elementary school students. The more teachers collaborated, the more their content skills were enhanced, impacting the way the teachers taught and students learned. However, Bunker’s research also indicated that PLCs and teacher perception of collaborative value failed to show any significant measureable impact of teacher collaboration on math academic achievement. Whereas their research was conducted on the topic of teacher collaboration, they did not establish a definitive link between the collaborative practices and student achievement in math. Thus, how one measures teacher perception of collaboration is critical; furthermore, the value of collaboration indicated no effect, whereas skill accusation from collaboration indicated an impact.

In his mixed-methods study, Muñoz (2008) measured teacher self-efficacy in a selected PLC and found that PLC practices enhanced teacher efficacy and positively influenced student achievement. He focused on self-efficacy as developed in the collaborative portion of their PLC interactions. Munoz’s (2008) analysis of teachers’ qualitative responses overwhelmingly showed that teacher participation in PLCs impacted their collective efficacy, which he connected to improvements in math student achievement; however, quantitatively, the link was not evident, as he did not find a direct correlation between teacher collaboration and student achievement. He determined that teachers who collaborate will see an increase in the efficacy, resulting in a
positive impact on student achievement. It is possible that direct correlation was insignificant due to the small sample size of teachers (N = 7) and students (N = 240). However, Muñoz (2008) argued that collaboration and math student achievement are indirectly linked; hence, a direct link must exist.

Zito’s (2011) study expanded the work of Munoz (2008) by investigating the impact of collaboration on student achievement by teacher practices, such as utilizing student data and establishing common goals. Zito used teacher responses based on Likert-scale items from the Teacher Collaboration Survey to assess teacher perception of the quality of collaboration. Zito found no direct cor relational relationship between collaboration and student achievement in mathematics; however, he found a significant relationship between teacher collaboration, changes in instructional practices, and student math outcomes based on the correlational analysis. Zito (2011) found that because of collaboration, teachers established common goals for their students in specific content areas, and the sharing of knowledge and best practices became common.

Like Munoz (2008) and Bunker (2008), Zito (2011) found no direct link between teachers’ perceptions of collaboration and student achievement. The current study and Zito’s study differ in three significant ways. First, the construct of teachers’ perceptions of collaboration are measured and related to student achievement differently. The teacher was the unit of analysis, and the survey used also thoroughly focused on collaboration, questioning teachers’ perceptions of all three core aspects of a PLC: sharing of vision and norms, professional collaboration, and focus on student achievement. This study uses the student as the unit of analysis and investigates teachers’ perception of professional collaboration on students’ math achievement. Secondly, the teachers’ primary PLC was not domain specific. According to
his survey data, teachers could be part of any type of PLC. This study looks at professional collaboration in PLCs specifically within the domain of mathematics. Lastly, although mathematics was considered in his study, a close look at his results yielded the students’ achievement results for mathematics was too highly correlated with students’ results for science, reading, and writing, especially between science and reading. For this reason, he used a composite student-achievement outcome variable to correlate his results. This study uses a domain-specific outcome variable (student algebraic achievement) to measure the relative impact of teacher perception of collaboration.

Naughton (2006) found no link between teacher collaboration and middle school student math achievement. Naughton (2006) explored causal comparative and correlational links between teacher perception of collaboration and middle school student achievement in mathematics. His study only found a causal comparative relationship between teacher collaboration and student achievement in mathematics but no correlational link between the two variables. The relative significance of teacher collaboration as a predictor of student achievement was minimal; however, after integrating student socioeconomic status (SES) into their regressions, SES was extremely significant, and collaboration was not. In their study, absent of other factors, SES proved to be a very powerful indicator of student math achievement; this was supported by the literature (Ayers, 1993; Kohn, 1999; Rotberg, 1998, as stated in Naughton, 2006). As a result, for practical purposes, he deemed that teacher perception of collaboration was irrelevant in explaining variance in math achievement. This study uses current data in light of new federal support for increased professional development and collaboration. It focuses on high mathematics algebraic achievement and the impact of teachers’ perception of collaboration with math PLC at the high school level.
Currently, there is a lack of empirical evidence in the existing literature that quantitatively connects teacher perceptions of collaboration and student achievement (Goddard, et al., 2015; Piccardi, 2005), and empirical evidence is even scarcer in the domain of mathematics (Goddard et al., 2015; Naughton, 2006). This dissertation does not seek to make general claims about all teacher collaborative groups but rather to provide empirical evidence, contributing to current math-education literature on the impact of teachers’ perception of collaboration in math PLCs on student algebraic achievement. Teacher collaboration provides opportunities for teachers to develop professionally, improves teacher quality and instruction, and has the possibility to directly impact student learning and achievement.

Similar to Naughton (2006), it is important to consider the effect of collaboration separate of predicting factors but also in lieu of predicting factors. Numerous factors are considered in this study to determine the overall impact of collaboration on math achievement. The next section explores literature related to pertinent student demographic variables and achievement.

**Students’ Characteristics**

This research dissertation explores five demographic variables related to student achievement: gender, race and ethnicity, socioeconomic status, type of school, and school locale. Each of these variables has a unique effect on student achievement and gives insight into contextual factors affecting student learning. Moreover, controlling for these variables can give insight into whether teacher collaborative efforts promote or hinder student algebraic achievement.

Since the early 1980s there has been heated debate about the role that gender plays in predicting student math achievement and its impact on future STEM selection. Research at that time showed that females were underrepresented in STEM fields (Stoet & Geary, 2013). Another
study revealed that “the gender gap grows larger as the students get older” (Ross, Scott, & Bruce, 2012, p. 279). Currently, research lacks consensus on the gender gap and mathematics achievement but seeks to deepen the contextual understanding for why gender differences in mathematics and STEM related fields exist. Some researchers attribute lower female achievement in mathematics to innate and biological differences in ability, while others argue that socio-cultural factors are responsible (Halpern et al., 2007). Some argue that male students are more likely to be called on, receive positive reinforcement, benefit from the traditional instructional practices common in many mathematics classrooms, choose to take advanced mathematics courses, and perform better on assessments. Meanwhile, current research finds the gap no longer exists (Kane & Mertz, 2012 Welch, 2011) or at the very least has substantially narrowed (Else-Quest, Hyde, & Linn, 2010; Beekman & Ober, 2015). Where current research has found gaps, it has linked them to the persistence of sociocultural factors over gender and argues the need to explore sociocultural and contextual factors (Kane & Mertz, 2011; Welch, 2011).

For example, even if their preparation and ability are equivalent, their self-assessed ability and self-confidence towards STEM courses and careers are different. Bharadwaj, de Giorgi, Hansen, and Neilson (2012) provided evidence that (in developing countries) girls are more likely than boys to state that math is difficult and that girls report lower self-assessed ability than boys. Their finding suggested that this might be a result of girls internalizing societal expectations and discrimination, resulting in lower self-confidence even when their ability is adequate. Most research focuses on K-6 education, where most researchers argue that the gap no longer exists. Else-Quest et al. (2010) and Ross et al. (2012), argue that more research needs to be conducted at the adolescent level exploring the effect of contextual and school environment
factors on the gender gap. This dissertation disaggregates the data to inquire whether differences in math achievement can be related to teacher collaboration.

In trying to understand current gender gaps, research still suggests that the teacher matters. Leder, Forgasz, and Jackson (2014) in their exploratory study investigated the public’s view of two core elements common to gender differences: the social milieu and perceptions of the teacher. Many respondents, though not prompted, suggested that the teacher attitudes and behaviors were relevant factors related to educational outcomes in mathematics. Additionally, a small yet a statistically significant percentage (10%) of respondents stated that they felt that teachers have higher expectations of boys. The majority indicated that they were not sure how teachers felt about the comparative achievement of boys and girls in mathematics. Surprisingly, teachers who responded echoed the views of the general public. When prompted for a rationale behind the gender difference, respondents (general public and teachers) reiterated stereotypes that have persisted for the past 30 to 40 years. For example, girls were more likely to do homework, study harder, and were more interested in and displayed the will to persist. While boys were better at math, girls generally did not like math, and boys felt more pressured to succeed. They concluded that teachers had both a positive and negative impact on student achievements, attitudes towards mathematics, and future career directions. Hence, teacher beliefs may influence variations that exist in math achievement. Since it has been shown that teacher collaboration can effect teacher attitudes and beliefs about teaching and learning, what effect might teacher collaboration have on the gender gap in algebraic achievement?

To understand the role that gender plays there are other demographic variables that affect student algebraic scores. It is important to control for race/ethnicity because research has demonstrated that on average White students outperform their Hispanic and Black peers on
mathematics assessments. Results of the National Assessment for Educational Progress ([NAEP], 2015) indicate that on average White students score 18 and 32 points higher than their Hispanic peers in 4th and 8th grades, respectively. Between Whites and Hispanics, the gap is starting to marginally narrow as indicated by 4th grade scores since 1990, however, it is starting to grown by 8th grade. Moreover, findings show no significant change overall in the Hispanic-White score gap since 1990 (NAEP, 2015). Results of the 2007 NAEP point out that on average White students score 24 and 32 points higher than their Black peers in 4th and 8th grades, respectively. Findings show that although the Black-White achievement gap has narrowed significantly since 1978 (Vanneman, Hamilton, Anderson, & Rahman, 2009), no significant change has occurred since 2007 (NAEP, 2015).

Furthermore, some researchers control for socioeconomic status because several studies have demonstrated that students of high SES often have a better support system than their low SES schoolmates, are more likely to be in a position where they can take advantage of whatever school resources or practices are available, and may receive preferential treatment from stakeholders. Additionally, teacher use of different teaching process methods has been shown to matter differentially for the gains on tests of mathematics of students with high and low socioeconomic statuses (Goe, 2007).

Moreover, some researchers control for the type of school students attend. Public schools rely heavily on government funding that is based on standardized test performances. Therefore, teachers in public schools may feel even more pressure than their peers in private schools to teach to the test. As previously described this may have a negative impact on student performance (Le et al., 2006, 2009; Mayer, 1998). Additionally, studies have demonstrated that
the highest need public schools have the toughest time attracting and retaining effective teachers (Rothstein, 2010).

In an extensive meta-analysis of 90 studies Jeynes (2012) found that attending private religious schools is associated with the highest level of academic achievement, even when sophisticated controls are used to adjust for socioeconomic status. Students from public charter schools, however, performed no better than their counterparts in other public schools. Also, teachers from private religious schools are more demanding and expect higher levels of attainment from their students of equal status. In addition, it appears that the achievement gap is narrower at faith-based schools than it is at traditional public schools. An interaction may exist between these variables, in that the narrower achievement gap and higher overall achievement might partially be due to religious educators being more likely to believe that children, no matter what their color and background, can achieve and reach great potential (Jeynes, 1999, 2003; Sanders & Herting, 2000). In addition, private schools are not obligated to implement any particular teaching or learning standards, nor are their students required to take any state or national standardized tests. This may cause religious educators to be more inclined to embrace certain aspects of classroom flexibility such as class discussions that may promote student learning (Boyer, 1995; Gatto, 2001).

The literature is mixed on the effects of geographic location (rural, urban, suburban) on student achievement. Geographic location in conjunction with other variables is a predictor of student achievement. For example, using statistics published by the U.S. Department of Education shows that a number of states have nearly 50% or more of students enrolled in rural schools (Vermont (56%), Maine (54%), South Dakota (46%), Nebraska (80%). Of those students who are enrolled and have their school located in a rural area, 13.8% also live below the poverty
line. Coffey & Obringer (2000), conducting a study in Mississippi, outlined the problem of educating the rural poor. They stated for example that a greater majority of the students live in low SES rural area (69%), several coming from single-parent households (30%), and living below the poverty line (32%). The free and reduced lunch rate in Mississippi is over 50% with 36% of the students coming from various minority ethnicity groups, including African American, Asian American, Hispanic American, and Native American. Academically, Mississippi, scores lowest on national assessments, the Iowa Test of Basic Skills and the American College Test (ACT), and its students are seen at some of the lowest performing in the country, only 18% of fourth graders and 10% of eighth graders are proficient in mathematics. A large part of this poor performance has been linked to the geographic location of the students.

A study done in Tennessee by Hopkins (2005) analyzing student achievement with regard to school location and the percentage of low SES students within the school, found: (a) schools categorized as other non-rural ranked the highest in mathematics achievement followed by schools categorized as rural; (b) schools designated as large central city schools scored the lowest and significantly lower than the other non-rural and rural schools; and (c) students from large central schools showed a greater range of variability in scores than their other non-rural counterparts and little variability with their rural school counterparts.

Most studies focused on math achievement by geographic location have shown that there are differences in the math achievement levels between urban and rural students with urban students having better performance (Geske, Grinfelds & Kangro, 2001; Geske & Kangro, 2004; Hopkins, 2005; Coffey & Obringer, 2000). Much of this is attributed to differences in how schools manage their physical and human resources on a day-to-day basis much more than with disparities in learning achievement. Geske et al. (2006) in their study show that when geographic
location, gender and SES are controlled for rural school students actually score on par or better than urban or suburban schools. They call for research to investigate the role that school resources and school processes have in predicting achievement. This dissertation incorporates teacher collaboration as a school process with geographic location to better understands its impact on predicting student math achievement.

This dissertation explores nine student sociocultural variables related to student achievement: prior math curriculum studied, prior math achievement, math class effort, math identity, math utility, math self-efficacy, math interest, school belonging, and school engagement. Each of these variables has a unique effect on student achievement and gives insight into contextual factors affecting student learning. Controlling for these sociocultural variables has the ability to give insight into the varying impact of teacher collaborative efforts on student algebraic scores.

**Student Sociocultural Variables**

Prior curriculums have been shown to be predictors of math achievement. Research has also shown that students are more likely to perform well on an assessment if it is aligned with the curriculum and materials that they currently are studying or that they have studied in the recent past. Finally, students who enroll in advanced math courses in high school are more likely to earn higher standardized test scores, graduate from high school, be accepted to college, major in a STEM field, and graduate from college (Goe, 2007; Goe et al., 2008; Long, Conger, & Iatarola, 2012). According to Long and colleagues (2012) the effect of enrolling in advanced math courses is larger for minority and lower SES students.

Prior achievement has been shown to be the single largest predictor of student achievement in several studies, and the results of studies that do not control for prior
achievement are not considered valid or reliable (Goe, 2007). Some researchers even argue that the inclusion of prior achievement in teacher effectiveness models adequately accounts for other potentially confounding student characteristics and allows students to serve as their own controls (Ballou, Sanders, & Wright, 2004). Others, however, have demonstrated the improved validity of models that incorporate several years of past performance as well as student, teacher, and school characteristics (Hill, et al., 2011). Students’ prior achievement, gender, race/ethnicity, SES, the type of school, the curriculum studied, when the assessment is administered, and students’ self-reported math efficacy, utility, interest, and identity may predict learning outcomes.

Recent definitions of math proficiency include not only student math achievement, but also their math attitude. A caveat in teacher effectiveness models is that they rarely include math attitude constructs despite several studies that have shown that reciprocal relationships exist between student math attitudes and their math achievement (Fisher et al., 2012; Leatham & Hill, 2010; Ma & Kishor, 1997; Schwartz, 2006).

According to Wigfield & Eccles’ (2000) expectancy-value theory, the most immediate influences on achievement and choice of achievement tasks are student expectations of success and how much they value succeeding on those tasks. These expectancies and values are in turn predicted by their perceptions the difficulty of the tasks, their self-efficacy, and their goals. These are in turn predicted by students’ interpretations of past performance, as well as perceptions of their peers’ perceptions. Influences include actual past performance, actual peers’ perceptions and the broader cultural milieu. Expectancy value theory and self-regulation theory, which describes the relations between cognition, motivation, behavior and self-regulation, are closely aligned (Murayama, Pekrun, Lichtenfeld, & vom Hofe, 2012; Pintrich & Zusho, 2002).
The literature clearly demonstrates that student math attitudes are significantly related to their achievement. Additionally, studies show that students’ math attitudes and achievement are related to multiple outcomes along the pipeline, including courses taken, grades, college acceptance, college major, college graduation, career, and earnings (NCES, 2008). Based on these research findings, the teacher effectiveness conceptual models investigated in the present study included student math attitudes as potential predictors of student achievement. Relying on expectancy-value theory (Wigfield & Eccles, 2000) math attitude would include four components: interest, efficacy, identity, and utility. My hypothesis is that student math attitudes and their achievement develop interactively, as displayed in Figure 2.7.
A student’s math identity includes students’ beliefs about what it means to be good at math and whether they consider themselves to possess these attributes. It is affected by their view about the nature and utility of mathematics. Finally, it is influenced by their self-efficacy and interest (Leatham & Hill, 2010).

In a study of Black secondary school boys, Berry et al. (2011) found four factors positively contributed to students' mathematics identity. The first was the students’ development of computational fluency by third grade. The second greatest predictor was extrinsic recognition in the form of grades, standardized test scores, tracking, and gifted identification. Additionally, relational connections between teachers, families, and out-of-school activities that promoted student interest and efficacy were critical. Lastly, students with high math identities enjoyed the

**Figure 2.7:** Reciprocal relationships among student math achievement, utility, interest, identity, and efficacy.
nature of math because it provided them with the opportunity to solve problems, engage interactively, and use many strategies while simultaneously making connections to other disciplines.

Students’ math values include their judgments about how useful and interesting mathematics is. Utility value is the degree that students perceive the tasks in math class as related to their everyday lives and future mastery and performance goals. While students may not enjoy an activity, they may have a high utility value of successfully completing it due to later rewards or outcomes it produces. These rewards or outcomes can be either extrinsic (i.e., prize, praise, grades, adult attention, peer admiration, graduation, college admission and success, and/or a career) or intrinsic (i.e., pride, happiness, self-confidence, or self-efficacy). According to self-perception theory, teachers should avoid providing extrinsic rewards for intrinsically motivating activities because doing so can decrease students’ subsequent intrinsic motivation for that activity (Lepper, Greene, & Nisbett, 1973). Teachers can have a positive influence on students’ utility by helping them set goals and intentionally pointing out connections between tasks and students’ goals (Shechter et al., 2011).

Self-efficacy is defined as a person’s subjective appraisal of his or her ability to succeed in a particular task. Students who possess the cultural capital of the math classroom and can successfully reason, present arguments, symbolize, and use tools are likely to have high self-efficacy beliefs. Like self-concept, self-efficacy is based on inferences drawn from prior performances. Unlike self-concept, however, self-efficacy excludes affective components (i.e. moods, feelings), is oriented more on the future than the past, is more malleable than stable, and is based more on mastery than performance goals. Self-efficacy has been shown to promote appropriate task choice, persistence in the face of difficulty, and, ultimately, achievement
(Pintrich & Zusho, 2002; Valentine, Dubois, & Cooper, 2004). Students with higher math self-efficacy are more likely to persist through the educational pipeline to obtain a career in a STEM field (Cech, Rubineau, Silbey, & Seron, 2011).

Student self-efficacy may be influenced by teachers’ and peers’ perceived and actual views of their ability. Additionally, unequal and inaccurate biases may exist within mathematics classrooms based on students’ membership or non-membership in a given community. Therefore, some mathematics classrooms are non-neutral value-laded environments. Teachers can positively influence their students’ math self-efficacy by intrinsically believing in them, extrinsically expressing this belief, and motivationally encouraging them to believe in themselves (Hodges, 2006; Turner, Bogner, Warzon & Christensen, 2011).

Students with a high math interest consider math enjoyable, among their favorite subjects, a productive use of their time, and fascinating. According to the literature, students who are interested in mathematics tend to also have the capacity to do mathematics. A meta-analysis conducted by Ackerman & Heggestad (1997) showed that measures of individuals' interest and ability were significant and positively related. It is important to note that students’ “ability” can be dissected into their actual ability, perhaps measured by a report card or test grade, and their perceived ability, or their math self-efficacy.
In addition to the above, a sense of school belonging has long been thought to be an important component of education. The concept of belongingness is a broad one, defined in many ways, such as relatedness, sense of community, sense of classroom membership, support, and identification (Osterman, 2000). Students can only be mentored through the development of caring relationships with adults and other students in the school. Belonging is often seen as an interaction between a person and the environment in which he or she has a place. It is not a function of the school, nor is it an intrapsychic phenomenon. Perceived friendliness from others and a sense of being valued personally are necessary but not sufficient for success. Belonging in a classroom must include participation in the shared educational goals of the class (Goodenow, 1991). For this reason, school belonging, engagement and effort are highly intertwined. Belonging is influenced by societal factors, personal traits, and contextual factors (Wehlage, Rutter, Smith, Lesko, & Fernandez, 1989).
Cothran and Ennis (1999) lend support to this theory through their research. These authors suggest that educational engagement is not an isolated construct but rather a function of individual and school characteristics. A key component that influences a student’s decision to engage in school is the student’s sense of membership. When a student believes there is a personal connection to the school, engagement is more likely to occur. This attachment involves caring about what others think and trying to fulfill those expectations (Cothran & Ennis, 1997). In addition, students must be more than enrolled; there must be a social bond among students and with adults in the school and norms governing the school (Goodenow, 1991).

Osterman (2000) tells us that the experience of belongingness is associated with important psychological processes. Children who experience a sense of relatedness have a stronger supply of inner resources. They perceive themselves to be more competent and autonomous and have higher levels of intrinsic motivation. They have a strong sense of identity, engagement, and performance. Those students who have a sense of belonging have more positive attitudes toward school, class work, teachers, and their peers. They are more likely to enjoy school, and they are also more engaged. They participate more in school activities, and they invest more of themselves in the learning process.

Goodenow (1992) asserts that there is no doubt that the sense of school belonging and support are important for all students. They may be crucial for the academic survival of many students. Ryan and Powelson (1991) suggest that to a large extent, motivation has become a significant problem because we have removed learning from the traditional social contexts that provided intrinsic motivation. Children who are preferred by peers and teachers tend to be those who are more academically competent. On the other hand, those who are most frequently rejected tend to be low achievers (Osterman, 2000).
Goodenow (1993) found that early adolescents may derive much of their academic motivation from the perceived support of others in the school environment. It should be noted that there was no difference in the absolute levels of belonging that the sixth graders reported as compared to eighth graders. However, the impact of belonging on motivation lessened from sixth to eighth grade (Goodenow, 1993) and in most cases continues to decrease through high school.

Goodenow (1992) argues that it is important to acknowledge the relationship between sense of belonging and motivation. Not only are they related, but they may also be reciprocal. Simply stated, as students feel themselves to be full and valued members of the school, they are willing to put forth more effort and commit themselves more fully to the purposes of the school. As they are more fully engaged in academic work and learning, they are accorded more acceptance and respect from the school and the people who work in the school. Goodenow (1992) states that belonging and motivation are so intertwined that it is difficult to say which is the cause and which is the effect.

**Teacher Sociocultural Variable**

Several studies sought to find relationships among specific teacher characteristics and student performance. These studies focused on characteristics of academic background (Monk, 1994) and teacher preparation (Boyd, Grossman, Lankford, Loeb, & Wykoff, 2005; Goldhaber & Brewer, 2000) that are generally acquired before a teacher begins working in a school, as well as years of teaching experience (Harris & Sass, 2011).

Monk (1994) ran regression models to understand the effects of secondary school teachers’ mathematics and science subject matter preparation on students’ performance gains in these subjects. Using data from the *Longitudinal Survey of American Youth*, Monk studied 2,829 students entering 10th grade in the fall of 1987, selected through a stratified random sampling of
public schools to represent U.S. geographic regions and community types. Survey data were collected between 1987 and 1991 from students, their teachers, and their parents. Mathematics and science achievement test data were collected from 1987, 1988, and 1989. Monk was able to match teacher data with student data. This study found positive relationships between the number of undergraduate mathematics courses a teacher took and student improvement in mathematics, with the most significant effects being associated with the addition of each mathematics course up to five.

Undergraduate mathematics pedagogy courses were also significant and, in fact, were found to be more significant than mathematics courses themselves. Having earned a major in mathematics was not found to be significant. It was found that teachers having a science major and the number of science education courses were significant predictors of student performance in science, but there was no relationship found between the number of science courses taken and student performance. This study did not find that the number of years of teaching experience had a significant effect on student performance. Although not consistent across subjects, in general, Monk found that teacher subject area content and educational preparation as measured by teachers’ college major, courses taken in the subject-area, and courses taken in pedagogical content positively affected student learning in mathematics and science.

Using the National Educational Longitudinal Study of 1988 (NELS:88), Goldhaber and Brewer (2000) studied 12th grade mathematics students (N = 3,786) and science students (N = 2,524) matched with their mathematics teachers (N = 2,098) and science teachers (N = 1,371) using multiple regression analysis to understand the relationship between teachers’ type of teaching certificate and students’ performance on standardized tests in science and mathematics. Significant findings from this study indicated that mathematics students who had teachers
holding either bachelors or master’s degrees in mathematics performed better than students of teachers with degrees in other subjects; however, there were no similar findings for science. Although there were no significant differences between teachers with emergency and traditional certifications, students of teachers who were not certified in mathematics performed worse than those of teachers who were certified. In addition, the researchers found some evidence that teachers holding certificates from states with higher certification standards showed positive effects on student performance in both mathematics and science; however, these relationships were not strong.

Several studies found relationships between student learning and teacher certification. Boyd et al. (2005) studied the relationship between student performance and teacher preparation by traditional and alternate routes to certification. Using data from students and teachers in grades 3-8 in high-poverty urban schools in New York City, They found teachers who entered through alternate pathways to certification demonstrated smaller initial student gains in both mathematics and English language arts compared with teachers entering through traditional pathways. Desimone and Long (2010) found that a student’s academic growth in first grade was significantly slower if the student’s teacher had less than a bachelor’s degree, and the academic growth happened significantly faster if the teacher had permanent, long-term, or alternative certification, rather than an emergency certificate or no certification to teach. Both of these studies, however, are of earlier grades than my target groups, and it is less common that a secondary school teacher will not minimally hold a bachelor’s degree. Finally, content area preparation is often very different for secondary teachers than primary teachers. Therefore, these two studies may be less relevant to my investigation; they do suggest, however, that there may be differential effects arising from teachers’ certification routes and preparation pathways.
While not measuring teacher characteristics directly, Darling-Hammond (1999) reported that states (Connecticut and North Carolina, and to a lesser extent, Kentucky, Arkansas, and West Virginia) that sought to improve teacher quality by investing in research-based reforms such as teacher pre-service education, licensing, teacher mentoring, and raising their teacher certification requirements between 1992 and 1996 showed some of the most significant gains in student performance on the NAEP 4th and 8th grade assessments over this time period. States that focused instead on student and teacher accountability through investments in high stakes achievement testing (Georgia and South Carolina) showed, at best, flat performance, but more often a decline in student performance over the same time period.

Harris and Sass (2011) carried out a large statistical analysis to understand the relationships between a teacher’s background training and other measures of teacher quality and student achievement. A large data set from Florida allowed the researchers to match students (between 160,000 and 260,000 students) and their performance on state standardized math and reading tests with teachers and teacher education programs. Aside from some professional development effects, this study found the only teacher characteristic having a significant positive effect on student performance across subjects was a teacher’s years of teaching experience. For middle school mathematics teachers, teachers’ professional development experiences were found to have a positive and significant effect on student achievement. The effect was negative, but non-significant, for the year the professional development was experienced, but positive and significant for the following 2-4 years. While there is an appeal to the comprehensiveness of studies such as Harris and Sass’s (2011), with few standardized tests assessing student learning aligned with teaching in all subject areas, it is difficult to convincingly demonstrate the relationship between teacher characteristics and student learning in high school courses. Similar
problems are a likely explanation for a lack of studies relating teacher preparation and types of certification at the secondary school level.

These studies on teacher characteristics and teacher quality identify the importance of teachers in student learning. High quality teachers have more positive effects on student learning than lower quality teachers. While an absolute measure of teacher quality is difficult to quantify, these studies suggest, particularly in science and mathematics, that several factors should be considered. Subject-content preparation and pedagogical-content preparation, teacher certification in the subject area being taught, higher standards for that certification, and years of teaching experience all have the potential to positively affect student academic performance.

In my study, an exploration of teachers’ academic backgrounds and teacher certifications relative to the subjects taught, along with their years of teaching experience, both in their current school and overall, provided some evidence of teacher preparation and teacher quality. In some of the literature described above, teacher professional development also emerged as contributing to and enhancing teacher effectiveness beyond the effects of individual teacher characteristics.

Teacher beliefs can also be decomposed into several elements. The construct of teaching self-efficacy evolved from Rotter’s (1966) locus of control theory and Bandura’s (1977, 1986, 1997) social cognitive theory. Teaching self-efficacy refers to the extent to which a teacher believes in the efficacy of their teaching to overcome student learning or behavioral problems, and it indicates to what extent a teacher judges his or her capabilities to bring about desired outcomes of student engagement and learning (for all students). Investigations have suggested a significant positive relationship between teachers’ math self-efficacy, the quality of their instructional practices, and their students’ outcomes (Brookover et al., 1977; Bursal & Paznokas, 2006; Guskey, 1988; Ross 1998; Turner et al., 2011). Teachers with higher efficacy have been
shown to be more likely to invest the time and effort necessary to learn how to implement new teaching strategies (Raudenbush, Rowen, & Cheong, 2002; Ross, 1998). Additionally, teachers with higher self-efficacy may be better at instructing both low- and high-achieving students (Ashton, Webb, and Doda, 1983) and have better classroom management skills (Knoblauch & Woolfolk Hoy, 2008). It is likely that a teacher’s educational background affects self-efficacy. Receiving positive feedback from others about the quality of their teaching can have a positive impact on a teacher’s self-efficacy. This suggests that administrators who provide deliberate recognition and concrete opportunities for career development may be more likely to attract and retain high quality teachers which may prevent the loss of “irreplaceable” teachers. Losing such teachers is considered to cause interruptions in the network of colleagues and mentor relationships that are built over time and an erosion of institutional and cultural knowledge essential to running a successful school (Jacob, Vidyarthi, & Carroll, 2012).

Additionally, teachers’ beliefs about the ability or achievement levels of their students may shape their practices (Barr & Dreeben, 1983; Gamoran, 1986, 1987; Oakes, 2008; Page, 1991; Seaver, 1973). In a phenomenon referred to as the Pygmalion effect or self-fulfilling prophecies researchers have demonstrated that when teachers expect students to perform (i.e., high or low), they behave in different ways, and these behaviors can bring about the expected performance (Rosenthal & Jacobsen, 1968). When working with “higher-ability” students, teachers are more likely to be warm and encouraging, offer evaluative comments, invest more effort into teaching, provide more opportunities to participate, and have higher expectations (Boaler & Staples, 2008; Oakes, 2008; Rubin, 2008). Despite evidence that “higher-order thinking skills can be learned along with lower-order ones early in the instructional process” (National Research Council, 2012, p. 171), many math teachers believe that students must
memorize and attain a basic procedural competency in math skills before being able to progress to higher reasoning skills and deeper conceptual understandings (Spillane & Jennings, 1997; VanDerHeyden, McLaughlin, Algina, & Snyder, 2012). Therefore, “lower-ability” students may be exposed to a less engaging, challenging, and rigorous curriculum than their “higher-ability” peers.

Teachers’ beliefs about students’ abilities are not necessarily accurate or intentional. Teachers may (either unintentionally or intentionally) approach students of lower economic standings (Alvidrez & Weinstein, 1999), students in urban settings (Causey, Thomas, & Armento, 2000), special education students (Soodak, Podell, & Lehman, 1998), or minorities and female students (Nosek & Smyth, 2011), differently based on perceptions of student abilities. Whether based on subjective or “objective” measures such as intelligence tests, given as early as kindergarten, lower socio-economic status and minority students are more likely to be placed in lower academically tracked classes. The underlying assumption of tracking is that some students have more academic ability than others. This is a stark contrast to countries such as Japan that do not track students in elementary or middle school and attribute success to effort and motivation. Inferior treatment of students based on teachers’ perceptions of their abilities may erode student interest, efficacy, identity, utility, and achievement (Turner et al., 2011).

After thoroughly reviewing the literature Jussim (2012) concludes that self-fulfilling prophecies, in which teacher expectations directly change students’ achievement, have an effect size between .1 and .2, and teachers’ expectations that indirectly alter their own judgments and perceptions of students’ achievement also have an effect size of approximately .2. Jussim (2012) points out that an effect size of .2 implies that sixty percent of students for whom the teacher has high-expectations will perform above average, and forty percent of the students for whom the
teacher has low-expectations will perform above average. Therefore, teachers’ high expectations increase the performance of ten percent of the students and low expectations decrease the performance of ten percent of the students. Similarly, assuming that two students began the school year earning Bs, and the teacher had high expectations of one of the students and low expectations of the other student, the high expectancy student may end the year with As, whereas the low expectancy student could end the year with Cs. According to Jussim (2012), however, only inaccurate expectations can produce self-fulfilling prophecies, and based on average correlations between teachers’ expectations and students’ achievement, teachers’ expectations are about 75% accurate. These effect sizes imply that compared to all other teacher-level factors (characteristics and practices) teachers’ perceptions of the achievement level of their students may be the single greatest predictor of student achievement and affective development (Goe, 2007, 2008).

**Contribution to the Field**

This dissertation will contribute to the field of math education research in four distinct ways:

1. By making conceptual and methodological contributions to the field of math teacher effectiveness by examining collaboration that involves teaching for mathematical proficiency as measured by the HSLS:09 follow-up algebraic reasoning assessment.

2. Keeping in mind that PLCs are founded on the premise that teachers benefit from critical discourse (Wood, 2007), in this study I construct perception of professional learning communities as a product of teachers’ perceptions of the critical discourse patterns, actions, and activities that support math student learning and collaborative leadership support. In order to develop a firm understanding of how PLCs impacts student
achievement, it is important to incorporate aspects that affect the quality of the collaborative experience (Chadbourne, 2004) and the discourse patterns teachers’ use within the collaborative experience (Horn & Little, 2010). Most studies lack the incorporation of both aspects of a collaborative experience in analyzing the impact it has on instruction change and student outcomes.

3. Teachers’ perception of PLCs have an extreme impact on the instructional climate of a school. This study also offers insight into the impact teacher perception of PLCs has on the algebraic scores of female and male students while controlling for student demographic and sociocultural factors as well as teacher sociocultural factors. Speer (2017) asserts that precollege academic factors account for a large portion of the gender gap, precollege factors being the culmination of forces that shape one’s academic career (parents, schools, teachers, peers, environmental influences, and innate ability) up until the time the test score is measured.

4. Lastly, this research project makes recommendations for professional development, teacher collaboration organization, teacher preparation programs, and education policies focused on improving teacher quality.

Overall this study gives insight into how teachers can be nurtured to be more effective. This study adds insight, suggestions, and information about how educators can work together to achieve the highest level of student academic performance, in turn, increasing the long-term projection for student success in STEM fields. When teachers are provided the opportunity to effectively work together, they can find solutions to instructional dilemmas and also work on ways to improve their teaching skills (Picard, 2005). Current research posits that teaching will
become more effective when educators recognize that true, effective, and efficient collaboration is a vital component in creating a positive learning environment (Souza, 2003).

This section discusses the theoretical frameworks which ground this study, teacher perception of professional learning communities related to student achievement, and other important student- and teacher-level variables within four domains that are predictors of student achievement. The next section discusses the methodology employed for this study and how the variables discussed in the literature review are used. Using a series of multivariate regression, the central question, what is the impact of teacher perception on student algebraic achievement, and how does the interaction manifest according to gender, is explored. Within the methodology section, the dataset, analytic sample and plan, and all variables are discussed in detail.
Chapter Three: Methods

The preceding chapter discussed literature on student- and teacher-level elements that affect student algebraic achievement. This chapter will explain the methodology that this dissertation will use to explore the research questions. First, I will give an overview of the methodology employed, followed by a description of the development of the data set, instrument, and sample being used for the investigation. Then, I will describe the variables within each domain, followed by the analytic strategy used to connect all parts of the study together.

Introduction

Using the data retrieved from the High School Longitudinal Study of 2009 ([HSLS:09], NCES, 2009) and the first follow-up survey, including algebraic assessment scores collected from the cohort of students in 2012, this dissertation investigates the following question: What is the relative impact of a teacher’s perception of professional learning communities on student algebraic achievement? Accordingly, does the relationship manifest differently for males and females?

I conducted the analysis in three distinct phases. To characterize the student sample, data analysis began with an exploration of the descriptive statistics of each of the variables. The second phase involved exploration of bivariate analysis to determine the relationships among the variables. This was done using a t-test that examined the significance between the dichotomous variables, exploring one-way analysis of variance (ANOVA) results, and using Pearson’s correlation matrices to explore potential pair-wise relationships between the continuous variables involved within the four conceptual models. Finally, the third phase involved using four ordinary least squares (OLS) regression models to test whether teacher collaboration (Model I), student demographic variables (Model II), student sociocultural variables (Model III), and teacher
sociocultural variables (Model IV) could significantly explain variances in student algebraic ability. Regression analysis was performed for the entire sample of students (Models I through IV), for male students only (Models V through VIII), and finally for female students only (Models IX through XII).

The subsequent section describes the development, rationale, and purpose for selecting the data set and the data-collection procedure. This is followed by discussion of the analytic sample, the dependent and independent variables used within the regression models, and a description of the analytic strategy employed to answer the research question.

**Dataset**

The present study is a secondary analysis of the public-use data file retrieved from the base year of the High School Longitudinal Survey (HSLS:09) conducted by the National Center for Education Statistics (NCES, 2009). The HSLS:09 is a nationally representative, longitudinal study of more than 21,000 ninth-graders in 944 schools across ten states. It will follow the students throughout their secondary and postsecondary years. I collected base-year data in 2009 and focused on uncovering when, what, why, and how students make decisions, particularly STEM courses, majors, and careers. The first follow-up of the HSLS:09 study was administered to students, parents, school counselors, and school administrators in the spring of the students’ 11th-grade year, 2012. Similar to the base survey, the follow-up consisted of a math assessment component and a survey designed to expand on and capture evolving attitudes and plans. Both are available for review.

The HSLS:09 is the fifth and currently the only active longitudinal study supported by the NCES’s Secondary Longitudinal Studies program. The Secondary Longitudinal Studies program supported four prior long-term studies: the National Longitudinal Study of the High School Class
of 1972 (NLS:72), the High School and Beyond (HS&B) longitudinal study of 1980, the National Education Longitudinal Study of 1988 (NELS:88), and the Education Longitudinal Study of 2002 (ELS:2002), which was recently completed in 2012. Together, these studies, including the HSLS:09, focus on describing student educational experiences for the past four decades as a basis for understanding the contextual component of educational success in the United States (Ingles et al., 2013, p. 2).

HSLS:09 builds on its predecessors by following a nationally representative sample of ninth graders from the fall of 2009, without refreshing the sample, to the spring term of their 11th year (2012), three years out of high school (2016), and then 13 years after their expected graduation date (2025). The core research questions for the HSLS:09 are to explore secondary to postsecondary transition plans and the evolution of those plans; paths into and out of science, technology, engineering, and mathematics; and the educational and social experiences that affect these shifts. The HSLS:09 and previous studies have a number of differences that are relevant to this study. The most distinctive is the HSLS:09’s enhanced focus on understanding contextual factors that affect student mathematics achievement and growth. In addition, it explores academic (especially in math), social, and interpersonal growth throughout high school, as well as students’ choices about, access to, and persistence in math and science courses, majors, and STEM careers. Furthermore, it is committed to identifying the characteristics of high schools and postsecondary institutions and their impact on student outcomes, and is similar to many of the other studies committed to understanding the context of education, including how minority and at-risk status is associated with education and labor market outcomes.

The student survey component asked about student demographics; school experience; attitudes about school, mathematics, science, college, and career plans; and educational and
occupational expectations. The HSLS:09 also surveyed parents, teachers, school counselors, and school administrators to provide contextual information about the students. The HSLS:09 investigated specific teacher characteristics and practices to link them to the student learning contexts and educational outcomes in the study. The teacher component of the study involved collecting background information on the specific teachers regarding their demographics; educational and professional background; beliefs about how the mathematics and science abilities of males and females compare; class, departmental, and school climates; and perceptions of barriers to effective teaching.

The data in the present study came from the HSLS:09 student and teacher surveys. The design for the HSLS:09 was guided by a conceptual model that takes the student as the fundamental unit of analysis and attempts to identify factors that lead to academic goal setting and decision-making. Broad research domains were identified as relevant from this theoretical framework, and key constructs were drawn from each domain. Next, the items that could best measure the constructs were determined. The rigorous development and review process for each survey consisted of the following steps: a literature review, consultation, circulating drafts of work in progress, technical review, panel review, writing of justifications for Office of Management and Budget review, field testing, and revisions. The field test analysis included the evaluation of item non-response, examination of test-retest reliability, calculation of scale reliability, and examination of correlations between theoretically related measures. For the achievement test in mathematics, both classical and item response theory (IRT) techniques were employed to determine the most appropriate items to include in the final form of the test. The psychometric analyses included various measures of item difficulty and discrimination, an investigation of reliability and factor structure, and analysis of differential item functioning.
Items were not included on the final forms of the survey unless they exhibited acceptable psychometric properties (Ingels et al., 2011)

All of the surveys in the HSLS:09 study were computerized, and 98% of students completed their surveys in school sessions, while 2% completed their surveys out of school. The in-school sessions were 90 minutes in length, with 15 minutes allocated for proctors to setup and read instructions, 35 minutes for the student questionnaire, and 40 minutes for the two-part, 40-question adaptive algebraic reasoning assessment. Parent and school staff surveys (for administrators, counselors, mathematics teachers, and science teachers) were designed for computerized administration in either of two modes—Web-based self-administration or computerized interviewer-administration (CATI, Ingels et al., 2011).

The algebra assessment component gauged student algebraic skills, focusing on six algebraic content domains (language of algebra, proportional relationships, linear functions, nonlinear functions, systems of equations, and sequence and recursive relationships) and four algebraic reasoning processes (algebraic skills, using representations, algebraic reasoning, and algebraic problem solving). The algebra assessment is considered ability-adaptive because it was built as a two-stage test, with a router (completed by all students) and a second-stage assignment of one of three forms with variable difficulty (Ingels et al., 2011).

The questionnaire data were stored in a database that was consistent across data collection modes for a particular questionnaire. Editing programs were developed to output inconsistent items across logical patterns within the questionnaire. These items were reviewed, and rules were written either to correct previously answered (or unanswered) questions in order to match the dependent item or blank out subsequent items in order to stay consistent with
previously answered items. Programs were also developed to review consistencies across multiple sources of data and identify discrepancies that require further review and resolution.

The student-level public-use data file (ASCII), which contains information from the HSLS:09 base year and first follow-up survey, came from the following website: https://nces.ed.gov/surveys/hsls09/hsls09_data.asp. It provides access to the Education Data Analysis Tool from which the SPSS syntax file can be retrieved. I analyzed the data using SPSS. The data file documentation and questionnaire for the surveys, which provides valuable information for understanding and analyzing the data, also came from the above site.

This dissertation will focus on the entire student sample and the corresponding math teacher population that participated in the study. Although the HSLS:09 contains several opportunities for important research that is relevant to students, parents, teachers, school counselors, and administrators, this study will only employ student- and teacher-level data from the base year and algebraic achievement data from the 2012 junior year follow-up.

**Analytic Sample**

According to the National Center for Educational Statistics (NCES), in the base-year survey of HSLS:09, students were sampled through a two-stage stratified process. First, stratified random sampling and school recruitment resulted in the identification of 1,889 eligible schools. The target population at the school-level was defined as regular public schools in all 50 states and the District of Columbia, including public charter schools, and private schools that provided instruction in ninth and 11th grades. A total of 944 of these schools participated in the study, resulting in a 55.5% (weighted) or 50.0% un-weighted response rate at the school level (Ingels et al., 2011).
In the second stage of sampling, students were randomly sampled from schools’ ninth-grade enrollment lists. The target population of students was defined to include all ninth-grade students who attended the study-eligible schools in the fall 2009 term. We selected 25,206 students, or about 27 students per school. Of these students, 548 were unable to participate directly in the study due to language barriers or severe disabilities, but they were retained in the sample, and contextual data about them were gathered. Of the sampled students, about 86% (weighted) participated, totaling more than 21,000 students (Ingels et al., 2011).

Teachers were selected by virtue of teaching an HSLS:09 student in mathematics. This sampling procedure was essential to link teachers to the students who participated, thus making the contextual information more valid within the study. Only teachers linked to students for the HSLS:09 base-year study were identified for the mathematics-teacher survey. If students were assigned to multiple mathematics courses, then one teacher within each subject was randomly chosen for the survey. A total of 5,710 mathematics teachers were contacted to participate in the study, which equaled an average of 6.2 math teachers per school. Roughly, 17,882 (71.9% weighted) of the participating students with completed data also had completed data from their math teachers (Ingels et al., 2011).

The follow-up sample consisted of students who were selected for the base-year study administered during the 2009–10 school year and were still eligible for HSLS:09. No new sample of schools was selected for the follow-up; thus, the first follow-up is not representative of high schools with ninth and 11th grades in the 2011–12 school year, but rather was intended as a follow the base-year students who were originally analyzed for school-level effects on longitudinal student outcomes. Of the 944 participating schools, 939 continued their participation. All 25,206 base-year eligible students were included in the first follow-up sample.
The follow-up estimated only from the sample associated with the ninth-grade cohort 2.5 years later, not a universe of students attending the 11th grade in the spring of 2012 (Ingels et al., 2011).

HSLS:09 school and student samples are nationally representative and also state representative for a subset of 10 states. For this data set, the student is the unit of analysis. In addition, data from the school, classroom, or home level were attached to the students’ records as contextual data. Several contextual respondent populations were sampled, including the school’s head administrator, lead counselor, the student’s mathematics and science teachers, and parents. Student and mathematics-teacher survey responses provided most of the information used in this study; responses on parent and administrator questionnaires provided additional contextual information that informs student and school demographic variables. I use pertinent variables related to student algebraic achievement from the base year and the first follow-up survey.

Measures

This dissertation uses data from the High School Longitudinal Survey of 2009 (HSLS:09) and the 2012 follow-up to explore the impact of teacher collaboration, student demographic variables, and student-/teacher-level sociocultural variables on the dependent variable, student algebraic achievement. Four multivariate hierarchical regression models will be used to examine whether teacher collaboration has a relative impact on student algebraic achievement. The sample is later disaggregated by gender to explore possible effects. All variables are derived from the HSLS:09 and the 2012 follow-up public-use file. Some variables were used in their original form, while others were recoded for analysis through SPSS software. The following sections describe all variables used within this dissertation.
Dependent Variable

Student achievement was operationalized in terms of theta algebraic ability scores, "X2TXMTH," for the population of students during the 2012 HSLS:09 follow-up. The test framework was designed to assess a cross-section of understanding representing the major domains and key processes of algebra. The test and item specifications described six algebraic content domains: *the language of algebra, proportional relationships, linear functions, non-linear functions, systems of equations, and sequence and recursive relationships*. It also included four algebraic reasoning processes: *demonstrating algebraic skills, using representations of algebraic ideas, performing algebraic reasoning, and solving algebraic problems*.

The first follow-up mathematics assessment for the HSLS:09 was administered by computer using a two-stage design. Each student completed a Stage 1 “router test” that consisted of 11 base-year linking question items and four question items that were unique to the first follow-up. Based on their Stage 1 performance, students were routed to low (approximately 25% of students), moderate (approximately 50%), or high (approximately 25%). Stage 2 tests, each consisting of 25 items. During the testing process, all of the students were aware that they were taking a 40-item test in two parts: a 15-item part and a 25-item part. The test was specifically designed to represent a balance across the six content domains and the four algebraic processes.

The scores used to describe students’ performance on the mathematics assessment were based on item response theory (IRT; Ingels et al., 2013) modeling. The IRT model utilizes a three-parameter logistic model to calibrate the test items and estimate a student’s ability. More specifically, it uses patterns of correct, incorrect, and omitted responses to obtain ability estimates that are comparable across the low-, moderate-, and high-difficulty test forms. The HSLS:09 used BILOG-MG (Zimowski et al., 2003) to calibrate the items and estimate each
student’s theta ability score. In the present study, the theta ability score provided a summary measure of achievement for the individual students that is useful for correlational analysis with contextual variables. For more information regarding the algebraic reasoning framework, assessment construct, scoring, or theta ability score estimations, see Appendix A.

**Independent Variables**

Twenty-two independent variables were used in this study. Nominal variables were used as stated in the public-use HSLS:09 file. For many of the variables that were common to each other, a number of composite variables were created in order to measure collaborative effects. A number of these variables were used in this study. Some of the original variables were recoded in SPSS to fit the purpose of analysis in this study.

For the purpose of interrogating the research question, independent variables were grouped into four domains. Domain One included only the teacher’s perception of professional learning communities. This domain was used to create a baseline model to track changes in this predictor when other variables were controlled for. Domain Two included student demographic variables: student gender, race/ethnicity, socioeconomic status, whether the student attended public school, and urbanicity. Domain Three incorporated student-level sociocultural variables, prior achievement, prior curriculum studied, math-class effort, math identity, math utility, math self-efficacy, math interest, sense of school belonging, and a metric for school engagement. Lastly, Domain Four controlled for teacher sociocultural variables, including teacher gender, race/ethnicity, certification type, degree level, whether the teacher held a prior math job, years of experience, self-efficacy, and perception of average math-class achievement level.
Teacher-perception variable.

X1TMCOMM, “teacher’s perception of professional learning communities,” is a composite of 12 variables. This variable is used to predict student sensitivity to the teacher’s perception of professional learning communities on algebraic academic achievement. The following variables were used to create the scale for this variable: math teachers in this department share ideas on teaching (M1SHRIDEAS), math teachers in this department discuss what was learned at a workshop/conference (M1WORKSHOP), math teachers in this department share and discuss student work (M1SHRSWTRK), math teachers in this department discuss lessons that were not successful (M1SHRLLESSONS), math teachers in this department discuss beliefs about teaching/learning (M1SHRBELEIFS), math teachers in this department share research on effective teaching methods (M1SHRMTTHDS), math teachers in this department share research on ELL instructional practices (M1SHRELL), math teachers in this department explore approaches for underperforming students (M1SHRAPPRCH), math teachers in this department coordinate course content with other teachers (M1SHRCNTNT), math teachers in this department provide support to new math teachers (M1MENTOR), and math teachers are supported/encouraged by the math department’s chair (M1CHAIR). The coefficient of reliability (Cronbach’s alpha) for the scale was 0.90. This measurement of internal consistency informed the level of homogeneity of items to determine whether item responses grouped together measured the same construct (Henson, 2001). According to Henson, the desired level of internal consistency for general research purposes should be close to or exceed 0.80. For this reason, and for greater reliability of the results, teacher perception of professional learning communities was used as a composite variable instead of using the variables independently.
**Student demographic variables.**

X2SEX, “student sex,” was obtained from the students who participated in the base-year survey and participated in the first follow-up. This information was compiled from the student questionnaire, parent questionnaire, and/or school-provided sampling roster. If the sex indicated by any of these three sources was inconsistent, it was coded based on manual review of the sample member’s first name (Ingels et al., 2011). For the purpose of analysis, a dummy variable was created that indicated whether the student was female (1) or male (0).

X2RACE, “student’s race/ethnicity-composite,” was obtained from the first-follow-up data. This variable characterized the sample member’s race/ethnicity into six dichotomous race/ethnicity composites: X2HISPANIC, X2WHITE, X2BLACK, X2ASIAN, X2PACISLE, and X2AMINDIAN. Similar to student sex, this variable was based on data from the student/parent survey and/or the school-provided sampling roster. For the purpose of this study, I created dummy variables to categorize each race/ethnicity.

X2SES, “socioeconomic status composite,” was taken from the first-follow-up data. NCES computed this composite variable based on parent/guardians’ education (X2PAR1EDU and X2PAR2EDU), occupation (X1PAR1OCC2 and X2PAR2OCC2), and family income (X2FAMINCOME). The range for this variable runs from -1.75 to 2.28.

X2CONTROL, “school control,” identified students from the follow-up survey school as being public (1) or private/Catholic (0). This information was derived from the source data for sampling: the Common Core of Data (CCD) 2007–2008 and the Private School Survey (PSS) 2007–2008.

X2LOCALE, “school locale (urbanicity),” characterized the students’ school location from the follow-up survey as *urban* (1), *suburban* (2), or *rural* (3). Similar to school control, this

**Student sociocultural variables.**

S1M8, “most advanced math course taken by a student in the eighth grade,” describes the student’s highest math course taken prior to high school as reported in the base-year survey. For the purpose of linear regression analysis, student responses were grouped into either has not completed one year of algebra (Math 8, Adv. Math 8, pre-algebra, other) prior to high school (denoted by 0) or completed at least one year of algebra (Algebra I, Algebra II, Trig, geometry) prior to high school (denoted by 1).

S1M8GRADE, “final grade in ninth grader’s most advanced eighth-grade math course,” was taken from student responses on their self-reported final grade in their eighth-grade math course per the base-year survey. According to meta-analytical research, the correlation between self-reported grades and those obtained from school records was between 0.70 and 0.94 (Kuncel, Crede, & Thomas, 2005). For the purpose of regression analysis, students’ prior achievement was recoded in ascending order associated with lowest grade first: 1 = Below D, 2 = D, 3 = C, 4 = B, 5 = A.

X2EFFO, “scale of math-class effort,” is a composite of four variables used to measure students’ math-class effort. It was taken from the follow-up survey. This scale is composed of the following variables: How often did the student pay attention to his or her spring 2012 math teacher (S2MATTENTION)? How often did the student turn in assignments on time during the spring 2012 math course (S2MONTIME)? How often did the student stop trying in the spring 2012 math course (S2MSTOPTRYING)? How often did the student do as little work as possible during the spring 2012 math course (S2MGETBY)? This variable, like many of the others that
follow, was created through principal component factor analysis and standardized to a mean of 0 and a standard deviation of 1. After this transformation, the ranges for math-class effort had a minimum value of -3.79 and a maximum value of 1.18 with a coefficient of reliability (Cronbach’s alpha) of 0.74. A higher value on the scale indicates higher perception of effort in mathematics classes.

X2MTHID, “scale of student’s mathematics identity,” is a combination of two variables taken from the follow-up survey: teenager sees himself/herself as a math person (S2MPERSON1) and others see teenager as a math person (S2MPERSON2). After transformation, student math identity as a composite variable ranged from -1.54 to 1.82, with a Cronbach’s alpha of 0.89.

X2MTHUTI, “scale of student’s mathematics utility,” is composed of three variables taken from the first follow-up survey. The individual variables that make up this scale are as follows: teenager thinks math is useful for everyday life (S2MUSELIFES2), teenager thinks math will be useful for college (S2MUSECLGS2), and teenager thinks math is useful for his or her future career (S2MUSEJOB). Student’s math utility ranged from -3.94 to 1.21 with a Cronbach’s alpha of 0.82. A higher value of math utility indicated a higher perception of math usefulness.

X1MTHEFF, “scale of student’s mathematics self-efficacy,” was acquired from the base-year survey. This construct was a transformation of four variables: teen is confident he or she can do an excellent job on (spring 2012) math tests (S2MTESTS), teen is certain he or she can understand the (spring 2012) math textbook (S2MTEXTBOOK), teen is certain he or she can master skills taught in the (spring 2012) math course (S2MSKILLS), and teen is confident he or she can do excellent job on the (spring 2012) math assignments (S2MASSEXCL). The range for
this scale had a minimum value of -2.50 and a maximum of 1.73. Student math self-efficacy had a Cronbach’s alpha of 0.89.

X1MTHINT, “scale of student’s interest in fall 2009 math course,” is a composite of five variables: teen thinks (spring 2012) math course is a waste of time (S2MWASTE), teen thinks (spring 2012) math course is boring (S2MBORING), teen’s favorite school subject (S2FAVSUBJ), teen is taking the spring 2012 math course because he or she really enjoys math (S2MENJOYS), and teen is enjoying the (spring 2012) math course (S2MENJOYING). After transformation, this composite variable had a range of -2.02 to 1.99 with a Cronbach’s alpha of 0.69.

X1SCHOOLBEL, “scale of student’s sense of school belonging,” is also a composite of five variables: ninth grader feels safe at school (S1SAFE), ninth grader is proud to be part of his or her school (S1PROUD), ninth grader has teacher/adult in school he or she can talk to about problems (S1TALKPROB), ninth grader feels that school is often a waste of time (S1SCHWASTE), and getting good grades is important to the ninth grader (S1GOODGRADES). School sense of belonging ranged from -4.35 to 1.59. Higher measures of belonging indicated a higher perception of feeling like a part of a school community. The variable had a coefficient of reliability (Cronbach’s alpha) of 0.72.

X1SCHOOLENG, “scale of student’s school engagement,” is a transformation of four variables: How often does the ninth grader go to class without his or her homework done (S1NOHWDN)? How often does the ninth grader go to class without pencil or paper (S1NOPAPER)? How often does the ninth grader go to class without books (S1NOBOOKS)? How often does the ninth grader go to class late (S1LATE)? This construct varied from -3.38 to 1.39 with a Cronbach’s alpha of 0.67.
**Teacher sociocultural variables.**

M1SEX, “math teacher’s sex,” was obtained from the teachers who participated in the base-year survey. The information was compiled from the teacher survey and/or school-provided sampling roster. For the purpose of analysis, a dummy variable was created identifying females as 1 and males as 0.

X1TMRACE, “math teacher’s race/ethnicity-composite,” identified the teachers’ race/ethnicity as determined by their response on the base-year survey or school-provided sampling roster. X1TMRACE is a composite of M1HISPANIC, M1WHITE, M1BLACK, M1ASIAN, M1PACISLE, and M1AMINDIAN. This variable was provided as a composite variable; for the purpose of this study, however, dummy variables were created to split this category into a series of dichotomous variables to measure individual effects.

X1TMCERT, “math teacher’s math teaching certification,” indicated the type of mathematics teaching certificate the teacher had among four categories: no certificate, not a regular certificate, regular certificate not high school, or a regular high school certificate. Dummy variables were created for each one (1 = has the respective certificate; 0 = does not have that respective certificate).

M1HIDEG, “math teacher’s highest degree earned,” disaggregates the education level of the math teachers who participated in the base-year survey. M1HIDEG provided four categories for teachers to choose from: bachelor’s degree, master’s degree, education specialist, and Ph.D. This study operationalized this predictor into a dichotomous variable (0 = bachelor’s degree; 1 = master’s degree or higher).

M1MATHJOB, “math teacher held math-related job prior to becoming a teacher,” was another categorical variable that characterized the background of the teacher (0 = did not hold a math job prior to becoming a teacher; 1 = held a math-related job prior to becoming a teacher).
M1MTHYRS912, “years the math teacher has taught high school math,” specified the number of years each base-year teacher taught high school math, which ranged from 1 to 31 years.

M1ACHIEVE, “math teachers’ perception of the average achievement level of students in their class,” is a categorical variable that measured whether the teachers who participated in the base-year survey perceived their students to have low, widely differing, average, or high-average achievement levels in their class. A dummy variable was created for each marker (0 = did not indicate that category; 1 = having that perception of average class achievement).

X1TMEFF, “scale of math teacher’s self-efficacy,” is a teacher composite predictor indicating teacher self-efficacy for teaching mathematics. The predictor is a combination of the following eight variables: the amount a student can learn is primarily related to family background (M1FAMILY); students not disciplined at home are unlikely to accept school discipline (M1DISCIPLINE); teachers are limited because the home environment influences student achievement (M1STUACHIEVE); if parents would do more for children, then the teacher could do more for students (M1PARENT); teacher knows how to increase student retention of info from lesson to lesson (M1RETAIN); teacher knows techniques to redirect disruptive students quickly (M1REDIRECT); teacher can get through to even the most difficult or unmotivated students (M1GETTHRU); and teacher cannot do much because student motivation/performance depends on the home environment (M1HOMEFX). This scaled variable ranged from a minimum of -3.26 to a maximum of 3.01. The coefficient of reliability (Cronbach’s alpha) was 0.71. Higher scores represented higher self-efficacy.
Analytic Strategy

The present study involves several stages of analysis to explore the relative impact teacher collaboration has on student algebraic achievement in the presence of the following control variables: student demographics and student and teacher sociocultural variables. The goal of the initial stage will be to develop a deeper understanding of the constructs that make up the study. Univariate analysis will be employed to provide descriptive statistics for all variables of interest. The second stage will include a detailed bivariate analysis of all the variables of interest. A bivariate analysis will be used to determine the strength, direction, and significance of the association among independent variables with the dependent variable, student algebraic achievement, as yielded from their correlations. Since student algebraic achievement is a continuous variable, three independent tests will be used to explore the strength, direction, and significance of the association: t-test, ANOVA, and Pearson’s correlations.

A t-test for equal means is normally used to compare whether dichotomous categorical variables have significantly different mean values over a continuous variable (Snedecor & Cochran, 1989), in this case, for students’ algebraic achievement. The dichotomous categorical independent variables that will be tested for significant differences in their means will include student gender, type of school (public versus private or Catholic), prior curriculum studied, teacher gender, whether the teacher held a math job prior to teaching, and teacher’s highest degree earned.

An extension of a t-test used to compare the means of categorical variables with more than two categories over a dependent continuous variable is ANOVA, which will be used to examine the statistical difference between the means for student race, urbanicity, teacher race, teacher certificate level, and teacher perception of math-class achievement.
Subsequently, Pearson’s product-moment correction coefficients \( r \) were used to characterize the nature of the relationship among all continuous independent variables with the dependent variable. The sign of the correlation coefficient, \( r \), indicates the direction of the relationship, and its absolute value indicates the strength, with larger absolute values indicating stronger relationships. Possible values range from -1 to 1. The strength of the correlation coefficient was determined according to the following parameters: \( 0 < |r| < 0.3 \) is a weak correlation, \( 0.3 < |r| < 0.7 \) is a moderate correlation, and \( |r| > 0.7 \) is a strong correlation. To guard against potential threats of multicollinearity if any predictors had correlation coefficients above 0.80, they were removed from the analysis. Multicollinearity is an unacceptably high amount of correlation among the independent variables used in a regression analysis. When the correlation is too great, the effect of the independent variable on the dependent variable cannot be distinguished. In addition, under multicollinearity, beta weights and R2 effects cannot be interpreted within a significant level of reliability. If independent variables have correlations with each other above 0.80, then multicollinearity is likely to exist (Garson, 2012). Thus, if any independent variable falls into this category, it will either be dropped from the analysis or combined into a composite variable. Eleven continuous independent variables will be explored within this analysis, using the parameters stated above: student socioeconomic status (SES), math-class effort, math identity, math utility, math self-efficacy, math interest, school belonging, school engagement, number of years teacher has taught mathematics, teacher self-efficacy, and teacher collaboration. Both univariate and bivariate analyses are used to check for violations of assumptions and outliers. Normality for this data set is assumed, non-normality is not an issue if \( n \) is very large (i.e., rule of thumb \( n > 1,000 \)) and correlation and OLS regression are relatively robust against moderate violations of normality.
Following univariate and bivariate analysis, an OLS regression analysis will be employed to determine the relative impact teacher collaboration, student demographics, and student and teacher sociocultural variables have on the dependent variable, students’ algebraic achievement. Four hierarchical models will be used in the regression to explore the relative impacts.

Model I, the baseline model, will examine the impact one unit change in the teacher-collaboration composite variable has on predicting students’ algebraic achievement. In addition, this model will determine the statistical significance (p-value) and coefficient of determination ($R^2$) for teachers’ perception of professional learning communities on the dependent variable, students’ algebraic achievement.

To address the research question, Model II will examine the effect teachers’ perception of PLCs has on student algebraic achievement while controlling for student demographic variables. These variables included student sex, race/ethnicity, SES, whether the student attended public school, and urbanicity.

Building on Models I and II, Model III further controls for student sociocultural variables. These variables include whether the student took algebra prior to high school, the student’s prior achievement in the previous math course, math-class effort, math identity, math utility, math self-efficacy, math interest, student sense of school belonging, and student school engagement. Prior achievement has been shown to be the single largest predictor of student achievement and when not controlled for studies is considered not valid or reliable (Goe, 2007). Some researchers posit that the inclusion of prior achievement in teacher-effectiveness models adequately accounts for other potentially confounding student characteristics and allows students to serve as their control (Ballou, Sanders, & Wright, 2004).
Finally, Model IV builds on the previous models by controlling for teacher-level sociocultural variables. This model will be used to determine the relative impact of teacher collaboration on students’ algebraic achievement when controlling for all other variables. Teacher sociocultural variables include teacher gender, race/ethnicity, degree level, years teaching high school math, whether the teacher held a math job prior, teacher self-efficacy, teacher certificate level, and teacher perception of average class-achievement level.

To determine the overall effect across gender, Models I through IV will examine the effect the four variable domains have on students’ algebraic achievement. Following, the file will be split and run separately for male students only (Models V through VIII) and for female students only (Models IX through XII).

The previous chapter discussed a series of hypotheses in each of these domains. To examine the validity of these hypotheses and answer the central research question, OLS regression will be used to predict the relative impact the independent variables within each domain have on student algebraic achievement.
Chapter Four: Results

The purpose of the present study is to contribute to teacher effectiveness and professional collaboration research by building and testing predictive models that identify the impact of teacher perception of professional learning communities on student algebraic achievement.

To answer this question, this dissertation uses data collected from the High School Longitudinal Study of 2009 ([HSLS:09] NCES, 2009). HSLS:09 is an ongoing longitudinal study that follows a representative cohort of ninth grade students as they progress through high school and enter post-secondary schools and, later, the labor market. The data in this study were taken from the base year, the first follow-up survey, and the algebraic assessments that were collected as part of the study. All parts of the study are used to provide context support for understanding student actions and behaviors. For the HSLS:09, students are considered to be the principal unit of analysis.

Analysis for this study was conducted in three distinct phases. Data analysis began with an exploration of the descriptive statistics of each of the variables of interest to characterize the student sample. The second phase involved an exploration of bivariate analyses to determine the relationships among the variables. This was done using a series of t-tests to examine the significance between the dichotomous variables, exploring ANOVA results, and using Pearson’s correlation matrices to explore potential pair-wise relationships between the continuous variables involved within the four conceptual models. Finally, the third phase involved using four OLS regression models to test whether teacher collaboration (Model I), student demographic (Model II), student sociocultural (Model III), and teacher sociocultural (Model IV) variables each explained a significant amount of variance in students’ algebraic abilities. Regression analysis
was performed for the entire sample of students (Models I through IV), for male students only (Models V through VIII), and finally for female students only (Models IX through XII).

**Univariate Analysis**

Table 4.1 presents descriptive statistics of means, standard deviations, ranges, and descriptions of variables for the entire sample of students in this study. Using Table 4.1, a summary of the univariate analysis results for each of the individual variables will be described below.

**Dependent Variable: First Follow-up Student Algebraic Ability Score**

The mathematics theta score describes the algebraic ability for the students who participated in the follow up-survey. The algebraic ability score (n = 20,594) has a range of -2.6 to 4.5. The mean of .72 indicates that on average, students’ algebraic ability scores were slightly below the middle of the range of the scale; a standard deviation of 1.15 indicates a high level of variance in students’ algebraic ability scores.

**Independent Variables**

Twenty-three independent variables were selected for analysis in this study. These variables were grouped into four domains: base year teacher collaboration, student demographic, student sociocultural, and teacher sociocultural.

**Base Year Teacher Perception Variables**

Teachers’ perception of professional learning communities is a composite of 12 variables used to create a scale of math teacher perceptions of math professional learning communities and, more important, their perceptions of how teachers collaborate with each other. This composite variable has a Cronbach’s alpha coefficient of reliability of 0.9, which is considered an extremely strong correlation. To avoid multicollinearity, it was best that variables were
compared together instead of individually to understand better how teacher collaboration provides a context for measuring student algebraic abilities.

Teacher perception (n = 14,490) has a range of -4.07 to 1.70. A mean of 0.03 indicates that the average student has a teacher whose perception of professional learning communities is toward the mid-high range of the scale; a standard deviation of .99 indicates a high level of variance in teacher collaboration.

**Student Demographic Variables**

After reviewing the literature on student level factors that affect student achievement, I chose five variables to measure student and school level characteristics.

A dummy variable created for student gender ranged from 0 to 1. The mean for females was .49, representing 49% of the sample, and for males was .51, representing 51% of the sample. This indicates a fairly even ratio of females to males among the students who participated in the HSLS:09 follow-up for the entire sample (n = 23,415).

The range for the dummy variables that were created for student race and ethnicity were based on the students who participated in the first follow-up study; these dummy variables also ranged from 0 to 1. The means indicate that the majority of the student population (n = 23,415) is White (54%), followed by Hispanic (16%), Black (10%), students coded as Other Race (10%), and Asian students (8%).

Student socioeconomic status (SES) is a composite variable based on the first follow-up with a range of -1.75 to 2.28. The mean of .08 shows that the average student falls within the middle range of SES for all students in the study; the standard deviation of .75 indicates that there is a wide dispersion in SES within the student population.
Next, I explored school context (i.e., public or private) and urbanicity (n = 23,415). Using a series of dummy variables, the univariate analysis indicated that for the students who participated in the first follow-up, 82% attended public school, 40% attended schools in urban areas, 36% attended a suburban school, and 24% attended a rural school.

Student Sociocultural Variables

After reviewing the literature on student level process variables (attitude and interactional) that affect student achievement, I chose nine variables to measure student sociocultural variables.

The range of the dummy variables created for the students who participated in the base year study and who took algebra prior to high school ranged from 0 to 1. A mean of .38 (n = 21,157) indicates that 38% of the students within the sample took algebra prior to high school.

Taken from the base year study, the students’ final grades in their most advanced eighth grade math courses ranged from 1 to 5, with 1 representing below a D and 5 representing an A. Algebra taken prior to high school had a mean of 4.01 (n = 20,824), which indicates that on average the students scored about a B in their most advanced eighth-grade math classes.

The scale of math class effort ranged from -3.79 to 1.18 (n = 17,047). With a mean of .06, the average student put forth slightly below the median math class effort. A standard deviation of 1.02 indicates a high level of dispersion within the math class effort scale.

The scale of students’ levels of identification with mathematics ranged from -1.54 to 1.82 (n = 20,024). With a mean of .05, the average student who identified as a math person fell within the lower middle range of all students in the study.
The scale of students’ mathematics utility ranged from -3.94 to 1.21 (n = 19,967). This variable had a mean of .004, which indicates that the average student’s perception of utility was within the higher middle range of all students in the study.

The scale of students’ mathematics self-efficacy ranged from -2.5 to 1.73 (n = 19,971) and had a mean of .04, which was within the middle range for all students in the study.

The scale of student’s mathematics interest ranged from -2.02 to 1.99 (n = 16,847). The average student has a mean of .03, which was within the higher to middle ranges for all students in the study.

The scale of student’s sense of belonging in school ranged from -4.35 to 1.59 (n = 20,680). With a mean of .07, the average student was within the higher middle range for all students within the study.

The scale of student’s school engagement ranged from -3.38 to 1.39 (n = 20,902). School engagement had a mean of .05, which is slightly below the center range for all students in the study.

**Teacher Sociocultural Variables**

After reviewing the literature on teacher-level variables that affect student achievement, I chose eight variables to control for their effects on students’ algebraic achievement levels. A series of dummy variables was created to evaluate all of the teacher sociocultural variables except for the scale of math teacher self-efficacy.

A univariate analysis of the teacher sociocultural variables that was made from the base year study demonstrates that for the students who participated in the study, 39% had a male teacher and 61% had a female teacher (n = 17,070). A majority of the students had White teachers (89%), followed by Hispanic teachers (4%), Black teachers (3%), Asian teachers (2%),
and teachers coded as Other Race (2%; n = 17,024). Additionally, for the students who participated, 79% of their teachers had a regular high school teaching certificate, 13% had an alternate certificate, 8% had no certificate, and 1% had a certificate to teach, but not to teach high school (n = 17,001).

The math teacher’s highest degree earned ranged from 0 to 1, with 0 representing a bachelor’s degree and 1 representing a master’s degree, education specialist, or other specialized degree. For the sample, 51% of the students had a teacher who had a master’s or specialist degree, while 18% of the students were taught by a teacher who held a math-related job prior to teaching, and the average years of experience was 10.14 years. A standard deviation of 8.49 for years of experience teaching high school mathematics indicated a high level of dispersion within the results.

A series of dummy variables was also created to explore math teacher perceptions of the average achievement level of students in their classes (n = 13,317). In this sample, 43% of teachers perceived that achievement levels widely differed, 28% perceived them to be average, 20% perceived them to be low, and 9% perceived them to be high.

Lastly, the scale of math teacher’s self-efficacy ranged from -3.26 to 3.01. A mean of .08, which indicated that the average student had a teacher who fell within the middle range of all students in the sample.
Table 4.1: Means, Standard Deviations, Ranges, and Descriptions of Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>Range</th>
<th>Description: HSLS Variable Name and Label</th>
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<td></td>
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<tr>
<td>F1 Algebraic Ability Score</td>
<td>20,594</td>
<td>0.72</td>
<td>1.15</td>
<td>-2.6 – 4.5</td>
<td>X2TXMTH ‘Mathematics theta score’</td>
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<td><strong>Base Year Teacher Perception</strong></td>
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<td>Teacher’s Perception of Professional Learning Community</td>
<td>14,490</td>
<td>0.03</td>
<td>.99</td>
<td>-4.07 – 1.70</td>
<td>X1TMCOMM - Scale of math teacher’s perception of math professional learning community for 12 variables: M1SHRIDEAS “Math teachers in this department share ideas on teaching”; M1WORKSHOP “Math teachers in department discuss what was learned at workshop/conference”; M1SHRSTWRK “Math teachers in this department share and discuss student work”; M1SHRLESSONS “Math teachers in this department discuss lessons that were not successful”; M1SHRBELIEFS “Math teachers in this department discuss beliefs about teaching/learning”; M1SHRMTHDS “Math teachers in department share research on effective teaching methods”; M1SHRELL “Math teachers in department share research on ELL instructional practices”; M1SHRAPPRECH “Math teachers in department explore approaches for underperforming students”; M1SHRCONTENT “Math teachers in department coordinate course content with other teachers”; M1MENTOR “Math teachers in this department provide support to new math teachers”; M1CHAIR “Math teachers are supported/encouraged by math department’s chair” $\alpha = 0.9$</td>
</tr>
<tr>
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<td>S.D.</td>
<td>Range</td>
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<td>0.08</td>
<td>0.75</td>
<td>-1.75 – 2.28</td>
<td>X2SES “Socioeconomic status composite”</td>
</tr>
<tr>
<td>F1 Attended Public School</td>
<td>23,415</td>
<td>0.82</td>
<td>0.38</td>
<td>0–1</td>
<td>X2CONTROL “School control”</td>
</tr>
<tr>
<td>F1 Urbanicity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>23,415</td>
<td>0.40</td>
<td>0.49</td>
<td>0–1</td>
<td>X2LOCALE “School locale (urbanicity)”</td>
</tr>
<tr>
<td>Suburban</td>
<td>23,415</td>
<td>0.36</td>
<td>0.48</td>
<td>0–1</td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td>23,415</td>
<td>0.24</td>
<td>0.42</td>
<td>0–1</td>
<td></td>
</tr>
<tr>
<td>Variable</td>
<td>N</td>
<td>Mean</td>
<td>S.D.</td>
<td>Range</td>
<td>Description: HSLS Variable Name and Label</td>
</tr>
<tr>
<td>----------------------------------------------------</td>
<td>-------</td>
<td>------</td>
<td>------</td>
<td>-------</td>
<td>--------------------------------------------</td>
</tr>
<tr>
<td><strong>Student Sociocultural</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BY Algebra Taken Prior to High School</td>
<td>21,157</td>
<td>0.38</td>
<td>0.48</td>
<td>0 – 1</td>
<td>S1M8 “Most advanced math course taken by student in the 8th grade” 0 = not completed one year of algebra (math 8, adv math 8, pre-algebra, other) &amp; 1 = complete at least one year of algebra (algebra I, algebra II, Trig, Geometry)</td>
</tr>
<tr>
<td>BY Students' Prior Achievements</td>
<td>20,824</td>
<td>4.01</td>
<td>1.00</td>
<td>1 – 5</td>
<td>S1M8GRADE “Final grade in 9th grader's most advanced 8th grade math course” (1 = Below D, 2 = D, 3 = C, 4 = B, 5 = A)</td>
</tr>
<tr>
<td>F1 Math Class Effort</td>
<td>17,047</td>
<td>0.06</td>
<td>0.96</td>
<td>-3.79 – 1.18</td>
<td>X2EFFO - Scale of math class effort for 4 variables: S2MATTENTION “How often paid attention to spring 2012 math teacher”; S2MONTIME “How often turned in assignments on time in spring 2012 math course”; S2MSTOPTRYING “How often stopped trying in spring 2012 math course”; S2MGETBY “How often did as little work as possible in spring 2012 math course” α = 0.74</td>
</tr>
<tr>
<td>F1 Math Identity</td>
<td>20,024</td>
<td>0.05</td>
<td>1.02</td>
<td>-1.54 – 1.82</td>
<td>X2MTHID - Scale of student's mathematics identity for 2 variables: S2MPERSON1 “Teenager sees himself/herself as a math person”; S2MPERSON2 “Others see teenager as a math person” α = 0.89</td>
</tr>
<tr>
<td>F1 Math Utility</td>
<td>19,967</td>
<td>0.004</td>
<td>1.01</td>
<td>-3.94 – 1.21</td>
<td>X2MTHUTI - Scale of student's mathematics utility for 3 variables: S2MUSELIFES2 “Teenager thinks math is useful for everyday life”; S2MUSECLGS2 “Teenager thinks math will be useful for college”; S2MUSEJOB “Teenager thinks math is useful for future career” α = 0.82</td>
</tr>
<tr>
<td>Variable</td>
<td>N</td>
<td>Mean</td>
<td>S.D.</td>
<td>Range</td>
<td>Description: HSLS Variable Name and Label</td>
</tr>
<tr>
<td>--------------------------</td>
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<td>------</td>
<td>------</td>
<td>---------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>BY Math Self-Efficacy</td>
<td>19,771</td>
<td>0.04</td>
<td>1.00</td>
<td>-2.5 – 1.73</td>
<td>X1MTHEFF - Scale of student's mathematics self-efficacy for 4 variables: S2MTESTS “Teen confident can do an excellent job on (spring 2012) math tests”; S2MTEXTBOOK “Teen certain can understand (spring 2012) math textbook”; S2MSKILLS “Teen certain can master skills taught in (spring 2012) math course”; S2MASSEXCL “Teen confident can do excellent job on (spring 2012) math assignments” $\alpha = 0.89$</td>
</tr>
<tr>
<td>BY Math Interest</td>
<td>16,847</td>
<td>0.03</td>
<td>1.01</td>
<td>-2.02 – 1.99</td>
<td>X1MTHINT - Scale of student's interest in fall 2009 math course for 5 variables: S2MWASTE “Teen thinks (spring 2012) math course is a waste of time”; S2MBORING “Teen thinks (spring 2012) math course is boring”; S2FAVSUBJ “Teenager's favorite school subject”; S2MENJOYS “Teen is taking (spring 2012) math b/c he/she really enjoys math”; S2MENJOYING “Teen is enjoying (spring 2012) math course” $\alpha = 0.69$</td>
</tr>
<tr>
<td>BY Sense of School Belonging</td>
<td>20,680</td>
<td>0.07</td>
<td>1.01</td>
<td>-4.35 – 1.59</td>
<td>X1SCHOOLBEL - Scale of student's sense of school belonging for 5 variables: S1SAFE “9th grader feels safe at school”; S1PROUD “9th grader is proud to be part of his/her school”; S1TALKPROB “9th grader has teacher/adult in school he/she can talk to about problems”; S1SCHWASTE “9th grader feels that school is often a waste of time”; S1GOODGRADES “Getting good grades is important to 9th grader” $\alpha = 0.72$</td>
</tr>
</tbody>
</table>
Table 4.1 (Cont.): Means, Standard Deviations, Ranges, and Descriptions of Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>Range</th>
<th>Description: HSLS Variable Name and Label</th>
</tr>
</thead>
<tbody>
<tr>
<td>BY School Engagement</td>
<td>20,902</td>
<td>0.05</td>
<td>0.99</td>
<td>-3.38 – 1.39</td>
<td>X1SCHOOLENG - Scale of student's school engagement for 4 variables: S1NOHWDN “How often 9th grader goes to class without his/her homework done”; S1NOPAPER “How often 9th grader goes to class without pencil or paper”; S1NOBOOKS “How often 9th grader goes to class without books”; S1LATE “How often 9th grader goes to class late” α = 0.67</td>
</tr>
<tr>
<td>Teacher Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher is Male</td>
<td>17,070</td>
<td>0.39</td>
<td>.50</td>
<td>0 – 1</td>
<td>M1SEX “Math teacher's sex”</td>
</tr>
<tr>
<td>Teacher is Female</td>
<td>17,070</td>
<td>0.61</td>
<td>.50</td>
<td>0 – 1</td>
<td></td>
</tr>
<tr>
<td>Teacher Race/Ethnicity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher is Black</td>
<td>17,024</td>
<td>0.03</td>
<td>0.18</td>
<td>0 – 1</td>
<td>X1TMRACE “Math teacher race/ethnicity-composite”</td>
</tr>
<tr>
<td>Teacher is White</td>
<td>17,024</td>
<td>0.89</td>
<td>0.32</td>
<td>0 – 1</td>
<td></td>
</tr>
<tr>
<td>Teacher is Hispanic</td>
<td>17,024</td>
<td>0.04</td>
<td>0.19</td>
<td>0 – 1</td>
<td></td>
</tr>
<tr>
<td>Teacher is Asian</td>
<td>17,024</td>
<td>0.02</td>
<td>0.15</td>
<td>0 – 1</td>
<td></td>
</tr>
<tr>
<td>Teacher is Other Race</td>
<td>17,024</td>
<td>0.02</td>
<td>0.13</td>
<td>0 – 1</td>
<td></td>
</tr>
<tr>
<td>Teacher Certificate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Certificate</td>
<td>17,001</td>
<td>0.08</td>
<td>0.27</td>
<td>0 – 1</td>
<td>X1TMCERT “Math teacher's math teaching certification”</td>
</tr>
<tr>
<td>Not a Regular Certificate</td>
<td>17,001</td>
<td>0.13</td>
<td>0.33</td>
<td>0 – 1</td>
<td></td>
</tr>
<tr>
<td>Regular not High School</td>
<td>17,001</td>
<td>0.01</td>
<td>0.10</td>
<td>0 – 1</td>
<td></td>
</tr>
<tr>
<td>Regular High School</td>
<td>17,001</td>
<td>0.79</td>
<td>0.41</td>
<td>0 – 1</td>
<td></td>
</tr>
<tr>
<td>Variable</td>
<td>N</td>
<td>Mean</td>
<td>S.D.</td>
<td>Range</td>
<td>Description: HSLS Variable Name and Label</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>-------</td>
<td>------</td>
<td>------</td>
<td>-------</td>
<td>----------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Math Teacher's Highest Degree Earned</td>
<td>17,067</td>
<td>0.51</td>
<td>0.50</td>
<td>0–1</td>
<td>M1HIDE “Math teacher's highest degree earned” 0 = bachelor’s degree, 1 = master’s degree or higher</td>
</tr>
<tr>
<td>Math Teacher Math Job Prior to Teaching</td>
<td>17,036</td>
<td>0.18</td>
<td>0.39</td>
<td>0–1</td>
<td>M1MATHJOB “Math teacher held math-related job prior to becoming a teacher”</td>
</tr>
<tr>
<td>Years Teaching HS Math</td>
<td>17,020</td>
<td>10.14</td>
<td>8.49</td>
<td>1–31</td>
<td>M1MTHYRS912 “Years math teacher has taught high school math”</td>
</tr>
<tr>
<td>Perception of Class Achievement Level</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower</td>
<td>13,317</td>
<td>0.20</td>
<td>0.40</td>
<td>0–1</td>
<td>M1ACHIEVE “Math teacher’s perception of the average achievement level of students in their class”</td>
</tr>
<tr>
<td>Widely Differ</td>
<td>13,317</td>
<td>0.43</td>
<td>0.50</td>
<td>0–1</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>13,317</td>
<td>0.28</td>
<td>0.45</td>
<td>0–1</td>
<td></td>
</tr>
<tr>
<td>Higher</td>
<td>13,317</td>
<td>0.09</td>
<td>0.29</td>
<td>0–1</td>
<td></td>
</tr>
</tbody>
</table>
Table 4.1 (Cont.): Means, Standard Deviations, Ranges, and Descriptions of Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>Range</th>
<th>Description: HSLS Variable Name and Label</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math Teacher's Self-Efficacy</td>
<td>14,974</td>
<td>0.08</td>
<td>0.95</td>
<td>-3.26 – 3.01</td>
<td>X1TMEFF - Scale of math teacher's self-efficacy for 8 variables: M1FAMILY “Amount a student can learn is primarily related to family background”; M1DISCIPLINE “Students not disciplined at home not likely to accept school discipline”; M1STUACHIEVE “Teachers are limited b/c home environment influences student achievement”; M1PARENT “If parents would do more for children teacher could do more for students”; M1RETAIN “Knows how to increase student retention of info from lesson to lesson”; M1REDIRECT “Knows techniques to redirect disruptive students quickly”; M1GETTHRU “Can get through to even the most difficult or unmotivated students”; M1HOMEFX “Cannot do much b/c student motivation/performance depends on home” α = 0.71</td>
</tr>
</tbody>
</table>

Note: SD denotes standard deviation and α denotes the Cronbach’s alpha coefficient of reliability; Dept represents Department. BY = Variable taken from base year sample; F1 = Variable taken from HSLS:09 first follow-up.
Bivariate Analysis

This section presents bivariate analysis results for the variables of interest. This is done using a series of t-tests to examine the significance between the binary variables, exploring ANOVA results, and using Pearson’s correlation matrices to explore potential pair-wise relationships between the continuous variables involved within the four conceptual models.

Table 4.2 presents the results from t-tests performed on six dummy variables to determine if their mean scores on the dependent variable “algebraic ability score” are significantly different. Bivariate analysis revealed that among the students who participated in the HSLS:09 first follow-up survey, “Public School” appears to have had a significant impact on their algebraic ability scores. Students who reported not attending a public school had a higher algebraic ability score (N = 1.21) than students who reported attending public school (N = .64). This difference is statistically significant at the .01 level.

The following dummy variables were taken from the base year survey data. The variable “Took Algebra Prior to 9th Grade” had a significant impact on student algebraic ability scores. Students who took at least one full year of algebra had a higher algebraic ability score (N = 1.38) than student who did not complete one full year of algebra (N = .34). This difference is statistically significant at the .01 level.

The variables “Teacher Gender,” “Teacher Previously Held Math Job,” and “Teacher’s Highest Degree Earned” all had a significant impact on student algebraic ability scores. With regard to their teacher’s gender, students who had a female teacher scored higher (N = .77) than those who had a male teacher (N = .69). If the teacher held a math job prior, his or her students scored higher (N = .75) than those students whose teachers did not hold a job prior (N = .68). Lastly, students whose teachers had a bachelor’s degree scored higher (N = .81) than students
whose teachers had at least a master’s or specialist degree (N = .67). All the differences were statistically significant at the .01 level.

Of the dummy variables tested, the bivariate analysis of the mean difference between student gender and student algebraic ability scores was not significant.
Table 4.2: Comparison of Means for Student Algebraic Assessment Scores by Independent Variables

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>F1 Student Gender</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>10,384</td>
<td>.73</td>
<td>1.20</td>
</tr>
<tr>
<td>Female</td>
<td>10,210</td>
<td>.71</td>
<td>1.10</td>
</tr>
<tr>
<td><strong>F1 Public School</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>16,797</td>
<td>.64**</td>
<td>1.15</td>
</tr>
<tr>
<td>No</td>
<td>3,336</td>
<td>1.21</td>
<td>1.01</td>
</tr>
<tr>
<td><strong>BY Took Algebra Prior to 9th Grade</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One Full Year</td>
<td>7,185</td>
<td>1.38**</td>
<td>.99</td>
</tr>
<tr>
<td>Not Completed One Full Year</td>
<td>11,218</td>
<td>.34</td>
<td>1.09</td>
</tr>
<tr>
<td><strong>BY Teacher’s Gender</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>5,955</td>
<td>.69**</td>
<td>1.12</td>
</tr>
<tr>
<td>Female</td>
<td>9,137</td>
<td>.77</td>
<td>1.16</td>
</tr>
<tr>
<td><strong>BY Teacher Previously Held Math Job</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>2,722</td>
<td>.75**</td>
<td>1.14</td>
</tr>
<tr>
<td>No</td>
<td>12,341</td>
<td>.68</td>
<td>1.15</td>
</tr>
<tr>
<td><strong>BY Teacher’s Highest Degree Earned</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bachelor’s Degree</td>
<td>7,696</td>
<td>.81**</td>
<td>1.17</td>
</tr>
<tr>
<td>Master’s Degree or Higher</td>
<td>7,393</td>
<td>.67</td>
<td>1.11</td>
</tr>
</tbody>
</table>

**p<0.01

Note: Within each predictor on the dependent variable, the subscript of the level of statistical significance is placed only on one of the two categories to indicate that the relative mean scores are statistically different from each other. BY = Variable taken from base year sample; F1 = Variable taken from HSLS:09 first follow-up.
Table 4.3 displays the results from a one-way analysis of variance (ANOVA) performed to compare the mean student algebraic scores for five independent variables. Bivariate analysis revealed the following about the students within the survey population:

Among the students who participated in the HSLS: 09 follow-up survey, the variables “Student’s Race” and “Urbanicity” had a significant impact on student algebraic ability scores. The variable “Student’s Race” indicated that Asian students scored higher on average (N = 1.53), followed by White students (N = .80), students coded Other Race (N = .67), Hispanic students (N = .39), and Black students (N = .18). The mean for each racial group was statistically different from all other groups at the .05 level of significance.

The variable “Urbanicity” indicated that students who lived in the suburbs scored higher (N = .79) than students who live in urban areas (N = .78) or rural areas (N = .59). The mean algebraic ability score for rural students was statistically different from urban and suburban students at the .05 level of significance; however, urban and suburban students were not statistically different from each other at any of the levels of statistical significance considered.

Among the students who participated in the HSLS: 09 base year survey, the variables “Teacher Race,” “Teacher Cert Level,” and “Teachers Perception of Class Achievement” had a significant impact on student algebraic ability scores.

The variable “Teacher Race” indicated that students with an Asian teacher scored higher (N = .86) than those with White teachers (N = .77), followed by those with Hispanic teachers (N = .54), those with teachers coded Other Race (N = .38), and those with Black teachers (N = .28). Black teachers, Hispanic teachers, and teachers coded Other Race were not statistically different from each other at any of the levels of statistical significance considered. White and Asian
teachers also were not statistically different from each other; however, the two groups respectively were different from each other at the .05 level of significance.

The variable “Teacher Cert Level” showed that students of teachers with no certificate scored higher (N = .80) than students of teachers with a regular high school certificate (N = .77), followed by students of teachers with regular certificates but not high school certified (N = .63) and students of teachers not regularly certified (N = .50). Students of teachers without a regular certificate were significantly different from students of teachers with regular high school certificates at the .05 level of significance. Students of teachers with no certificate or with regular certificates but not high school certified were not statistically different from each other or the other two groups at any level of significance considered.

The variable “Teachers Perception of Class Achievement” showed that students of teachers with a higher perception of class achievement scored higher (N = 1.49) than students of teachers with an average perception level (N = .60), followed by students of teachers with widely differing perceptions (N = .41) and students of teachers with lower perceptions of student achievement (N = -.01). The mean algebraic scores for students within each teacher perception level were statistically different from all other groups at the .05 level of significance.
Table 4.3: Weighted Comparison of Means for Student Algebraic Assessment Scores by Independent Variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>F1 Student’s Race</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student is Black</td>
<td>2,121</td>
<td>.18&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.00</td>
</tr>
<tr>
<td>Student is White</td>
<td>11,532</td>
<td>.80&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.13</td>
</tr>
<tr>
<td>Student is Hispanic</td>
<td>3,271</td>
<td>.39&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.04</td>
</tr>
<tr>
<td>Student is Asian</td>
<td>1,675</td>
<td>1.53&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1.20</td>
</tr>
<tr>
<td>Student is Other Race</td>
<td>1,995</td>
<td>.67&lt;sup&gt;e&lt;/sup&gt;</td>
<td>1.12</td>
</tr>
<tr>
<td><strong>F1 Urbanicity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>8,227</td>
<td>.78</td>
<td>1.16</td>
</tr>
<tr>
<td>Suburb</td>
<td>6,146</td>
<td>.79</td>
<td>1.15</td>
</tr>
<tr>
<td>Rural</td>
<td>5,756</td>
<td>.59&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.12</td>
</tr>
<tr>
<td><strong>BY Teacher Race</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher is Black</td>
<td>502</td>
<td>.28&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.11</td>
</tr>
<tr>
<td>Teacher is White</td>
<td>13,400</td>
<td>.77&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.14</td>
</tr>
<tr>
<td>Teacher is Asian</td>
<td>356</td>
<td>.86&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.22</td>
</tr>
<tr>
<td>Teacher is Hispanic</td>
<td>559</td>
<td>.54&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.15</td>
</tr>
<tr>
<td>Teacher is Other Race</td>
<td>234</td>
<td>.38&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.06</td>
</tr>
<tr>
<td><strong>BY Teacher Cert Level</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Certificate</td>
<td>1,130</td>
<td>.80</td>
<td>1.21</td>
</tr>
<tr>
<td>Not Regular Certificate</td>
<td>1,856</td>
<td>.50&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.10</td>
</tr>
<tr>
<td>Regular not HS Certificate</td>
<td>158</td>
<td>.63</td>
<td>1.13</td>
</tr>
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<td>Widely Differ</td>
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<td>.41&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1.07</td>
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Note: Within the predictors on the dependent variable, two categories share a common superscript if their difference is not statistically significant at the 0.05 level. Those compared means without a common superscript do not differ from each other at any level of statistical significance considered. BY = Variable taken from base year sample; F1 = Variable taken from HSLS:09 first follow-up.
Next, the relationship among variables was examined using correlation matrices. Table 4.4 displays the results from Pearson’s Correlations that were performed to determine whether the continuous independent variables had a statistically significant ($p < .05$) association with the dependent variable “Algebraic Ability Score.” Correlation coefficients (Pearson’s $r$) indicate the degree of linear relationship that each of the continuous independent variables had with the dependent variable and with each other. The strength of the correlation coefficient was determined according to the following parameters: $0 < |r| < .3$ is a weak correlation, $.3 < |r| < .7$ is a moderate correlation, and $|r| > .7$ is a strong correlation. To guard against potential threats of multicollinearity, any predictors that had correlation coefficients above .80 were removed from the analysis. Pearson’s Correlations revealed the following in relation to the population of students in this study:

The student’s socioeconomic status (SES) had a moderate positive correlation with student algebraic ability score ($r = .41, p < .01$). SES had a weak positive correlation with all other continuous independent variables at the .01 level of statistical significant except for student math utility. SES was not significantly related to student math utility.

Student math class effort had a moderate positive correlation with math interest ($r = .49, p < .01$), math self-efficacy ($r = .45, p < .01$), and math identity ($r = .33, p < .01$). Math class effort had a weak positive correlation with student math utility ($r = .27, p < .01$), student school engagement ($r = .26, p < .01$), student algebraic ability score ($r = .23, p < .01$), student school belonging ($r = .22, p < .01$), teacher self-efficacy ($r = .04, p < .01$), teacher perception of professional learning communities ($r = .03, p < .01$), and teacher years of mathematics teaching ($r = .02, p < .01$).
Student math identity had a moderate positive correlation with student math self-efficacy ($r = .58, p < .01$), student math interest ($r = .57, p < .01$), student math utility ($r = .42, p < .01$), and student math identity ($r = .41, p < .01$). Student math identity also had a weak positive but significant correlation with student belonging and engagement ($r = .14, p < .01$), teacher years teaching mathematics ($r = .06, p < .01$), teacher self-efficacy ($r = .05, p < .01$), and teacher perception of professional learning communities ($r = .02, p < .05$).

Student math utility had a moderate positive correlation with student math interest ($r = .43, p < .01$) and student math self-efficacy ($r = .37, p < .01$). Math utility had a weak positive correlation with student algebraic ability ($r = .16, p < .01$), student school belonging ($r = .16, p < .01$), and student school engagement ($r = .09, p < .01$). Lastly, student math utility had a weak negative correlation with teacher perception of professional learning communities ($r = -.02, p < .01$). Math utility had no significance with teacher years of teaching mathematics or teacher self-efficacy at any level of significance tested.

Student math self-efficacy had a moderate positive correlation with student math interest ($r = .57, p < .01$) and student algebraic ability score ($r = .30, p < .01$). Student math self-efficacy had a weak positive correlation with student school belonging ($r = .17, p < .01$), student math engagement ($r = .13, p < .01$), teacher self-efficacy ($r = .05, p < .01$), teacher years teaching ($r = .03, p < .01$), and teacher collaboration ($r = .03, p < .01$).

Student math interest had a weak positive correlation with student algebraic ability score ($r = .24, p < .01$), student school belonging ($r = .19, p < .01$), student school engagement ($r = .15, p < .01$), teacher self-efficacy ($r = .04, p < .01$), teacher years teaching math ($r = .03, p < .01$), and teacher perception of professional learning communities ($r = .02, p < .05$).
Student math belonging had a moderate positive correlation with school engagement ($r = .30, p < .01$). Student math belonging had a weak positive correlation with student algebraic ability score ($r = .19, p < .01$), teacher years teaching mathematics ($r = .07, p < .01$), teacher self-efficacy ($r = .06, p < .01$), and teacher collaboration ($r = .03, p < .01$).

Student engagement had a weak positive correlation with student algebraic ability score ($r = .21, p < .01$), teacher years teaching mathematics ($r = .06, p < .01$), teacher self-efficacy ($r = .03, p < .01$), and teacher collaboration ($r = .02, p < .05$).

Teacher years teaching mathematics had a weak positive correlation with student algebraic ability score ($r = .14, p < .01$) and teacher self-efficacy ($r = .08, p < .01$). Teacher years teaching mathematics had no significant correlation with teacher collaboration at any level of significance studied. Teacher self-efficacy had a weak positive correlation with teacher collaboration ($r = .11, p < .01$) and student algebraic ability score ($r = .09, p < .01$). Lastly, teacher collaboration also had a weak positive correlation with student algebraic ability score ($r = .07, p < .01$).
Table 4.4: Pearson’s Correlations among Independent Variables and Students’ Algebraic Achievement Scores

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<td>.05**</td>
<td>.04**</td>
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<td>.03**</td>
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*p<0.05   **p<0.01

Note: R denotes Students; Tx denotes Teachers; Dept denotes Department; ELL denotes English Language Learners.
BY = Variable taken from base year sample; F1 = Variable taken from HSLS:09 first follow-up.
Multivariate Analysis

The primary goal of this dissertation is to examine the influence of teachers’ perception of professional learning communities on students’ achievement in algebra among other predictor variables (student-level and teacher-level variables). To this end, OLS regressions were used to determine the utility of selected independent variables for predicting students’ algebraic achievement scores.

Four multivariate regressions were used in this analysis. Model I: Perception of PLCs, explores the impact of teacher perception of professional learning communities solely on student algebraic abilities. This is a composite variable used to measure teacher perception of PLCs in the absence of other characteristic that are known to have an impact on student math outcomes. Model II: Student Demographics integrates student demographic and school-level variables into the prediction model. This includes variables that characterize students, such as the variables for gender, race, SES, and school identification (e.g., public versus private school and school urbanicity). Model III: Student Sociocultural incorporates student sociocultural variables that characterize the students’ prior academic histories and their affective attributes – i.e., math class effort, identity, utility, self-efficacy, and interest. Finally, Model IV: Teacher Sociocultural combines previous variables with teacher-level sociocultural variables. These include variables for teachers’ sociocultural characteristics to examine the relative impact they all have in light of teacher perception on student algebraic achievement levels.

Each of these four models will be included in regression analysis for the entire sample of students (Models I through IV), for male students only (Models V through VIII), and finally for female students only (Models IX through XII).
Analysis and Interpretation of Algebraic Ability Scores for All Students

Table 4.5 presents the Unstandardized Regression Coefficients for the dependent variable, “Student Algebraic Achievement.” The four models in Table 4.5 – Models I, II, III, and IV – show the utility of teacher perception of professional learning communities, student demographic, and student and teacher sociocultural variables for predicting student algebraic achievement for the entire sample.
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<tr>
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<th>Model I</th>
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<th>Model III</th>
<th>Model IV</th>
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<td>(-.08)</td>
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Table 4.5 (cont.): Unstandardized Regression Coefficients (Beta in parentheses) for Student Algebraic Achievement for Entire Sample (N = 7,078)

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<th>Model III</th>
<th>Model IV</th>
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Table 4.5 (cont.): Unstandardized Regression Coefficients (Beta in parentheses) for Student Algebraic Achievement for Entire Sample (N = 7,078)

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<tr>
<td>Widely Differ</td>
<td>.21***</td>
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<td>.96***</td>
<td>-.43***</td>
<td>-.59***</td>
</tr>
<tr>
<td>F</td>
<td>33.46***</td>
<td>178.26***</td>
<td>317.31***</td>
<td>203.74***</td>
</tr>
<tr>
<td>Adjusted R²</td>
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<td>.20</td>
<td>.46</td>
<td>.49</td>
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<tr>
<td>R² Change</td>
<td>.01</td>
<td>.20</td>
<td>.26</td>
<td>.04</td>
</tr>
</tbody>
</table>

† p < .1  * p < .05  **p < .01  ***p < .001; BY = Variable taken from base year sample; F1 = Variable taken from HSLS:09 first follow-up.
Teacher Perception Variable

Model I: Perception of PLCs indicates that without controlling for any other student- or teacher-level variables, teacher perception of PLCs had a positive impact on student algebraic achievement levels. For every unit of teacher perception, students scored .08 units higher in their algebraic achievement. This relationship is robust and statistically significant at the .001 level. With the incorporation of student- and teacher-level characteristics, the impact moderates. In Model II: Student Demographics, with the incorporation of the student demographic variable, students performed .04 units higher. This relationship is significant at the .01 level. Model III: Student Sociocultural, which incorporates student sociocultural variables. It had teacher perception adding .02 units to student algebraic achievement scores at a significance level approaching 0.1. The teacher perception of PLCs variable was not significant in Model IV: Teacher Sociocultural once other more significant teacher-level characteristics were controlled for.

Student Demographic Variables

Models II through IV showed significant gender differences in student academic achievement levels. Controlling for specific variables in each model, the student algebraic achievement of female students was .04, .05, and .06 units lower, respectively, than their male counterparts. The relationship was statistically significant at the .05 level in Models III: Student Sociocultural and at the .01 level in Model IV: Teacher Sociocultural.

Student race appears be an important factor in predicting algebraic achievement. Controlling for all other variables, the algebraic achievement for Black students was .49, .38, and .32 units lower than their White counterparts in Models II through IV, respectively. Hispanic students scored .17, .13, and .09 units lower than their White counterparts. In contrast to Black
and Hispanic students, students who identified as Asian scored .61, .32, and .28 units higher than their White counterparts. The Black, Hispanic, and Asian predictors were robust and statistically significant at the .001 level.

Student socioeconomic status (SES) appears to have been a significant predictor of student algebraic achievement levels when controlling for all other variables. For each unit of SES, students’ algebraic achievement increased by .51, .30, and .27 units for Models II through IV, respectively. The relationship was robust and statistically significant at the .001 level for all three models. Model II: Student Demographics showed that SES had the strongest effect on algebraic achievement (Beta = .34) prior to controlling for student and teacher sociocultural variables. The effect of SES decreased in Model III: Student Sociocultural and Model IV: Teacher Sociocultural, although it remained relatively strong when controlling for other variables.

Attending a public school was a significant factor only in Model II: Student Demographics. If a student attended public school, the model predicts that their algebraic achievement will be .10 units lower than their private school counterparts. This was statistically significant at the .01 level. The variable was not a significant predictor in Models III: Student Sociocultural and Model IV: Teacher Sociocultural.

Attending an urban school was significant in Models III: Student Sociocultural and Model IV: Teacher Sociocultural at the .1 significance level. Students who attended urban schools had an achievement level that was .05 units lower than their suburban counterparts. Rural school students’ algebraic achievement levels were .12, .10, and .08 units lower Models II through IV, respectively, when controlling for all other variables. This predictor was robust and
statistically significant at the .001 level for Model II: Student Demographics and Model III: Student Sociocultural, and at the .05 level for Model IV: Teacher Sociocultural.

**Student Sociocultural Variables**

Algebra taken prior to high school was an important factor in predicting student algebraic achievement levels. Controlling for all other variables, if a student took algebra prior to high school, this predictor increased their achievement level by .62 and .47 units for Models III: Student Sociocultural and Model IV: Teacher Sociocultural, respectively. This was robust and significant at the .001 level for both models. This variable also had the greatest effect (Beta = .28) on students’ algebraic achievement levels in Model III: Student Sociocultural.

A student’s prior achievement was also robust and a powerful predictor of student algebraic achievement levels. On a scale from 1 to 5, where 1 = below a D and 5 = A, every incremental increase in math achievement prior to high school increased the student’s algebraic achievement by .26 and .21 units for Models III: Student Sociocultural and Model IV: Teacher Sociocultural, respectively. This predictor was significant at the .001 level. Controlling for all other variables, a student’s prior achievement in Model III: Student Sociocultural also had the second-strongest effect (Beta = .22) on algebraic achievement, following the variable for algebra taken prior to high school.

Math class effort was a significant predictor of student algebraic achievement levels. Every unit of math class effort increased algebraic achievement by .04 units. The marker was significant at the .01 level for both models.

Math identity and self-efficacy were both robust and powerful predictors of algebraic achievement for students in the sample. Each unit of math identity added .22 and .21 units to algebraic achievement. Math identity also had the third-largest effect on algebraic achievement
in Models III: Student Sociocultural and Model IV: Teacher Sociocultural. Each unit of math self-efficacy increased algebraic achievement by .08 units in both models. Both variables were significant at the .001 level.

Math utility was not a significant predictor in Model III: Student Sociocultural; however, it approached significance in Model IV: Teacher Sociocultural. Controlling for all other variables in Model IV: Teacher Sociocultural, math utility contributed .02 units for every unit of math utility. This was statistically significant at the .1 level.

School engagement was also a significant predictor of student algebraic achievement levels. Each unit of student engagement increased algebraic achievement by .03 in Models III: Student Sociocultural and Model IV: Teacher Sociocultural. This was statistically significant at the .05 level.

Neither math interest nor sense of school belonging were statistically significant in predicting math students’ algebraic achievement levels.

**Teacher Sociocultural Variables**

When controlling for all other variables, the teacher sociocultural variables that were added to Model IV: Teacher Sociocultural also offered significant markers for predicting student algebraic achievement levels. Teacher gender was not significant in predicting algebraic achievement; however, algebraic achievement was sensitive to the race and ethnicity of the teacher. Students who had a Black teacher or a teacher categorized as Other Race decreased their achievement scores by .10 and .15 units respectively over students who had White teachers. Students of Black teachers and teachers categorized as Other Race were approaching significance at the .1 level. Students of Asian teachers increased their scores by .12 units over
their counterparts with White teachers. This was statistically significant at the .05 level. Students who had a Hispanic teacher had no significant changes in their scores over have a White teacher.

The teacher’s degree and certification levels also had significant effects on student algebraic achievement levels. Students of teachers with at least a master’s or specialist degree added .04 units to their algebraic achievement scores. Additionally, students who had a teacher with a regular high school math teaching certificate contributed .07 units to their algebraic achievement scores over students who had teachers without a certificate. Both indicators approached significance at the .1 level.

Lastly, teacher perception of average class achievement was a significant predictor of student algebraic achievement levels. Students of teachers who perceived average class achievement as being average increased algebraic achievement by .28 units over students of teachers who perceived achievement as being low. Students of teachers who perceived average class achievement as being high increased their achievement by .64 over students of teachers who perceived achievement as being low. When controlling for all other variables, this predictor had the strongest effect (Beta = .27) on student achievement over any other variable. In Model IV, this effect was followed by the variable algebra taken prior to high school (Beta = .21) and math identity (Beta = .19). Students of teachers who perceived average class achievement as being widely differing increased their achievement by .21 over students of teachers who perceived average class achievement as being low. All three categories were robust and statistically significant at the .001 level.

**Coefficients of Determination for Models I through IV**

The Adjusted $R^2$ for Models I through IV were .01, .20, .46, and .49, respectively. This indicated that without controlling for student or teacher characteristics, teacher perception of
PLCs accounted for 1% of the variance in students’ algebraic abilities. The remaining Models II through IV accounted for 20%, 46%, and 49%, respectively. The F-test for each model was statistically significant at the .001 level, confirming that the independent variables in each model were useful for predicting the outcome variable.

**Analysis and Interpretation of Algebraic Ability Scores for Male Students**

Table 4.6 presents Unstandardized Regression Coefficients for the dependent variable “Student Algebraic Achievement.” The four models in Table 4.6 – Models V, VI, VII, and VIII – show the utility of teacher perception of PLCs, student demographics, and student and teacher sociocultural variables for predicting student algebraic achievement for male students only.
Table 4.6: Unstandardized Regression Coefficients (Beta in parentheses) for Student Algebraic Achievement for Male Students (N = 3,501)

<table>
<thead>
<tr>
<th></th>
<th>Model V</th>
<th>Model VI</th>
<th>Model VII</th>
<th>Model VIII</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Base Year Teacher Perception</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher Perception of PLCs</td>
<td>.08***</td>
<td>.03†</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td></td>
<td>(.07)</td>
<td>(.03)</td>
<td>(.00)</td>
<td>(.00)</td>
</tr>
<tr>
<td><strong>Student Demographic</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F1 Student’s Race (Ref: White)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student is Black</td>
<td>-.60***</td>
<td>-.48***</td>
<td>-.41***</td>
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<tr>
<td></td>
<td>(-.14)</td>
<td>(-.11)</td>
<td>(-.10)</td>
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<tr>
<td>Student is Hispanic</td>
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<td>-.15***</td>
<td>-.11*</td>
<td></td>
</tr>
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<td></td>
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<td>(-.05)</td>
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<td>Student is Asian</td>
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<td>.31***</td>
<td>.27***</td>
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</tr>
<tr>
<td></td>
<td>(.15)</td>
<td>(.07)</td>
<td>(.06)</td>
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</tr>
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<td>.00</td>
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<tr>
<td></td>
<td>(.01)</td>
<td>(-.01)</td>
<td>(.00)</td>
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<tr>
<td>F1 Student’s Socioeconomic Status</td>
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<td>.28***</td>
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<td></td>
<td>(.35)</td>
<td>(.20)</td>
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<td>F1 Attended Public School</td>
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<td>F1 Urbanicity (Ref: Suburban)</td>
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<td>-.03</td>
<td>-.04†</td>
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<td>(-.02)</td>
<td>(-.02)</td>
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<tr>
<td>Rural School</td>
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<td>-.10**</td>
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</tr>
<tr>
<td></td>
<td>(-.06)</td>
<td>(-.04)</td>
<td>(-.03)</td>
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<tr>
<td><strong>Student Sociocultural</strong></td>
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<tr>
<td>BY Algebra Taken Prior to High School</td>
<td>.63***</td>
<td>.49***</td>
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<td></td>
<td>(.27)</td>
<td>(.21)</td>
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<tr>
<td>BY Student’s Prior Achievement</td>
<td>.24***</td>
<td>.18***</td>
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<td></td>
<td>(.20)</td>
<td>(.15)</td>
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<td>F1 Math Class Effort</td>
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<td>.04**</td>
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<td>(.03)</td>
<td>(.03)</td>
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<tr>
<td>F1 Math Identity</td>
<td>.26***</td>
<td>.24***</td>
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<tr>
<td></td>
<td>(.23)</td>
<td>(.21)</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Model V</td>
<td>Model VI</td>
<td>Model VII</td>
<td>Model VIII</td>
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<tr>
<td>---------------------------</td>
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<td>F1 Math Utility</td>
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<td>(.00)</td>
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<tr>
<td>BY Math Self-Efficacy</td>
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<td>.09***</td>
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<td>BY Math Interest</td>
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<td>(.01)</td>
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<tr>
<td>BY Sense of School Belonging</td>
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<tr>
<td>BY School Engagement</td>
<td>.04**</td>
<td>.04*</td>
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<tr>
<td></td>
<td>(.04)</td>
<td>(.03)</td>
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<td><em>Base Year Teacher Sociocultural</em></td>
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<td>(.01)</td>
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<td>Mathematics Teacher is Black</td>
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<td>-.10</td>
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<tr>
<td></td>
<td>(-.01)</td>
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<tr>
<td>Mathematics Teacher is Hispanic</td>
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<td>.12</td>
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<td></td>
<td>(.02)</td>
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<td>(.02)</td>
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<tr>
<td>Mathematics Teacher is Asian</td>
<td>.17†</td>
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<td>.17†</td>
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<td>(.02)</td>
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<td>(.02)</td>
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<tr>
<td>Mathematics Teacher is Other Race</td>
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<td></td>
<td>-.18</td>
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<td></td>
<td>(-.02)</td>
<td></td>
<td>(-.02)</td>
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<tr>
<td>Teacher’s Degree Level</td>
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<td></td>
<td>(.00)</td>
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<td>(.00)</td>
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<tr>
<td>Years Teacher Taught HS Math</td>
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<td>(.02)</td>
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<tr>
<td>Math Teacher Held Job Prior</td>
<td>-.03</td>
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<td>-.03</td>
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<td></td>
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<td>(-.01)</td>
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<tr>
<td>Math Teacher Self-Efficacy</td>
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<td>(.01)</td>
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<td>(.01)</td>
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</table>
Table 4.6 (cont.): Unstandardized Regression Coefficients (Beta in parentheses) for Student Algebraic Achievement for Male Students (N = 3,501)

<table>
<thead>
<tr>
<th>Teacher Certificate Level (Ref: No Certificate)</th>
<th>Model V</th>
<th>Model VI</th>
<th>Model VII</th>
<th>Model VIII</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not a Regular Certificate</td>
<td>.04</td>
<td>( .01)</td>
<td></td>
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<tr>
<td>Regular Certificate not HS</td>
<td>.08</td>
<td>( .01)</td>
<td></td>
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<tr>
<td>Regular HS Certificate</td>
<td>.12†</td>
<td>( .04)</td>
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</table>

<table>
<thead>
<tr>
<th>Teacher’s Perception of Class Achievement (Ref: Lower)</th>
<th>Model V</th>
<th>Model VI</th>
<th>Model VII</th>
<th>Model VIII</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>.32***</td>
<td>( .13)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher</td>
<td>.66***</td>
<td>( .26)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Widely Differ</td>
<td>.21***</td>
<td>( .05)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Constant | .90*** | .97*** | -.33*** | -.54*** |
| F        | 14.75*** | 104.26*** | 182.38*** | 113.85*** |
| Adjusted R² | .004 | .21 | .48 | .52 |
| R² Change | .004 | .21 | .27 | .04 |

† p < .1     * p < .05    **p < .01    ***p < .001; BY = Variable taken from base year sample; F1 = Variable taken from HSLS:09 first follow-up.
**Teacher Perception Variables**

Model V: Perception of PLCs indicates that without controlling for any other student- or teacher-level variables, teacher perception of PLCs had a positive impact on male student algebraic achievement levels. For every unit of teacher perception, students scored .08 units higher in their algebraic achievement levels. This relationship was robust and statistically significant at the .001 level.

In Model VI: Student Demographics, the teacher perception of PLCs variable contribution decreased, adding only .03 units and approaching significance at the .1 level. Teacher’s perceptions of PLCs were not significant in the later models (Model VII: Student Sociocultural or Model VIII: Teacher Sociocultural) for male students.

**Student Demographic Variables**

Race appears to be an important factor in predicting algebraic achievement for male student across all races except for students who identified in the Other Race category. Hispanic male student algebraic achievement scores were .17, .15, and .11 units lower than those of their White counterparts in Models VI through VIII, respectively. The relationship was statistically significant at the .001 level for Model VI: Student Demographics and Model VII: Student Sociocultural and at the .05 level for Model VIII: Teacher Sociocultural. Controlling for all other variables, the algebraic achievement for Black male students was .60, .48, and .41 units lower than their White counterparts in Models VI through VIII, respectively. Students who identified as Asian achievement scored .65, .31, and .27 units higher than their White counterparts. The Black and Asian predictors were robust and statistically significant at the .001 level across Models VI through VIII for male students.
Students’ socioeconomic status (SES) appears to have been a significant predictor of male student algebraic achievement levels when controlling for all other variables. For each unit of SES, male student algebraic achievement levels increased by .55, .32, and .28 units in Models VI through VIII, respectively. The relationship was robust and statistically significant at the .001 level for all three models. Model VI: Student Demographics shows that SES had the strongest effect on algebraic achievement (Beta = .34) prior to controlling for student and teacher sociocultural variables. The effect of SES decreased over Model VII: Student Sociocultural and Model VIII: Teacher Sociocultural, although it remained relatively strong when controlling for other variables.

Attending a public school was a significant factor only in Model VI: Student Demographics. If a male student attended public school, the model predicts that their algebraic achievement will be .12 units lower than their private school counterparts. This was statistically significant at the .05 level. Attending an urban school approached significance only in Model VIII: Teacher Sociocultural at the .1 significance level. Male students who attended urban schools had an achievement level that was .05 units lower than that of their suburban counterparts. Male rural school student algebraic achievement levels were .15, .10, and .08 units lower for Models VI through VIII, respectively, when controlling for all other variables. This predictor was statistically significant at the .001, .01, and .1 levels for Models VI through VIII, respectively.

**Student Sociocultural Variables**

The variable for algebra taken prior to high school was an important factor for predicting male student algebraic achievement levels. Controlling for all other variables, if male students took algebra prior, this predictor increased their achievement levels by .63 and .49 units for
Models VII: Student Sociocultural and Model VIII: Teacher Sociocultural, respectively. Algebra taken prior to high school was robust and significant at the .001 level for both models. Algebra taken also had the greatest effect (Beta = .27) on student algebraic achievement levels in Model VII: Student Sociocultural.

When evaluated on a scale from 1 to 5, where 1 = below a D and 5 = A, students’ prior achievement increased the male student algebraic achievement levels by .24 and .18 units for Models VII: Student Sociocultural and Model VIII: Teacher Sociocultural, respectively. This predictor was robust and significant at the .001 level. Controlling for all other variables, students’ prior achievement levels had the third-largest effect (Beta = .20) on the algebraic achievement levels of male students in Model VII: Student Sociocultural.

Math class effort was a significant predictor of male student algebraic achievement levels. Every unit of math class effort increased algebraic achievement by .04 units. The marker was significant at the .01 level for Models VII: Student Sociocultural and Model VIII: Teacher Sociocultural.

Math identity and self-efficacy were both robust and powerful predictors of algebraic achievement for male students in the sample. Each unit of math identity increased algebraic achievement for male students by .26 and .24 units within Models VII: Student Sociocultural and Model VIII: Teacher Sociocultural. Controlling for all other variables, math identity had the second-largest effect on male student algebraic achievement levels in Models VII: Student Sociocultural and Model VIII: Teacher Sociocultural. Math self-efficacy increased male student algebraic achievement levels by .09 units in both models. Both variables were statistically significant at the .001 level.
School engagement was also a significant predictor of male student algebraic achievement levels. Each unit of student engagement increased male student algebraic achievement levels by .04 in Models VII: Student Sociocultural and Model VIII: Teacher Sociocultural. This was statistically significant at the .01 level for Models VII: Student Sociocultural but changed to the .05 level of significance in light of the variable controlled for in Model VIII: Teacher Sociocultural.

Neither math utility, interest, nor sense of school belonging were significant predictors of male student algebraic achievement levels.

**Teacher Sociocultural Variables**

Teacher race was only significant as a predictor of achievement levels for male students with Asian teachers. Male students with teachers who classified themselves as Asian increased their algebraic achievement levels by .17 units over their counterparts with White teachers. This variable approached significance at the .1 level.

Teacher certification level also had a significant effect on male student algebraic achievement levels. Male students who had a teacher with a regular high school math teaching certificate contributed .12 units to their algebraic achievement levels over students with teachers without a certificate. This indicator approached significance at the .1 level.

Lastly, teacher perception of average class achievement was a significant predictor of male student algebraic achievement levels. Male students of teachers who perceived average class achievement as being average increased algebraic achievement levels by .32 units over their counterparts with teachers who perceived achievement as being low. Male students of teachers who perceived average class achievement as being high increased their achievement levels by .66 units over their counterparts with teachers who perceived achievement as being
low. When controlling for all other variables, this predictor had the strongest effect (Beta = .26) on male student achievement over any other variable. In Model VIII: Teacher Sociocultural this effect was followed by both math identity and algebra taken prior to high school (Beta = .21 for each) and SES (Beta = .18). Male students of teachers who perceived average class achievement as being widely differing increased their achievement levels by .21 units over their counterparts with teachers who perceived average class achievement as being low. All three categories were robust and statistically significant at the .001 level.

**Coefficients of Determination for Models V through VIII**

For Models V through VIII, the Adjusted R², which indicates the effects the variables had on the male sample, were .004, .21, .48, and .52, respectively. This indicated that without controlling for student or teacher characteristics, teacher perception of PLCs accounted for 0.4% of the variance in male student algebraic abilities. The remaining Models VI through VIII accounted for 21%, 48%, and 52%, respectively. The F-test for each model was statistically significant at the .001 level, confirming that the independent variables in each model were useful for predicting the student algebraic achievement levels.

**Analysis and Interpretation of Algebraic Ability Scores for Female Students**

Table 4.7 presents Unstandardized Regression Coefficients for the dependent variable, “Student Algebraic Achievement.” The four models in Table 4.7 – Model IX, X, XI, and XII – show the utility of teacher perception of PLCs, student demographics, and student and teacher sociocultural variables for predicting student algebraic achievement levels for the female students only.
Table 4.7: Unstandardized Regression Coefficients (Beta in parentheses) for Student Algebraic Achievement for Female Students (N = 3,576)

<table>
<thead>
<tr>
<th></th>
<th>Model IX</th>
<th>Model X</th>
<th>Model XI</th>
<th>Model XI</th>
</tr>
</thead>
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<tr>
<td><strong>Base Year Teacher Perception</strong></td>
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<td></td>
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<td>Teacher Perception of PLCs</td>
<td>.08***</td>
<td>.04*</td>
<td>.03*</td>
<td>.02</td>
</tr>
<tr>
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<td>(.07)</td>
<td>(.04)</td>
<td>(.03)</td>
<td>(.02)</td>
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<tr>
<td><strong>Student Demographic</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>F1 Student’s Race (Ref: White)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student is Black</td>
<td>-.38***</td>
<td>-.29***</td>
<td>-.23***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-.10)</td>
<td>(-.08)</td>
<td>(-.06)</td>
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</tr>
<tr>
<td>Student is Hispanic</td>
<td>-.18***</td>
<td>-.10*</td>
<td>-.08†</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-.06)</td>
<td>(-.04)</td>
<td>(-.03)</td>
<td></td>
</tr>
<tr>
<td>Student is Asian</td>
<td>.58***</td>
<td>.32***</td>
<td>.28***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.15)</td>
<td>(.08)</td>
<td>(.07)</td>
<td></td>
</tr>
<tr>
<td>Student is Other Race</td>
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<td>.01</td>
<td>.04</td>
<td></td>
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<tr>
<td></td>
<td>(.00)</td>
<td>(.00)</td>
<td>(.01)</td>
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<tr>
<td>F1 Student’s Socioeconomic Status</td>
<td>.48***</td>
<td>.28***</td>
<td>.25***</td>
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<tr>
<td></td>
<td>(.34)</td>
<td>(.20)</td>
<td>(.18)</td>
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</tr>
<tr>
<td>F1 Attended Public School</td>
<td>-.09**</td>
<td>.00</td>
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<td></td>
<td>(-.04)</td>
<td>(.00)</td>
<td>(.00)</td>
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<tr>
<td>F1 Urbanicity (Ref: Suburban)</td>
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<tr>
<td>Urban School</td>
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<tr>
<td></td>
<td>(-.02)</td>
<td>(-.03)</td>
<td>(-.02)</td>
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<tr>
<td>Rural School</td>
<td>-.10*</td>
<td>-.11***</td>
<td>-.08*</td>
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<tr>
<td></td>
<td>(-.04)</td>
<td>(-.05)</td>
<td>(-.04)</td>
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<tr>
<td><strong>Student Sociocultural</strong></td>
<td></td>
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<td></td>
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<tr>
<td>BY Algebra Taken Prior to High School</td>
<td>.60***</td>
<td>.45***</td>
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<tr>
<td></td>
<td>(.28)</td>
<td>(.21)</td>
<td></td>
<td></td>
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<tr>
<td>BY Student’s Prior Achievement</td>
<td>.29***</td>
<td>.24***</td>
<td></td>
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<tr>
<td></td>
<td>(.24)</td>
<td>(.20)</td>
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<tr>
<td>F1 Math Class Effort</td>
<td>.03†</td>
<td>.04**</td>
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<td>(.03)</td>
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<td>F1 Math Identity</td>
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<td>.17***</td>
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<td>(.19)</td>
<td>(.17)</td>
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Table 4.7 (cont.): Unstandardized Regression Coefficients (Beta in parentheses) for Student Algebraic Achievement for Female Students (N = 3,576)

<table>
<thead>
<tr>
<th></th>
<th>Model IX</th>
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<th>Model XI</th>
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<td>F1 Math Utility</td>
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<td>(.03)</td>
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<td></td>
</tr>
<tr>
<td>BY Math Self-Efficacy</td>
<td>.07***</td>
<td>.07***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.07)</td>
<td>(.07)</td>
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<tr>
<td>BY Math Interest</td>
<td>-.04*</td>
<td>-.05*</td>
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<tr>
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<td>(-.04)</td>
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<tr>
<td>BY Sense of School Belonging</td>
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<td></td>
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<tr>
<td>BY School Engagement</td>
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<td>.05†</td>
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<td></td>
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<tr>
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<tr>
<td>Mathematics Teacher is Asian</td>
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<td>.09</td>
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<td></td>
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<td>(.01)</td>
<td>(.01)</td>
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<tr>
<td>Mathematics Teacher is Other Race</td>
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<td></td>
<td></td>
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<td>Teacher’s Degree Level</td>
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<td>Years Teacher Taught HS Math</td>
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<tr>
<td></td>
<td>Model IX</td>
<td>Model X</td>
<td>Model XI</td>
<td>Model XI</td>
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<td>Teacher Certificate Level (Ref: No Certificate)</td>
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<td>Not a Regular Certificate</td>
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<td>Regular Certificate not HS</td>
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<td>Regular HS Certificate</td>
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<td>Teacher’s Perception of Class Achievement (Ref: Lower)</td>
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<tr>
<td>Average</td>
<td>.23***</td>
<td>(.11)</td>
<td></td>
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<tr>
<td>Higher</td>
<td>.61***</td>
<td>(.27)</td>
<td></td>
<td></td>
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<tr>
<td>Widely Differ</td>
<td>.22***</td>
<td>(.06)</td>
<td></td>
<td></td>
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<tr>
<td>Constant</td>
<td>.85***</td>
<td>.90***</td>
<td>-.60***</td>
<td>-.72***</td>
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<tr>
<td>Adjusted $R^2$</td>
<td></td>
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<td>.44</td>
<td>.47</td>
</tr>
<tr>
<td>$R^2$ Change</td>
<td>.01</td>
<td>.19</td>
<td>.25</td>
<td>.04</td>
</tr>
</tbody>
</table>

† $p < .1$  * $p < .05$  ** $p < .01$  *** $p < .001$; BY = Variable taken from base year sample; F1 = Variable taken from HSLS:09 first follow-up.
Teacher Perception Variables

Model IX: Perception of PLCs indicates that without controlling for any other student- or teacher-level variables, teacher perception of PLCs had a positive impact on female student algebraic achievement levels. For every unit of teacher perception, the model predicts that female students will score .08 units higher in their algebraic achievement levels. This relationship was robust and statistically significant at the .001 level. In Models X and XI, the impact decreased to .04 and .03 units, respectively. Both models were statistically significant at the .05 level. Teacher perception of PLCs was not significant for female students in Model XII: Teacher Sociocultural.

Student Demographic Variables

Race appears to have been an important factor in predicting algebraic achievement for female students across all races except for those students who identified in the Other Race category. Hispanic female student algebraic achievement scores were .18, .10, and .08 units lower than those of their White counterparts in Models X through XII, respectively. The relationship was statistically significant at the .001, .05 and .1 levels for these models, respectively. Controlling for all other variables, the algebraic achievement for Black female students was .38, .29, and .23 units lower than those of their White counterparts in Models X through XII, respectively. Female students who identified as Asian had scores that were .58, .32, and .28 units higher than those of their White counterparts in these models, respectively. The Black and Asian predictors were robust and statistically significant at the .001 level across Models X through XII.

Student socioeconomic status (SES) appears to have been a significant predictor of female students’ algebraic achievement levels when controlling for all other variables. For each
unit of SES, female student algebraic achievement levels increased by .48, .28, and .25 units in Models X through XII, respectively. The relationship was robust and statistically significant at the .001 level for all three models. Model X: Student Demographics shows SES as the strongest effect on algebraic achievement (Beta = .34) prior to controlling for student and teacher sociocultural variables. The effect of SES decreased over Models XI: Student Sociocultural and XII: Teacher Sociocultural, although it remained relatively strong when controlling for other variables.

Attending a public school was a significant factor only in Model X: Student Demographics. If female students attend public school, the model predicts that their algebraic achievement levels will be .09 units lower than those of their private school counterparts. This was statistically significant at the .01 level.

Attending an urban school was not a significant predictor of algebraic achievement levels for female students. However, algebraic achievement levels for female students attending a rural school were .10, .11, and .08 units lower in Models X through XII, respectively, when controlling for all other variables. This predictor was statistically significant at the .001 level for Model XI: Student Sociocultural and at the .05 level for Models X: Student Demographics and Model XII: Teacher Sociocultural.

**Student Sociocultural Variables**

Algebra taken prior to high school was an important factor in predicting female student algebraic achievement levels. Controlling for all other variables, female students who took algebra prior to high school increased their algebraic achievement levels by .60 and .45 units for Models XI: Student Sociocultural and Model XII: Teacher Sociocultural, respectively. Algebra taken prior to high school was robust and significant at the .001 level for both models. Algebra
taken prior to high school also had the greatest effect (Beta = .28) on female students’ algebraic achievement levels in Model XI: Student Sociocultural and the second-largest effect on achievement in Model XII: Teacher Sociocultural.

Student prior achievement was also a robust and powerful predictor of female students’ algebraic achievement levels. On a scale from 1 to 5, where 1 = below a D to 5 = A, every unit of prior achievement increased female students’ algebraic achievement levels by .29 and .24 units for Models XI: Student Sociocultural and Model XII: Teacher Sociocultural, respectively. This predictor was significant at the .001 level. Controlling for all other variables and following algebra taken prior to high school, student prior achievement had the second-strongest effect (Beta = .24) and the third-largest effect (Beta = .20) on female student algebraic achievement levels in Models XI: Student Sociocultural and Model XII: Teacher Sociocultural, respectively.

Math class effort was a significant predictor of female students’ algebraic achievement levels. Each unit of math class effort increased female student algebraic achievement levels by .03 and .04 units for Models XI: Student Sociocultural and Model XII: Teacher Sociocultural, respectively. This variable approached significance at the .1 level in Model XI: Student Sociocultural and then became stronger at the .01 level of significance in Model XII: Teacher Sociocultural.

Math identity and self-efficacy were power predictors of algebraic achievement for female students. Each unit of math identity increased female students’ algebraic achievement levels by .19 and .17 units for Models XI and XII, respectively. Each unit of math self-efficacy increased female student algebraic achievement levels by .07 units for both Models XI: Student Sociocultural and Model XII: Teacher Sociocultural. Both variables were robust and statistically significant at the .001 level.
Math interest was a significant predictor of female student algebraic achievement levels. Each unit of female math interest decreased algebraic achievement levels by .04 and .05 units for Models XI: Student Sociocultural and Model XII: Teacher Sociocultural, respectively. This was statistically significant at the .05 level.

Math utility approached significance in Model XII: Teacher Sociocultural. Controlling for all other variables in that model, math utility contributed .02 units for every unit of math utility. This was statistically significant at the .1 level.

School engagement was not a significant predictor of female student algebraic achievement levels.

Teacher Sociocultural Variables

Female student algebraic achievement levels were sensitive to teacher gender. Female students with a female teacher increased their algebraic achievement scores by .05 over female students who had male teachers. The variable approached significance at the .1 level.

Teacher’s degree level was also a significant predictor of female student algebraic achievement levels. Students of teachers with at least a master’s or specialist degree increased female students’ algebraic achievement levels by .06 over students of teachers who only had a bachelor’s degree. This variable was statistically significant at the .05 level.

Lastly, teacher perception of average class achievement was a significant predictor of female student algebraic achievement levels. Female students of teachers who perceived average class achievement as being average increased their algebraic achievement levels by .23 units over those with teachers who perceived achievement as being low. Female students of teachers who perceived average class achievement as being high increased their student’s achievement levels by .61 over those with teachers who perceived achievement as being low. When
controlling for all other variables in Model XII: Teacher Sociocultural, this predictor had the strongest effect (Beta = .27) on female student achievement. Female students of teachers who perceived average class achievement as being widely differing increased student achievement levels by .22 over students with teachers who perceived average class achievement as being low. All three categories were robust and statistically significant at the .001 level.

Teacher race was not a significant predictor of female student algebraic achievement levels.

**Coefficients of Determination for Models IX and XII**

The Adjusted $R^2$ values for Models IX through XII were .01, .19, .44, and .47, respectively. This indicated that without controlling for student or teacher characteristics, teacher perception of PLCs accounted for 1% of the variance in female students’ algebraic abilities. The remaining Models X through XII accounted for 19%, 44%, and 47%, respectively. The F-test for each model was statistically significant at the .001 level, confirming that the independent variables in each model were useful for predicting the outcome variable for female students.

**Summary of Results**

In this study a series of twelve regression models was used to probe the utility of teacher perception, student demographics, and student and teacher sociocultural variables for predicting student algebraic achievement levels. The models proved that there were several significant predictors of student algebraic achievement. In this study, teacher perception of PLCs was a predictor for several models. In fact, teacher perception of PLCs was a significant predictor of algebraic achievement for both genders prior to controlling for other independent variables. It was significant for female students up to the point of controlling for teacher sociocultural variables, while male students were only mildly sensitive to this variable up to the point of
controlling for student demographic variables. With the incorporation of teacher sociocultural variables, teacher perception of PLCs was not significant for either gender.

The impacts of gender, race, and socioeconomic status were robust throughout all twelve models. Rural school was a significant predictor for both genders, while attending an urban school as a predictor appears to have approached significance only for male students. As for the student sociocultural variables—i.e., algebra taken prior to high school, student prior achievement, their math identity, and self-efficacy—these were robust and strong predictors of student algebraic abilities for both genders. Math class effort was also a moderate predictor for male and female students. Math interest was a significant predictor for female students only. Female students also appeared to be more sensitive to math utility, while school engagement was a predictor of algebraic ability for male students only. In addition, male students appeared to be more sensitive to a teacher’s certificate level, whereas female algebraic achievement levels were more sensitive to a teacher’s degree level. Lastly, the strongest predictor of student algebraic achievement levels for both genders was teacher perception of class achievement. This predictor was robust and highly significant for both genders, even greater than race, gender, or socioeconomic status.

In all models, when only controlling for student demographics, SES had the strongest effect on students’ algebraic achievement levels regardless of gender. Upon incorporating student sociocultural variables, the prior curriculum variable (i.e., “Algebra Taken Prior to High School”) had the strongest effect on student algebraic achievement levels regardless of gender. For male students, this was followed by math identity, SES, and prior achievement, whereas for female students the prior curriculum variable was followed by prior math class achievement, SES, and finally math identity, which had the forth-strongest effect on female student algebraic
achievement levels. Lastly, when controlling for all other variables, teacher perception of class achievement had the strongest effect on student algebraic achievement levels regardless of gender.

The following chapter will develop these results in relation to the theoretical framework and relevant literature previously discussed in chapter 2.
Chapter Five: Discussion

This dissertation employed ordinary least squares (OLS) regression analysis to examine the impact of teacher perception of PLCs with various student- and teacher-level variables to predicting student algebraic achievement. As presented in chapter four, the results of this analysis indicate that multiple student- and teacher-level variables are significant predictors of algebraic achievement. The remainder of this chapter will discuss these results as they relate to the findings of previous research. Findings will also be contextualized within the framework of social constructivist and expectancy value theory.

Domains

A number of independent variables were selected for analysis in this dissertation based upon a review of the literature surrounding teacher perception of PLCs and student - teacher effects on student algebraic achievement. These variables were grouped into four major domains: teacher perception of PLCs variable, student demographic variables, student sociocultural variables, and teacher sociocultural variables. The remainder of this chapter will discuss the findings regarding each of these domains and the literature that informs this study.

Teacher Perception Variable

This study found that for math teachers who collaboratively engage within departmental professional learning communities (PLCs), perception of PLCs has a small significant impact on student algebraic achievement upon controlling for all student level variables, however, perception of PLCs was not significant upon controlling for teacher sociocultural variables. This indicate that teachers’ perception of PLCs was only a proxy to some other characteristic of the teacher. At the end of the day, this demonstrates that overall the teacher has a direct effect on student achievement although engagement in professional learning communities may not.
McClure (2008) declared that a small but increasing amount of evidence implies that a positive relationship exists between teacher collaboration and student achievement. Patterson et al. (2008) declared that the best collaborative teams begin by identifying student needs pertaining to student achievement and specific academic outcomes. In school settings where collaboration occurs, students recognize that consistent expectations result in a better learning environment. Thus establishing learning communities among collaborating teachers can affect student achievement (Bloom & Stein, 2004). They stated that collaborative teachers’ problem solve, share strategies and resources, and work together to fulfill student needs aimed at positive academic outcomes. Blankstein (2004) agreed that if teacher collaboration is to be successful, the primary goal must be to improve student achievement.

In one of the largest studies conducted by Goddard, Goddard, & Taschannen-Moran (2007, 2015), they reported “a paucity of research investigating the extent to which teachers’ collaborative school improvement practices are related to student achievement” (p. 877). Most research at that time was in the form of surveys and case studies. It did not seek to provide evidence of a cause and effect relationship linking teacher collaboration with student achievement. In their study of a large urban school district in the Midwest, they found a positive relationship between teacher collaboration and differences among schools in mathematics and reading achievement. More specifically, they found in elementary school that after controlling for several student and school level variables schools with higher levels of collaboration also had higher levels of student achievement (Goddard et al., 2009). In their follow-up study, they showed that teachers’ collaboration and collective efficacy were highly linked and contributed to achievement growth (Goddard et al., 2015). In a call to extend the exploration of the affects of teachers’ collaboration on student achievement, this dissertation found that collaboration among
secondary school teachers has a relative impact on student achievement specifically within the domain of mathematics.

Building upon the limitations of the Goddard and colleagues (2007; 2009; 2015) study, this dissertation was domain specific and focused on teachers’ collaboration within math departmental professional learning communities (PLCs). Egodawatte et al. (2011), who investigated the types of collaboration secondary math teachers use in working together towards mathematical educational reform, noted that teacher collaboration within departments can have mixed effects on teacher instruction and on student achievement. The positive impact is a result of increased focus on student achievement, curriculum, and the quality of social interactions. This study is in accordance with these results. According to Egodawatte et al. (2011), the negative impact within departments can result from sociopolitical forces within an institution imposing issues on the teacher. In their qualitative study they noted that teachers who faced increased workload and lack of direction within their teams had their instruction negatively affected, resulting in lower student achievement. This study demonstrates that within math PLCs, when math teachers share discourse related to student achievement and teaching beliefs, learning communities can have a direct impact on student math achievement. In addition, like a number of studies, this study confirms that, especially in secondary school, the most efficacious communities tend to reside at the level of subject matter department (McLaughlin & Talbert, 2001; Siskin and Little, 1995). Within those departments, teachers also interact to enact the norms of teaching, learning, grouping, and assessment of the school culture, which in turn shapes their work and their students’ classroom experiences (Gutierrez, 1996).

This dissertation also builds on the Goddard et al. (2007; 2009) by attending to other dimensions of collaboration quality and by using the student as the unit of analysis. The Goddard
et al. (2007; 2009) study was based on measures of amounts (i.e., frequency or extensiveness) of collaboration gathered from five questions. This dissertation measures teachers’ perception of PLCs as a function of discourse (discussion of ELLs, best practices, student misconception, etc.), teacher beliefs, and PLC leadership support used within math departmental PLCs. The current study confirms that after controlling for student- and teacher-level variables, teacher collaboration has a relative positive impact on student algebraic achievement, once all student level variables are controlled for.

Regarding the effects of teacher collaboration within the professional community, Lomos, Hofman & Bosker (2011a) conducted a meta-analysis, establishing that current empirical research shows a positive relationship between work within PLCs and student achievement in secondary Dutch school especially in mathematics. This project agrees and also adds to the work conducted by Lomos et al. (2011a) within the American context. Most of the quantitative studies investigated professional communities as an aggregated school trait and focused on its relationship with student achievement (Bryk, Camburn, & Louis, 1999; Louis & Kruse, 1995; Newmann & Wehlage, 1995). They showed that schools where teachers work in professional communities are associated with higher student achievement (Lee & Smith, 1996; Louis & Marks, 1998; Newmann et al., 1995).

The remaining studies on teacher collaboration are qualitative in nature and use a combination of field notes, observations, interviews, and case studies. The qualitative research studies have shown that teacher collaborative approaches within departments relate with effective schools and student achievement (Harris et al., 1995; Little, 1995; McLaughlin & Talbert, 2001). However, Lomos et al. (2011a) also noted that most literature on the topic, especially studies using large scale data sets relied on data collected prior to 2000, prior to
current reforms (NCLB or Race to the Top) that mandate schools systematically implement programs to develop educators. In addition, prior to 2000 the focus on national standardized testing was not as strong as it currently is, as a result of the implementations of NCLB. There is also been an increased focus on testing and inter-state competition on the new Common Core State Standards with Race to the Top legislation. In the Lomos et al. (2011b) study, although they used a more precise measurement of department professional communities, similar to that used in this dissertation, to gauge of teachers’ perception of collaboration within PLCs, their study used data from the Third International Mathematics and Science Study (TIMSS), conducted in 2003 at the eighth-grade level (TIMSS-03) in the Netherlands. This dissertation utilizes national data from the High School Longitudinal Survey of 2009 (HSLS:09) with a math assessment conducted in 2012. Currently, this is one of the most up-to-date large-scale surveys being conducted on the topic. The results show that even though reforms have been required nationally for almost two decades, teacher collaboration in secondary school still has only a relatively small positive impact on student achievement.

Patterson et al. (2008) declared that the best collaborative teams begin by identifying student needs pertaining to student achievement and specific academic outcomes. In school settings where collaboration occurs, students recognize that consistent expectations are the norm, resulting in a better learning environment. Thus, establishing learning communities among collaborating teachers can affect student achievement (Bloom & Stein, 2004). Bloom and Stein stated that collaborative teachers problem solve, share strategies and resources, and work together to fulfill students’ needs toward positive academic outcomes. These studies refer to the affects the learning environment can have on improving student learning. This study agrees with these statements.
This study is partially in contract to the work of Bunker (2008), Munoz (2008), Zito (2011) and Naughton (2006). Their studies supported that there is no direct link between teachers’ perception of collaboration but two variables are likely indirect connected through teacher collective efficacy (Munoz, 2008) or changes in instructional practices and culture (Naughton, 2006; Zito, 2011). Bunker (2008), out of the included studies is the only one who was able to establish a partial link between collaboration and achievement. Measuring two aspects of collaboration, he was able to show teachers skills developed through collaboration accounted for increasing in student math outcomes, but teachers’ perception of collaborative value (teachers feelings about the collaborative process) had no link to student achievement. This study builds on Bunkers work by incorporating pertinent student and teacher-level variable to analyze nationally if teachers’ perception of collaboration impact math achievement.

Muñoz (2008) measured teacher self-efficacy in a selected PLC and found that PLC practices enhanced teacher efficacy and positively influenced student achievement. He focused on self-efficacy as developed in the collaborative portion of their PLC interactions. Munoz’s (2008) analysis of teachers’ qualitative responses overwhelmingly showed that teacher participation in PLCs impacted their collective efficacy, which he connected to improvements in math student achievement; however, quantitatively, the link was not evident, as he did not find a direct correlation between teacher collaboration and student achievement. This study disaggregates teacher beliefs into three categories, teachers’ perception of collaboration, math teacher self-efficacy, and teachers’ perception of class achievement and found that in light of all three, efficacy and perception of collaboration were insignificant, while perception of class achievement became the largest predictor within the model. This still demonstrates that teachers’
beliefs have a significant impact on student achievement and empirically supports this conclusion.

Naughton (2006) found a causal comparative relationship between teacher collaboration and student achievement in mathematics in middle school but no correlational link between the two variables. The relative significance of teacher collaboration as a predictor of student achievement was minimal; however, after integrating student socioeconomic status (SES) into their regressions, SES was extremely significant, and collaboration was not. In their study, absent of other factors, SES proved to be a very powerful indicator of student math achievement; this was supported by the literature (Ayers, 1993; Kohn, 1999; Rotberg, 1998, as stated in Naughton, 2006). This current study found that is a direct link between teachers’ perception of PLCs and student achievement in math in high school. In summary, the results produced from this study are in line with current research but improve upon previous studies through more up-to-date data, focusing on clarifying the dimensions of collaboration quality, and by using the student as the unit of analysis to directly link teacher collaborative efforts to student algebraic achievement.

This dissertation also understands that teacher collaboration is considered a part of the school environmental context, which affects student achievement as a whole. The next section will explore student demographic variables and their relationship to student achievement as presented in this study and the literature.

**Student Demographic Variables**

Five student demographic variables were examined in this study: student gender, student race, socioeconomic status, attended public school, and locale. My findings coincide with
previous research on student demographic variables and student algebraic achievement, both in
general and in the domain of mathematics.

The findings from this study confirm that the average algebraic assessment scores for males and females were not statistically difference from each other, however, in the presence of other student- and teacher-level variable, females were predicted to score lower than their male counter parts. Research shows, on average, females generally earn higher grades in school in math classes across all grade levels (Kimball, 1989; Willingham & Cole, 1997) and however, score slightly lower on national assessment (NAEP, 2015). Even if their preparation and ability are equivalent, their self-assessed ability and self-confidence towards STEM courses are different. Bharadwaj, de Giorgi, Hansen, and Neilson (2012) provided evidence that girls are more likely than boys to state that math is difficult and that girls report lower self-assessed ability than boys. Their finding suggested that this might be a result of girls internalizing societal expectations and discrimination, resulting in lower self-confidence even when their ability is adequate. This is also possibly because of algebra’s language-like structure. Girls tend to score lower on quantitative tests when the content is not directly related to what is taught in their own curriculum but males are better with problems that involve critical thinking (Geary, 1996; Halpern, 2000).

The level of the school age child gives insight into where differences in achievement lie. In elementary school, the differences between boys and girls in mathematics ability tend to be small and to favor girls. These differences have been related to factors such as behavior and turning in assignments on time. In addition, especially in the younger grades the literature has found that girls are slightly better at required computational knowledge and speed. During later grades, males gain an advantage in mathematics as concepts start to require more reasoning and
are more spatial in nature. For example, in the context of solving problems in geometry and calculus, subjects typically taught in the higher secondary school grades and post-secondary school, boys do better (Geary, 1996; Hyde, Fennema, & Lamon, 1990). This study supports the findings that for adolescent students in the 11th grade, there is not a statistical difference between the math scores for males and females, however, male students are predicted to score slightly higher than their female counterparts. In addition, with the incorporation of student and teacher sociocultural variables the variation widens between their predicted algebraic scores.

The correlation between student race and algebraic achievement also confirms previous research. This study has shown that White students are outperforming their Hispanic and Black peer counterparts on math assessments. The National Assessment for Educational Progress reveals that since the early 1990s the gap has narrowed yet remained constant between White, Hispanic, and Black student’s in mathematics (NAEP, 2015). Similar to gender, these differences are linked to sociocultural factors such as math identity, prior achievement, and teacher perception of class achievement rather than student race. In addition to investigating the White-Black-Hispanic disparities, this study also incorporates the achievement scores for Asian students, which are often overlooked in studies (Robinson, 2016). Similar to past research, this study has shown that Asian students are outperforming other racial groups, and this gap has not narrowed in the last two decades. Hsin and Xie (2014) concluded that this advantage results from their culture of academic effort, not cognitive or socioeconomic advantages. Rodrigue, Joo, and Reeves (2016) also justify that part of this difference is due to Asians living in areas with better schools, nearly or on par with whites. Robinson (2016) suggests that similar to research that investigates the discrepancies in the White-Black-Hispanic achievement gaps in mathematics; narratives should also include Asian students as part of the conversation.
The results from this study indicate that SES is a strong predictor of high school adolescent algebraic achievement. “Socioeconomic status has the strongest influence on student academic achievement indicating that an individual’s poverty status has a greater influence on their academic achievement than any other characteristics” (Brown-Jeffy, 2009). The higher the student’s socioeconomic status, the higher their algebraic achievements score. This relationship was positive and strong within all models. This result is in agreement with the Coleman Report, which found that SES is the single most powerful predictor of academic achievement (Coleman, 1966). SES takes into account several aspects of a student sociocultural background and past, such as poverty, homeownership, parental influence, parental involvement, parents’ education, family structure, and family income. Previous studies have found that in most cases there is a strong relationship between SES and mathematic achievement (Coleman, 1996; Berliner and Biddle, 1995; Valencia & Solorzano, 1997; Cortes Jr., 2010; Brown-Jeffy, 2009; Rowley and Wright, 2011; Nisbett, 2011). In addition to the factors mentioned above, SES accounts for other critical factors such as one parent, lack of involvement, interest, support, limited adult supervision, absence of books and education resources at home, and no structure at home, which all affect the ability of students to succeed (Hofferth & Sandberg, 2001).

The outcomes of this analysis also indicate that by separating student demographic, student sociocultural, and teacher-level variables, the effects of each can be viewed in conjunction and separately in predicting adolescent algebraic achievement. Within Models III and IV, with the incorporation of student sociocultural and teacher level variables, the effect of SES in predicting math achievement was halved. This is in accordance with the work of Moller et al. (2013) and Lee and Smith (1996) who found that student-teacher relationships have indirect effects on decreasing socioeconomic gaps in achievement.
The results from this study also show that there is a statistically significant difference between rural students and their suburban counterparts with rural students scoring lower in their algebraic achievement. However, that difference is minimized with the inclusion of student and teacher sociocultural variables. The markers also indicate that after controlling for all student and teacher variables there is a marginal difference between urban and suburban student algebraic achievement scores favoring suburban students. Between rural and their suburban/urban counterparts, Geske et al. (2006) attribute much of their difference to disparities in how schools manage their physical and human resources on a day-to-day basis much more than with discrepancies in learning achievement. Geske et al. (2006) showed that when geographic location, gender and SES are controlled for rural students actually score on par or better than urban or suburban students. The results from this study also show a similar narrowing effect in the regressions’ ability to predict student algebraic achievement score in the midst of other critical student and teacher sociocultural variables.

Geske and colleagues (2006) investigated differences by locale in the mathematical literacy scores of 15-year old students in Latvia. They focused on the extent to which students’ individual family background (SES), and school characteristics are responsible for those differences. This dissertation’s results are in accordance with that work and the research conducted by Mersch (2012). While past research suggest that non-rural schools rank higher in mathematics achievement than rural schools, especially in US states with large rural populations, such as Mississippi, Vermont, Maine, South Dakota, Nebraska, and Tennessee. Much of this difference is due to low SES family background in those areas and a lack of resources rather than geographic local. Mersch (2012) found that geographic location was not a strong predictor of academic achievement and had no effect on test scores especially in mathematics or science. She
also noted, suburban students had higher test scores in other subject areas but not in math or science. Additionally, where she did see a statistical difference, the magnitude of the effect was low compared to SES, race, or other sociocultural variables. In summary, consistent with other work investigating geographic location effects on student achievement, this study shows that, nationally, rural students are scoring lower than their non-rural counterparts. The magnitude of the effect, however, is small and further diminished when other relevant student-, teacher-, and school-level variables are controlled for.

This section discussed the relevancy of the results regarding student demographic variables (student gender, student race, socioeconomic status, attended public school, and geographic locale) within the context of the present literature.

**Student Sociocultural Variables**

This section explores the predictive effects prior achievement, prior curriculum, and affective variables such as math class effort, identity, utility, interest, efficacy, sense of school belonging, and school engagement have on student algebraic achievement. Of the sociocultural variables explored, this study shows that prior curriculum, prior achievement, and math identity are strong predictors of math achievement with math class effort, math self-efficacy, and school engagement also having positive marginal effects on math algebraic achievement. Some research has shown that math interest and ability are positively related (Ackerman & Heggestad, 1997) and that sense of school belonging is indirectly linked to student motivation and school academic growth (Osterman, 2000; Goodenow, 1992,1993; Ryan and Powelson, 1991). This study shows that neither are significant factors in predicting math outcomes. The results of the present study are in agreement with and contribute to the theories behind the cognitive, social, cultural, and environmental factors that affect learners’ construction of knowledge.
In Ballou, Sanders, & Wright’s (2004) article investigating value-added assessments of
teachers, they concluded that controlling for student prior achievement alone could be used as a
control to account for cognitive, social, cultural and environmental student-level factors in
teacher effectiveness models. This dissertation demonstrates that when considered together,
student prior achievement, curriculum previously studied, SES, and student’s math identity,
accounted for more of the variance in students’ achievement than prior achievement. These
findings also suggest that student prior achievement may not be the strongest predictor of
achievement and that it might be necessary to account for other confounding factors within
teacher effectiveness models.

The results from this study strongly agree with the work of Long and colleagues (2012)
that prior curriculum is a strong positive predictor of student math achievement. They posit that
the courses taken by students regardless of achievement are expected to improve their skills and
knowledge and to prepare them for future courses. They also provide them with more
academically challenging curricula and through selection into the course, a more academically
motivated peer group than lower-level courses. It is also possible that these courses are also
assigned more effective teachers, thus improving student learning through increased teacher
quality. This dissertation results reveal that prior academic achievement and prior course-taking
are strong predictors of student algebraic achievement.

Recent definitions of math proficiency include not only student math achievement but
also math attitude. A caveat in teacher effectiveness models is that they rarely include student
math attitude constructs despite several studies that have shown that reciprocal relationships exist
between students’ math attitudes and their math achievement (Fisher et al., 2012; Leatham &
Hill, 2010; Ma & Kishor, 1997; Schwartz, 2006). For this reason, in addition to prior academic
achievement and prior course-taking, I investigated and controlled for other affective variables. The literature clearly demonstrates that student math attitudes are significantly related to their achievement. Additionally, studies show that students’ math attitudes and achievement are both related to a plethora of other outcomes along the pipeline, including student courses taken, grades, college acceptance, college major, college graduation, career, and earnings (NCES, 2008).

In their work with the Search Institute on developmental assets in youth, Scales and Leffert (1999, p. 193) asserted that identity could best be defined “as an integrated view of oneself encompassing self-concept, beliefs, capacities, roles, and personal history.” According to this definition, identity is a variable influenced by self and others. Identity is socially constructed and changes through interactions within different communities in which individuals live, work, and learn (Holland & Lave, 2001). Sfard and Prusak (2005) compared identity with stories that people hear and tell about themselves; therefore, an individual’s mathematics identity is most likely connected to the stories about their mathematics experiences. Mathematics experience in most cases is linked to interest in the course, which can be highly influenced by social interactions within the environment.

According to Voss and Schauble (1992), higher levels of interest and identity combined would result in higher levels of cognitive activation leading to higher achievement. This dissertation shows that a higher sense of identity results in a higher algebraic achievement score; and it disaggregates math identity and interest into two separate components. The regression results show that a student math identity is a strong predictor of math achievement; yet math interest is not a statistically significant factor in predicting a student’s math achievement. When disaggregated by gender, math identity results were consistent with the whole population. Math
interest results, however, showed no significant relationship for male students but a significant, negative relationship for female students.

Researchers of longitudinal studies contended the significance of adding interest in mathematics was to influence a student’s commitment to learning and pursuing STEM careers (Chan & Rao, 2010; Heller & Perleth, 2008; Lubinski & Benbow, 2006). According to Hidi (2000), interest in academic courses typically decreases over time for students; this trend is more commonly seen in mathematics and science-related courses (Krapp, 2002). This study shows that by adolescence student math interest is not a significant factor in predicting math achievement, but this result is only true for male students (see also Krapp, 2002). Math interest has a relatively negative impact on the algebraic achievement of female students.

Researchers have examined self-identity, mathematics identity, and interest in relationship to achievement in mathematics (Hackett & Betz, 1989; Martin, 2000). Identity and interest are important constructs that can inform how students enact norms, beliefs, and characteristics of mathematicians and how they engage with mathematics related content. Additionally, advocates of the identity and interest constructs have contended that these factors allow researchers to broaden the scope of analysis and understanding related to achievement to consider why students commit to and value content material (Cobb, Gresalfi, & Hodge, 2009). Although there has been an emerging interest in identity as a construct for understanding student choices and behaviors in relation to STEM coursework and careers, there is a lack of substantive quantitative research focused on the matter (Carlone & Johnson, 2007). The results of this study show that student math identity is a strong positive predictor of math achievement, but math interest for male students is not a significant predictor of achievement and a negative predictor for females.
In research, links have been found between implicit gender stereotypes, math domain-specific ability self-concept, interest, and achievement-related choices and performance. They corroborate the expectancy-value model. This model supports the notion that these couplings can be guided by spontaneous, automatic, or implicit processes (Eccles, 2005). Girls’ implicit gender stereotypes could be a reason why statistically significant links between math achievement and interest are more likely to be found among girls than boys (Denissen, Zarrett, & Eccles, 2007). Part of this may be due to gender stereotypes stressing perceived incompetence of females in mathematics. This notion appears to greatly affect girls as they go through middle school, to high school, and beyond by lowering their performance and interest in math (Davies, Spencer, Quinn, & Gerhardstein, 2002; Spencer, Steele, & Quinn, 1999). Such stereotypes are not necessarily conscious or open to analysis (Greenwald & Banaji, 1995; Nisbett & Wilson, 1977) but are known to be present.

Nosek, Banaji, and Greenwald (2002) assessed implicit math-related cognitions in college students. Both men and women showed strong math-gender stereotypes, and women revealed more negative attitudes towards math than men. On a measure of implicit self-concept, women identified more with arts than math; men as a group did not show a tendency towards identifying with math or arts. Implicit—but not explicit—math-gender stereotypes were related to implicit and explicit math attitudes, math self-concepts, and performance.

Another study, with 11th graders and undergraduates, showed that girls held stronger implicit gender stereotypes than boys with regard to physics, and girls also held more negative implicit attitudes toward physics than boys (Kessels, Rau, & Hannover, 2006). Moreover, women’s implicit attitudes towards math were more negative after they were subtly reminded of gender as compared to a control condition (Steele & Ambady, 2006), indicating that a
stereotyped identity can affect attitudes consistent with that identity (Devos, Blanco, Rico, & Dunn, 2008). In a prospective study, stronger implicit math-gender stereotypes predicted worse math performance and lower interest in math-related careers in female college students (Kiefer & Sekaquaptewa, 2007b). In sum, it is possible that implicit gender stereotypes may play an important role in math-related outcomes in general and in particular in undermining women’s math interests and performance (Kiefer & Sekaquaptewa, 2007a). This project supports that this starts for female during their adolescent years.

Another affective variable considered in this study is the effect of a student’s math self-efficacy on math achievement. The results indicate that math self-efficacy is positively associated with math achievement, which is consistent across gender. Self-efficacy is defined as a person’s subjective appraisal of ability to succeed in a particular task. Students who possess this cultural capital, in sociocultural terms, in a math classroom, can successfully reason, present arguments, symbolize, and use math tools appropriately. They are likely to have high self-efficacy beliefs. Like math self-identity, self-efficacy is based on inferences drawn from prior performances. Unlike self-identity, however, self-efficacy excludes affective components such as moods or feelings and is oriented more to the future than the past. Research suggests that for this reason math self-efficacy is more malleable than stable and is based more on mastery than performance goals. Self-efficacy has been shown to promote appropriate task choice, persistence in the face of difficulty, and, ultimately, achievement (Pintrich & Zusho, 2002; Valentine et al., 2004). The self-efficacy outcomes within this study are consistent with the conclusion that student math self-efficacy is positively related to math achievement. Cech et al. (2011) asserts that students with higher math self-efficacy are more likely to persist through the educational pipeline to obtain a career in a STEM fields.
It is important to note that student self-efficacy can be influenced by teacher and peer perceptions of ability. Additionally, unequal and inaccurate biases may exist within mathematics classrooms based on student membership or non-membership in a given community. Therefore, some mathematics classrooms are non-neutral value-laded environments. Teachers can positively influence student math self-efficacy by intrinsically believing in them, extrinsically expressing this belief, and motivationally encouraging them to believe in themselves (Hodges, 2006; Turner, Bogner, Warzon & Christensen, 2011). Teacher effects on student achievement will be explored more later.

Engaging students in their own learning has challenged educators for decades. Studies show students become more disengaged from school as they progress from elementary to middle to high school (Marks, 2000; McDermott, 2001). By high school as many as 40% to 60% of students become chronically disengaged from school—urban, suburban, and rural—not counting those who have already dropped out (Sedlak et al., 1986; Steinberg et al., 1996). For this reason, student engagement has become one of the most immediate and persistent issues for improving student learning. Research indicates that the most obviously disengaged students disrupt classes, skip them, or fail to complete assignments. In contrast, engaged students make a psychological investment in learning and try hard to learn what a school offers. They take pride not simply in earning a successful grade but in understanding the material and incorporating or internalizing it in their lives (Newmann, 1992). This study shows that student school engagement has a small but positive effect on math achievement after controlling for all other student demographic, sociocultural, and teacher sociocultural variables. This result is consistent with previous research results that show the positive relationship between engagement and student academic achievement (Finn, 1993; Greenwood, 1991; Newmann et al., 1992). This result is also
significantly significant within the domain of mathematics (Park, 2005).

**Teacher Sociocultural Variables**

This section explores the predictive effects of teacher characteristics on student algebraic achievement. The domain clusters teacher demographic variables (gender and race) and teacher sociocultural variables (degree level, years of teaching, prior work experience, certificate level, teacher self-efficacy, and teacher perception of achievement).

Focusing on teacher demographic variables first, the results from this study indicate that the race/ethnicity does but gender of the teacher does not have a relative impact on the math achievement scores. This was evident for the whole sample. However, female high school students who have a female teacher tend to score higher than female students who have a male teacher. The gender of the teacher for male students was not a statistically significant factor in predicting math achievement. On a fundamental level, research on this topic has focused on fairness, and equal opportunity continues to motivate highly contentious debates over the root causes of gender differences in educational outcomes. Investigating environmental determinates, the literature suggests student-teacher interactions may shape the relative cognitive development and intellectual engagement of boys and girls differently (AAUS, 1992; Sadker, 2002; Sommers, 2000). For example, it could influence student engagement or behavior through role-model effects and stereotype threat. Furthermore, same gender teachers may also communicate different (and self-fulfilling) expectations to male and female students in their classrooms. This idea is supported by classroom observation evidence that teachers are more likely to offer praise and remediation in response to comments by boys but merely acknowledge comments by girls (AAUW, 1992; Kleinfeld, 1998; Lewin, 1998; Sadker and Sadker, 1994; Saltzman, 1994; Sommers, 2000). Similarly, cognitive process theories (Jones and Dindia, 2004) suggest that
teachers may subtly communicate that they have different academic expectations of boys and girls. These biased expectations become self-fulfilling when students respond to them. Although teachers may not systematically or consciously discriminate against students of the opposite sex, it still occurs.

Another focus into the “gender war” has been investigating role-model effects in education. Research has focused on the educational relevance of a teacher’s gender and how students respond to a teacher’s gender rather than a teacher’s behavior. This supports the potential existence of a role-model effect where students have improved intellectual engagement, conduct, and academic performance when assigned to a same-gender teacher. The results of this study demonstrate, at least, for females the role-model effect might be true. Female students who have female teachers score higher than female students who have male teachers.

Analyzing teacher sociocultural variables and student math achievement also offers several insights into understand factors that affect student achievement. The results of this study indicate that both degree level and holding a high school certificate to teach mathematics have significant positive effect on student math achievement. These teacher characteristics also have differential effects according to student gender. Male students who have teachers with a HS certificate to teach mathematics score better than their female counterparts. Certificate level was not a significant factor in predicting the math achievement for female students. The degree level of the teacher had the opposite effect. Although it appeared to have a positive effect on the math achievement scores for all students, when disaggregated, teacher degree levels were significant mainly for female students in contrast to their male counterparts.

These teacher effects, certificate level and degree level, agree with the work of D.H. Monk (1994) whose core work investigates the economics of education. In his quantitative study,
he ran regression models to understand the effects of secondary school teachers’ mathematics and science subject matter preparation on student performance gains. Monk found a positive relationship between the number of mathematics courses taken and undergraduate mathematic pedagogy courses and student math achievement scores. In addition, the study concluded that more than the number of math content courses, where the effect was significant up the five courses, the teaching mathematics courses a teacher took had a significant lasting positive effect on student math achievement. Similar to this dissertation, which indicates a positive relationship between math teacher degree level and teacher certificate type for teaching high school mathematics, the work of Goldhaber and Brewer (2000) shows that these characteristics matter. Their significant findings suggest that mathematics students who had teachers holding either bachelor’s or master’s degrees in mathematics scored better than students of teachers with degrees in other subjects. This study shows more specifically that students with a teacher who holds a master’s degree or higher score better than their bachelor counterparts. Studies conducted at the elementary and middle school level (Boyd et al., 2005; Desimone and Long, 2010) show that these teacher characteristics are critical across education level.

Interestingly, this study also shows that math teacher self-efficacy has no significant effect on math achievement while the teacher perception of class achievement has a relatively large effect on math achievement. Teacher beliefs can be decomposed into several elements. The construct of teaching self-efficacy evolved from Rotter’s (1966) locus of control theory and Bandura’s (1977, 1986, 1997) social cognitive theory. Teaching self-efficacy refers to the extent to which a teacher believes in the efficacy of their teaching to overcome student learning and behavioral problems, and it indicates to what extent a teacher judges his or her capabilities to bring about desired student engagement and learning outcomes (for all students).
Investigations have suggested a significant positive relationship between teacher math self-efficacy, the quality of their instructional practices and student outcomes (Brookover et al., 1977; Bursal & Paznokas, 2006; Guskey, 1988; Ross 1998; Turner, et al., 2011). Teachers with higher efficacy have been shown to be more likely to invest the time and effort necessary to learn how to implement new teaching strategies (Raudenbush, Rowen, & Cheong, 2002; Ross, 1998). Additionally, teachers with higher self-efficacy may be better at instructing both low- and high-achieving students (Ashton, Webb, and Doda, 1983) and have better classroom management skills (Knoblauch & Hoy, 2008). This dissertation is in contrast to the literature identified above in part due to the nature of the study. There are very few quantitative studies with the student as the unit of analysis—and not the teacher or instructional practices—that have tried to link teacher self-efficacy directly to student achievement. Additionally, this study disentangled teacher perception of class achievement from the math teacher perception of ability to teach mathematics. This study indicated that the former has a relatively large positive impact on student achievement while the latter does not.

Research suggests that it is likely that teacher educational background affects self-efficacy. Teachers’ beliefs about the ability or achievement levels of their students may shape their practices (Barr & Dreeben, 1983; Gamoran, 1986, 1987; Oakes, 2008; Page, 1991; Seaver, 1973). This dissertation indicated that teacher belief about the average class achievement level has a large positive impact on student math achievement. This phenomenon can be referred to as the Pygmalion effect or self-fulfilling prophecies. Researchers have demonstrated that when teachers expect students to perform (i.e., high or low), they behave in different ways, and these behaviors can bring about the expected performance (Rosenthal & Jacobsen, 1968). When working with “higher-ability” students, teachers are more likely to be warm and encouraging,
offer evaluative comments, invest more effort into teaching, provide more opportunities to participate, and have higher expectations (Boaler & Staples, 2008; Oakes, 2008; Rubin, 2008). Despite evidence that “higher-order thinking skills can be learned along with lower-order ones early in the instructional process” (National Research Council, 2012, p. 171), many math teachers believe that students must memorize and attain a basic procedural competency in math skills before being able to progress to higher reasoning skills and deeper conceptual understandings (Spillane & Jennings, 1997; VanDerHeyden, et al., 2012). Therefore, “lower-ability” students may be exposed to a less engaging, challenging, and rigorous curriculum than their “higher-ability” peers.

Teacher beliefs about student abilities are not necessarily accurate or intentional. Teachers may (unintentionally or intentionally) approach students of lower economic standings (Alvidrez & Weinstein, 1999), students in urban settings (Causey, Thomas, & Armento, 2000), special education students (Soodak, Podell, & Lehman, 1998), and minorities and female students (Nosek & Smyth, 2011), differently, based on their perception of student abilities. This dissertation indicates that for the entire sample, male and female students, teacher self-efficacy was not significant and that teacher perception of average class achievement is a relatively large, positive predictor of high school student math achievement. This effect although strongly positive across gender is slightly stronger for male students.

Whether based on subjective or “objective” measures such as intelligence tests, which are often administered as early as kindergarten, students of lower socio-economic status and minority students are more likely to be placed in lower academically tracked classes. The underlying assumption of tracking is that some students have more academic ability than others. This is a stark contrast to countries such as Japan that do not track students in elementary or
middle school and attribute success to effort and motivation. Inferior treatment of students based
on teacher perceptions of student abilities may erode students’ interest, efficacy, identity, utility,
and achievement (Turner et al., 2011).

Furthermore, the work of Jussim (2012) concludes that self-fulfilling prophecies, in
which teacher expectations directly change student achievements, have an effect size between .1
and .2, and teacher expectations, which indirectly alter their own judgments and perceptions of
students’ achievements, also have an effect size of approximately .2. Jussim (2012) points out
that an effect size of .2 implies that sixty percent of students of whom teacher have high-
expectation will perform above average, and 40% of students of whom teachers have low-
expectations will perform above average. Therefore, teachers’ high expectations increase the
performance of 10% of the students and low expectations decrease the performance of 10% of
the students. Similarly, assuming that two students began the school year earning Bs, and the
teacher had high expectations of one of the students and low expectations of the other student,
the high expectancy student may end the year with an A, whereas the low expectancy student
could end the year with a C. According to Jussim (2012), however, only inaccurate expectations
can produce self-fulfilling prophecies, and based on average correlations between teacher
expectations and student achievement, teacher expectations are about 75% accurate. Supported
by the literature, this dissertation concludes that teacher perceptions of the achievement level of
their students may be the single greatest predictor of student achievement and affective
development (Goe, 2007, 2008).

Theoretical Discussion

A framework incorporating the ideas of two major theories, social constructivism and
social constructivist theory were used to situate the theoretical grounding of this study in the
existing literature on student math achievement. The current study provides interesting results on the roles that teachers, students, and school environmental interactions have in influencing student achievement.

**Social Constructivists Theory**

Current educational reforms are asking teachers to stretch their thinking and to examine their teaching methods in a new light in order to raise teaching and learning to a new level. A collaborative view of knowledge generation allows for authority for learning, understanding, and distributing experience to all participants rather than just one person leading the group or monopolizing knowledge (Peterson, 1994). Social constructivism suggests that while working cooperatively, each teacher constructs new meaning without deemphasizing the importance of what each individual teacher brings to the shared interaction. Professional learning communities (PLCs) encourage the use of professional collaboration as a core tenet to have educators share previously constructed knowledge and construct new knowledge (Bertsch, 2012).

Social constructivist theory also considers the critical importance of the sociocultural aspects of cognitive development (Chen, 2010). Teachers and students bring their past beliefs, cultural histories, experiences, perceptions, and worldviews into the process of learning (Gordon, 2008). All of these factors influence how they interact with one another to construct meaning within the school environment. Giroux (1983) mentioned that meaning cannot be removed from the worlds of the people who “constitute, shape, and live within its definition” (p. 184). As teachers’ work and share experiences within their environment, they generate their own “rules” and “mental models,” which they use to make sense of their world.

As teachers interact, formally or informally, they acquire informal rules and alter their assumptions. Based on social constructivist theory, the ways in which teachers think are
predisposed by their experiences, which are coupled with the world in their minds. Their experiences are a part of what they see and to which they react. Learning, then, is a process of adjusting mental models to accommodate new experiences. Discourse is one vehicle used in that construction process. When participants are engaged in dialogic acts, which permit them to make knowledge their own by speaking in their own voice and language, it is empowering for all participants (Sprague, 1992). As teachers interact with each other, they alter their instruction, and, in turn, this fosters changes in student learning. As a result of this transaction, both parties leave the interaction having gained some form of knowledge (Teague, 2000). Vygotsky’s theory explains consciousness as the end product of socialization (Kearsley, 2001). Within a school environment, all participants are affected by the climate of the school.

This study considered a number of students’ personal factors (demographics and past experience) and those of the mathematical instructional environment (teacher characteristics, teacher expectation, and teacher attitudes) to predict students’ algebraic achievement outcomes. This dissertation confirms that both personal and environmental interaction variables have a significant influence on student algebraic achievement, confirming the belief social interactions are an important part of development.

This study also demonstrates that teacher beliefs had a substantial direct affect on student achievement. Teacher collaboration has been linked to impacting teachers’ collective efficacy (Munoz, 2008) and instruction practices (Bunker, 2008; Jussim 2012; Goe, 2007, 2008; Zito, 2011) influencing student achievement. In addition, student personal factors (demographics and past experience) had a significant impact on student achievement.

The next section explores the results of this study within the expectancy value paradigm. Individual perceptions of other peoples’ attitudes and expectations, their affective memories, and
their own interpretations of their previous achievement outcomes affect achievement outcomes (Eccles, 2002). Individual task perceptions and interpretations of past outcomes are assumed to be influenced by unique historical events and socializer’s behavior and beliefs, and cultural milieu.

**Expectancy Value Theory**

Expectancy value theory (EVT) proposes that the expectation of success at a given task and the degree to which this task is valued are determinants of achievement-related performance and choices (Eccles, 1994, 2009). Eccles and her colleagues (Eccles, 1994, 2009; Eccles & Wigfield, 2002; Eccles et al., 1983) elaborated multiple components of subjective task values and linked motivational beliefs to other psychological, social, and cultural factors, leading to differential performance. EVT (Eccles et al., 1983) defines expected success as a task-specific belief about the possibility of experiencing future success in that task, which is directly related to the evaluation of competency within a specific academic domain (e.g., academic self-concept, Marsh, 1986). In this model choices are assumed to be influenced by both negative and positive task characteristics, and all choices are assumed to have costs associated with them precisely because one choice often eliminates other options.

Expectations and values are influenced by task-specific beliefs such as perceptions of competence, perceptions of the difficulty of different tasks, and individuals’ goals and self-schema. These social cognitive variables, in turn, are influenced by individual perceptions of other peoples’ attitudes and expectations for them, by their affective memories, and by their own interpretations of their previous achievement outcomes. Individual task perceptions and interpretations of past outcomes are assumed to be influenced by the socializer’s behavior and beliefs and by cultural milieu and unique historical events. In addition, changes in student
academic performance are hypothesized to occur from differential interactions with teachers that provide different opportunities to learn (direct effects) as well as from social cues that communicate differential ability (indirect effects). These direct and indirect effects also act as mediators, which affect student self-expectations, motivation, and learning.

This dissertation operationalized the five motivational component of EVT—self-efficacy, identity, utility value, interest, and math class effort (cost perception)—and found that they were highly correlated. To better understand the motivational undercurrents that influence math achievement, this study indicates that the five components, while highly related, should be studied as independent factors (Pintrich, 2000). In addition, while controlling for teacher perception of PLCs as a contextual factor that affects teacher effectiveness, the subjective task value variables demonstrated mixed effects in predicting student algebraic achievement. There is also evidence that teacher interactions in conjunction with subjective task value variables have different effects on student academic outcomes, especially when comparing males and female students within the sample.

Summary

The goal of this study was to investigate the impact of teachers’ perception of PLCs on student algebraic achievement. Teachers’ perception of PLCs was constructed as a function of teacher beliefs about discourse (discussing of strategies for working with ELLs, at-risk student, workshops, sharing best practice, etc), collaborative interactions, and leadership support within PLCs. This study reports that teachers’ perception of PLCs has a small, yet positive affect of student achievement in mathematics. This affects also impact the achievement of male and female students disproportionately. Naughton (2006) states that if an interactional variable (such as perception of collaboration) is not significant in the presence of student socioeconomic status
(SES), the interactional variable can be considered practically irrelevant to the outcome variable (student algebraic achievement). Perception of collaboration can be considered ultimately to impact the math achievement of female students, while not having a practical impact on the scores of male students.

As part of this study, a number of control variables were incorporated to gain an understanding of their interactional effects on the primary dependent variable (student algebraic achievement) and independent variable (teachers’ perception of PLCs). A number of the variables included in this study provided results that were consistent with the existing literature regarding student achievement. Student level variables such as race, gender, SES, and various motivational factors were particularly strong predictors. The most notable results, were that motivational factors had unequal effects on male and female math achievement. Among student sociocultural variables, math utility and math interest had positive significant effects on female student math achievement scores. Interestingly, these two variables were not significant in predicting the achievement of male students. On the other hand, school engagement has a positive effect on male student math outcomes, while it had no effect on female student math outcomes. All three, math utility, interest, and school engagement, are important variables which are part of the environmental and instruction climate of a school. Finding ways to improve these factors would improve student achievement for all students.

Most teacher level characteristics that had previously been linked to student learning (race, degree level, teacher self-efficacy, certificate type) proved to be weak or insignificantly linked in predicting student math achievement. The most notable of the teacher level variables, was teacher perception of class achievement. It proved to be very stronger in predicting of student achievement in mathematics greater than student race or SES.
The next chapter explores the implications of these findings for educators, schools and policymakers, as well as the limitations of this study and areas for future investigation.
Chapter Six: Conclusion

This dissertation provides an analysis of the relative impact of math teacher collaboration on student algebraic achievement along with other variables that predict math achievement and success. The preceding chapter discussed the findings of this study in conjunction with the literature and theoretical frameworks that have grounded this study. This final chapter includes four major components. First, the introduction will provide a summary of the dissertation, methods, and major findings. Next, the limitations of the dissertation, then the implications of the study, and finally areas for future research will be explored.

Introduction

In this age of high accountability and high-stakes testing, extensive stress has been placed on classroom teachers. School administrators under pressure from shrinking budgets and government demands for accountability need compelling data showing that school initiatives have a positive impact on student learning (Lange, Magee, & Montgomery, 2003). Under the reauthorized Elementary and Secondary Act, called the Every Student Succeeds Act (ESSA), all students are held academically accountable for their preparedness for college and careers (Every Student Succeeds Act, 2015). Under the Obama administration, the Race to the Top legislation called for more intensive and more structured teacher observations as well as higher student achievement mandates. As a result, states, districts, and schools have been insistent on focusing on educator learning and development with current reform efforts (Caroll, 2009; Commissioner’s Task Force on Quality Teaching and Learning, 2005; Forum on Educational Accountability, 2010; Obama, 2010) as a way of enhancing student performance. This line of thinking is currently a part of most state education agendas. The National Research Council (NCR; 2011) suggested that “teacher quality is considered the most critical factor affecting academic
achievement” yet goes on to say that although “there is no consensus on what defines teacher quality . . . the most common measures are content knowledge, experience, pedagogical skills, and academic skills and knowledge” (p. 79). Researchers have been working extensively to isolate contextual factors and expand on the knowledge that interrogates teaching and learning.

With a plethora of teaching strategies and teacher quality improvement initiatives introduced every academic year, school districts and administrators struggle with a myriad of issues and choices related to educator development for improving student academic outcomes. Creating PLCs is one option many elect to implement in order to change their school cultures. PLCs provide a good structure for schools to improve student achievement and are grounded in the idea that professional development for teachers should result in the greatest success for all students (DuFour, DuFour, & Eaker, 2008). A PLC is distinguished and led by three core elements: a team of educators focused on learning, professional collaboration, and systemic reflection on accountable results (Dufour, 2004). In this dissertation, I focus on the impact of the teacher collaboration aspect of a PLC on student algebraic achievement. Dufour (2011) defined teacher collaboration as “a systematic process in which teachers work together interdependently to analyze and impact professional practice [and] improve results for [their] students, [their] teams, and [their] schools” (p. 10). Schmoker (2007b) proposed that collaboration enables teachers to deepen their understanding of teaching. “In collaborative working environments, teachers have the potential to create the collective capacity for initiating and sustaining ongoing improvement in their professional practice so each student they serve can receive the highest quality of education possible” (Pugach & Johnson, 2002, p. 6).

The quality of a collaborative experience a substantial amount depends on the type of collaboration experienced (Chadbourne, 2004) and the discourse patterns teachers’ use within the
collaborative experience (Horn & Little, 2009). Thus it is important to contrast aspects of teacher collaboration that support student learning. In the last two decades, interest in investigating direct links between particular aspects of collaboration has been growing among educational policymakers and researchers.

While the focus has been on actual classroom behavior, at present more focus is looking at contextual factors that are important indicators of student achievement and affect teacher quality (Darling-Hammond, 2000b; Ferguson, 1991; Goldhaber & Brewer, 2000; Laczko-Kerr & Berliner, 2002). Over that time, “growing research evidence suggests that teacher’s quality is not fixed and depends a great deal upon a school’s working environment and climate, and the quality of colleagues” (Ronfeldt as quoted in Hart, 2005). The quality of a teacher can change over time.

This dissertation does not seek to make general claims about all teacher collaborative groups but rather to contribute to the existing literature on the contextual conditions conducive to instructional improvement. In answering the question, what is the impact of teachers’ perception of PLCs on student algebraic achievement and does the impact manifest differently according to gender, the principal aim of this study is to advance understanding of the ways in which collaborative teacher interactions provide opportunities for teachers to development themselves professionally and impact student achievement.

**Theoretical Overview**

This study employs two theoretical frameworks, social constructivist and expectancy value theory, to examine the complexities of teacher perceptions and interactions, student achievement, and variations in male/female academic outcomes. From a socio-constructivist perspective, Vygotsky’s (1978) states social interactions plays a key role in understanding the process of teacher collaboration and cognition as well as student learning. A learner is much
more actively involved in a joint enterprise with a teacher in creating (constructing) new meanings (Chen, 2010). When teachers participate in collaboration, communication, experimentation, and inquiry with their colleagues, they are constructing meaning without deemphasizing the importance of what each individual teacher is bringing to the shared interaction. All participants also bring their past beliefs, cultural histories, experiences, perceptions, and worldviews into the process of learning. All of these factors influence how teachers interact with one another and their students to make meaning.

Expectancy value theory (EVT) proposes that expectations of success at a given task and the degree to which the task is valued are determinants of achievement-related performance and choices (Eccles, 1994, 2009). (EVT) posits expectations and values are assumed to directly influence performance, persistence, and task choices. Expectations and values are also assumed to be influenced by domain-specific and task-specific beliefs such as perceptions of competence, the difficulty of the tasks, and individuals’ goals and self-schemas. These social cognitive variables, in turn, are influenced by individual perceptions of other peoples’ attitudes and expectations for them, by their affective memories, and by their own interpretations of previous achievement outcomes.

Research has portrayed the gender dynamic in classrooms as an important source of the gender difference in educational outcomes (American Association of University Women [AAUW], 1992; Sommers, 2000). Studies suggest that teachers are strong socializing agents within the learning environment and play pivotal roles in shaping boys’ and girls’ expectations and achievements. The math gender gap varies depending on the context of a class. This indicates the key role that the environment and socialization play in the formation of these gaps (Else-Quest, Hyde, & Linn, 2010).
Social constructivism is the overarching framework employed, followed by expectancy value theory. Social constructivist theory assists in understanding how collaborative interactions or the perception of them impact student learning, while expectancy value theory looks a combination of sociocultural and psychological factors, which affect student achievement. It has been noted that, teachers might subtly communicate different academic expectations of boys and girls and indirectly this bias becomes a self-fulfilling prophecy when students respond to them (Jones & Dindia, 2004). This makes a teacher and his or her perception of PLCs and expectations an important socializer within the students’ social world.

Methods Overview

This dissertation employed data retrieved from a national survey, the High School Longitudinal Study of 2009 (HSLS:09), the follow-up survey conducted in 2012, and secondary assessment scores collected from the cohort of students in 2012. It focuses on the entire student sample and the corresponding math teacher population that participated in the study. The HSLS:09 has the student as the unit of analysis. Thus the design of the mathematics teacher survey does not provide a standalone analysis sample of teachers but instead permits specific teacher characteristics and aspects of the school environment to be related directly to the learning context and educational outcomes of sampled students.

The dependent variable, student algebraic achievement, is operationalized in terms of its theta ability scores on the algebraic assessment administered to the population of students during the 2012 HSLS:09 follow-up. The test framework was designed to assess a cross-section that is representative of the major algebra domains (language of algebra, proportional relationships, linear functions, non-linear functions, systems of equations, and sequence and recursive relationships) and key reasoning processes of algebra (demonstrating algebraic skills, using
representations of algebraic ideas, performing algebraic reasoning, and solving algebraic problems). For this study, theta ability scores provide a summary measure of achievement for individual students that is useful for correlational analysis. This dissertation compares all models according to their effects on student ability scores.

I invoke several stages of analysis. The goal of the initial stage was to develop a deeper understanding of the constructs that make up the study. Descriptive statistics and correlation matrices accomplished this goal. Subsequently, an OLS regression analysis was employed to determine the relative impact teacher collaboration had on student algebraic achievement. To test the research question, a series of four hierarchical regression models explored the impact four domains—teacher perception of PLCs, student demographics, student sociocultural and teacher sociocultural variables—had on the dependent variable, student algebraic achievement. I examined the relationship between the independent variables from these four domains and the dependent variable of student algebraic achievement for the entire HSLS:09 population of students and then separately for female and male students.

Findings Overview

Findings reveal that math teacher perception of PLCs has an impact on student achievement in mathematics. Teacher perception of PLCs also had disproportionate effects on the achievement of males and female students. Naughton (2006) states that if an interactional variable (such as perception of PLCs) is not significant in the presence of socioeconomic status (SES), the interactional variable can be considered practically irrelevant to the outcome variable (student algebraic achievement). Perception of PLCs can be considered to impact the math achievement of female students, while not having a practical impact on the scores of male students. Moreover, perception of PLCs was not significant in the presence of other teacher
sociocultural variables. Which indicates perception of PLCs was serving a proxy variable to some other teacher sociocultural characteristics. Further investigation needs to be conducted to determine the impact of engaging in professional learning communities on student achievement in math.

Student-level variables such as race, gender, SES, and various motivational factors were particularly strong predictors, a finding strongly supported in the existing literature. The most notable results from the student-level variables were that motivational factors, which are known to predict math achievement, had unequal effects on male and female students. Math utility had a positive significant effect on female student math achievement scores along with math interest. Interestingly, these two variables had no significant effect on male student scores. On the other hand, school engagement had a positive effect on male student math outcome, while it had no effect on female student math outcomes. Most teacher level characteristics proved to be weak or insignificant in predicting student math achievement. The most notable of the teacher level variables was teacher perception of class achievement. This variable proved to be a strong predictor of student math achievement, stronger than even student race or SES.

Limitations

The present study explored the impact of teacher perception of PLCs on student algebraic achievement scores, but there are several limitations to be considered.

The first apparent limitation of this dissertation is that it is purely quantitative. This guides the types of conclusions one can draw from the results. This methodology, however, was chosen to best meet the objectives of this study, which was to distinguish factors that influence or predict a specific outcome (Creswell, 2009), more specifically to predict the impact of teacher collaboration along with other student-, teacher-, and school-level variables on student algebraic
achievement. Consequently, the results are restricted to identifying significant predictors that have an effect on the outcome variable and describe the influence (strength and direction) it has on the variable. Student algebraic achievement, the outcome variable for this dissertation, is a sole product of the variables selected to predict it. Thus, the description of process or mechanism cannot be explicated from the result. To develop an understanding of how or why teacher collaboration affects student algebraic achievement, the research methodology would have to be extended beyond quantitative analysis.

The constructs selected for analysis were difficult to measure, and it is possible the chosen method of measurement was not ideal for this purpose. Student and teacher characteristics and teacher collaboration measures were all measured based on participants’ self-reported responses to survey questions. The reliability of self-reported measures can be compromised if participants have unrealistic perceptions and if they are not motivated to provide accurate and honest responses. Additionally, the validity of self-reported measures can be undermined if participants do not understand the vocabulary or wording of the questions (Mayer, 1999; Rowan et al., 2002). Moreover, HSLS:09 teachers and students were notified that their answers on the tests and surveys would only be used for research purposes and no identifiable information would be publicly disclosed. Thus participants may not be highly motivated to provide thoughtful responses that validly represent their true understanding or beliefs (Liu, Bridgeman, & Adler, 2012). In addition, responses to questionnaire items do not provide full insights into the complicated nature of certain factors.

For all twelve teacher collaboration markers, which comprised the teacher perception of PLCs composite variable, teachers were asked to report whether they strongly agree, agree, disagree, or strongly disagree. Teachers’ interpretations of what defines these categories as well
as their opinions to what extent they discuss or use each marker may vary widely from educator to educator. Additionally, based on their professional learning community experience, teachers may place varying degrees of emphasis on the markers. Horn and Little (2010) emphasize the sociopolitical nature of a school or department affects the norms and discourse patterns teachers use within professional learning communities. Researchers would need to use extensive videotaping or observations that were objectively scored by multiple raters to obtain a valid and reliable measure of the extent teachers discuss each of the markers and how those discussions influence changes in their instruction.

The use of a composite indicator has pros and cons. Composite indicators in most studies are used to summarize a multi-dimensional issue in order to provide a clearer view of the big picture. This makes a multi-dimensional issue easier to interpret than trying to find a trend in several indicators. Since its inception, this dissertation, using a national representative sample, has sought to investigate the extent to which educators’ discourse patterns affect student algebraic achievement. However, with a Cronbach’s alpha coefficient of reliability of 0.9, which is considered an extremely strong correlation, comparing individual marks was not possible. This creates the possibility of an over simplified conclusion.

There are also limitations in the methods used to measure prior and current student achievement. Measuring student prior achievement based on the grades is inherently subjective and biased by teacher beliefs and opinions. Additionally, although measuring student achievement on standardized test performance is more objective, assessments may not cover a representative sample of teaching and learning standards, may not assess students’ higher-level thinking skills, and students’ performance may be influenced by non-academic factors (e.g.,
students’ mood, sleep, anxiety, motivation) not captured by the sociocultural variables that are controlled for (Liu, Bridgeman, & Adler, 2012; Polikoff et al., 2011).

Ordinary least square linear regression using multiple control variables to predict student algebraic achievement also has flaws. For one, OLS models measure classroom not teacher effects. Additionally, the HSLS:09 did not randomly assign students to classrooms. There are potentially other factors that affected student results that were not included (e.g., prior retention, special education status, ELL status, student-teacher ratio, extra-curricular activities). Omitting potentially confounding variables can also result in an overestimation of effects and an overall inability to discern the markers of effective teaching from unmeasured aspects of students’ backgrounds (Harris, 2011; Cantrell & Kane, 2013).

The current study utilized longitudinal sequence data, employing data collected from the HSLS:09 and the HSLS:09 first follow-up in 2012. As part of the study, student, school, and administrative information was updated in 2012. Teachers, however, were not. Teachers were selected by virtue of teaching an HSLS:09 student in mathematics from the base year cohort. This sampling procedure was essential to link teachers to the students who participated, thus making the contextual information more valid within the study. Only teachers linked to students for the HSLS:09 base-year study were identified for the mathematics-teacher survey. The follow-up sample consisted of students who were selected for the base-year study administered during the 2009–10 school year and were still eligible for HSLS:09. No new sample of schools was selected for the follow-up; thus the first follow-up is not representative of high schools with ninth and 11th grades in the 2011–12 school year but rather was intended as a follow-up to the base-year students who were originally analyzed for school-level effects on longitudinal student outcomes. The results of this study can only be interpreted within this context.
Finally, the data used within this survey were derived from a nation data set, which represents the characteristics of students within the United States only. While the findings may be valid to discuss the mathematics achievement of American high school students, results may not be the same for students in other countries or different education systems (Horn & Little, 2010; Ingvarson et al., 2005). Educational policies shape much school experience; hence, the policies of other nations can create a school and classroom context that influences student expectations, drives, learning, and ultimately their academic achievement differently. In addition, the cultural norms of different countries may mean teachers’ implementation of reform practices and student academic mindsets vary. This is especially true within the domain of mathematics.

Notwithstanding its limitations, this dissertation produced a number of significant findings that will contribute to the development of mathematics achievement. The following sections will discuss important implications and recommendations for future research.

**Implications**

The results of the present study contribute to the theories that address cognitive, social, cultural, and environmental factors that impact learners’ construction of knowledge and thus have practical implications for policy. Many researchers and policymakers have noted that to improve student learning, teachers need to increase their content and practical teaching skills. This idea is supported at the federal, state, and local levels. This dissertation adds to knowledge about the school contextual effects of collaborative efforts and their impact on student-learning outcomes.

**Teacher Collaboration**

The present study contributes to teacher perception and beliefs research by providing empirical evidence that supports teacher perception of collaboration within PLCs has an impact
on student achievement within the domain of mathematics. Increased emphasis on measuring a PLCs effectiveness to develop educators’ skills can provide a useful addition to other traditional methods of evaluating program usefulness.

One of the most surprising findings to result from this study was the strength of teachers’ beliefs about their students’ academic ability as a predictor of students’ actual achievement. Compared to having a teacher who perceived the class to be below average, students of teachers who believed that the class was above average, average, or even widely differing in ability performed between .21 and .66 standard deviations better. According to Kane (2004) this effect size is equivalent to a difference of an additional 7 to 23 months of schooling. The strength of the teacher belief about student academic ability also had the effect of improving the scores of male students more than their female counterparts.

These results imply that it may be pivotal for teacher education programs and schools to provide pre-service and in-service teachers with training on reflective techniques that can be used to develop their meta-cognitive awareness of their thoughts, feelings, and actions on students’ affective and cognitive development. Teachers could also benefit from self-regulating their beliefs, perceptions of students, and actions to create equitable learning environments where all students are held to the same high expectations and treated with respect and fairness (NCTM, 2009a, 2009b). Moreover, as a policy implementation, administrators may want teacher education programs to include in their evaluations measures of teacher perceptions about student abilities to determine which individuals deserve the honor and responsibility of shaping our nation’s future generations. Finally, more rigorous response to intervention research is needed to investigate educators’ abilities to assess students’ cognitive development accurately and determine integrity at implementing differentiated instructional strategies. This research may
help resolve the debate over whether certain strategies benefit particular students or all students benefit equally from all strategies.

**Student Motivation**

One of this study’s more salient areas of investigation, derived from the expectancy value framework, was the impact of student motivational factors. This study tested seven motivational factors—math class effort, identity, utility, self-efficacy, interest, school belonging, and school engagement. Of these, math class effort, math identity and student math self-efficacy were highly significant in predicting student achievement. These results demonstrate that efforts to improve student class effort, math identity, and student math self-efficacy are not in vain.

The most notable results from the student level variables were that motivational factors, which are known to predict math achievement, had unequal effects on male and female students. Math utility had a positive significant effect on female student math achievement scores along with math interest. Interestingly, these two variables were not significant and had no effect on male student scores. On the other hand, school engagement had a positive effect on male student math outcome, while it had no effect on female student math outcomes.

These results have implications for women’s current success in mathematics and future STEM trajectories. Despite advances in the U.S. workforce, women’s entrance into STEM careers has been less successful. These fields still remain heavily male-dominated. Research has demonstrated that access to math and science careers, along with their accompanying economic benefits, are not proportionately extended to women. This study builds on a well-established literature by identifying motivational factors that contribute to women’s underrepresentation in STEM.
Girls consistently express less interest in math (Jacobs et al., 2002) and view math and STEM careers as less aligned with their personal career interests and goals (Su et al., 2009). Studies have shown that greater interest in and the utility value of math may lead to greater investment and persistence in math activity, which ultimately leads to higher math achievement (Wigfield and Eccles, 2002; Wang, 2012). This dissertation confirms that female math achievement is especially sensitive to interactions that effect math interest and utility. Hence, in addition to promoting greater math achievement, current policy initiatives should target the development of math task value, which refers to tasks that encourage interest in math and its utility value. When women see STEM fields as useful, widely applicable, and viable career options they will be more likely to opt into them.

In considering enhancing women’s math task value to inspire larger numbers of women to consider STEM fields as viable careers, it is important to consider how this would look in practice. It is not a secret that students are more engaged in classrooms that incorporate hands-on learning, creative thinking, and challenging real-world applications of problems and concepts (Marks, 2000). For women, and girls in particular, it is helpful to take a proactive approach that utilizes their strengths. For example, a recent study showed that girls are more likely than boys to have both high verbal and math skills (Wang et al., 2013). Therefore, incorporating storytelling into math may not only capitalize on the strengths of girls’ verbal skills but also increase female interest in math and science by making these subjects appear hands-on and practical. Additionally, incorporating specific teaching strategies such as focusing on women’s historical contributions to these fields and increasing girls’ exposure and access to female scientists and engineers as career role models (Steinke et al., 2007) may help combat the pervasive math-
gender stereotypes that affect girls’ math identities as young as six years of age (Cvencek et al., 2011).

Increased emphasis on math task value also offers opportunities to actively engage both males and females in learning. While there are an increasing number of programs that target student interest, enjoyment, and engagement in STEM (e.g., Detroit Area Pre-College Engineering Program, Great Explorations in Math and Science, Project Lead the Way), these crucial motivating factors should become a greater focus of all K-12 interventions. This is particularly important, given that increases in STEM course taking and achievement among females have not led to increases in STEM workforce participation. Programs need to strengthen teacher training and redesign curriculum to include targeted strategies for dispelling gender stereotypes and increasing female interest in STEM.

**Future Research**

This dissertation has various limitations, which also provide opportunities to pursue new research. This section will discuss future research prospects, which build on the current study. I hope that by building on the present study, forthcoming results can be used to further future studies.

First, although outside of scope of this dissertation, the impact variables and their relationship to student performance should be further investigated. This study focused on the perception of all teachers in the study and the impact on all student and then is manifestation according to gender. Future investigations can disaggregate the teaching sample (race, gender, level of perception) and the student sample (race, learning ability, urbancity) in subgroups and explore the interactional impacts on student math performance.

Findings demonstrated that at first glance students having a Black teacher had a negative
impact on the achievement of all students in the sample, while having an Asian teacher had an equally positive impact on achievement for all students. Upon investigating further, this influence was not consistent according to gender. Having an Asian teacher was only a positive predictor for all of the male students in the sample. Having Black teacher was insignificant for all males in the sample, and neither race teacher had a significant impact on all females in the sample. Studies exploring the mediating effects of teacher level characteristics on the relationship between student-level factors and student achievement are needed.

Future research should consider several methodological modifications. The current study was purely quantitative in nature, using OLS regression models to predict the outcome variable. Quantitative investigation limits the type of questions and conclusions that can be drawn to “what” impacts student algebraic achievement instead of answering questions of “how” or “why” student performance is affected. For this study to answer those questions, investigation beyond the survey data is needed. For this, a mixed-methods approach could be employed. Creswell (2009) describes mixed methodological approaches as combining the strengths of quantitative and qualitative research to provide a greater understanding of complex research problems.

The current study could be furthered by utilizing a sequential explanatory mixed methods design (Creswell, 2009). For example, the second phase of research would employ qualitative data collection and analysis to build on the results of this study. This could take the form of teacher interviews, recording, observations, case studies, etc. Moreover, this would also improve the reliability of the survey data by providing a way to triangulate the data gathered from interviews and observations over time. The current study also used a composite variable, which analyzed the impact 11 different discourse patterns used within teacher collaboration had on student math achievement. Results also indicated that there was limited variation between
teacher responses for those questions. Hence, it was more beneficial to analyze their combined effect on student achievement. Using a mixed methods approach, the impact of the individual variables could be further explored for their different effects on instruction and student achievement.

Considering other modifications, OLS regression models were used to best answer the research questions for this study. Future research, however, could consider a multi-level modeling approach. This study could not use a multi-level approach because the HSLS:09 data set did not include a teacher identifier variable. In addition, students were randomly sampled from schools limiting the number of student per teacher. Future studies could greatly reduce the potential of confounding variables if they randomly assign students to classrooms, randomly sample entire classrooms, include a teacher identifier variable, and use multi-level modeling.

Future research could also explore whether data are influenced by alternative motivational conditions, mediating effects, or other sociocultural factors not included in this study. For example, certain teacher characteristics show mediating effects on most student-level factors (e.g., prior achievement, the prior curriculum studied, SES, and race/ethnicity). This finding suggests that teacher characteristics can explain why a proportion of these student-level factors predict student algebra achievement. It implies that having an effective teacher can mitigate some of the effects of student-level factors. Further research is needed to investigate whether having a highly effective teacher has a varying impact on students from different backgrounds.
Appendices

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Appendix A. Dependent and Independent Variables of Interest

Dependent Variables:

**Student Algebraic Achievement** - Theta (X2TXMTH) - The theta (ability) scores provide a summary measure of achievement. The algebraic assessment test was administered at two points in time, during their ninth-grade year, 2009, and during the middle of their expected junior year, 2012. Theta is useful for correlational analysis against status and educational process variables, such as demographics, school type, or behavioral measures. In addition, it provides measures of gain in algebraic reasoning ability over time.

Independent Variables:

**Domain 1: Teacher Collaboration Strategies**
To what extent do you agree or disagree with each of the following statements about the math department at [your school]? Math teachers in this department... (teachers select (a) strongly agree, (b) agree, (c) disagree, or (d) strongly disagree for each option)

- Share ideas on teaching.
- Discuss what was learned at a workshop or conference.
- Share and discuss student work.
- Discuss particular lessons that were not very successful.
- Discuss beliefs about teaching and learning.
- Share and discuss research on effective teaching methods.
- Share and discuss research on effective instructional practices for English language learners (ELLs).
- Explore new teaching approaches for under-performing students.
- Make a conscious effort to coordinate the content of courses with other teachers in this school.
- Provide support to new teachers.
- Feel responsible for helping each other [teachers] do their best.

**Domain 2 and 3: Student-Level Demographic and Sociocultural Variables**

- **Demographic**
  - What is your sex?
  - Which of the following choices describes your race?
- **Socio-economic status from parent survey**
  - Household income – Categorically (P1INCOMECAT – P1C18)
  - Parent 1 highest degree earned (P1HIDEG1 – P1C01)
  - Parent 2 highest degree earned (P1HIDEG2 – P1C09)
- **Prior mathematics experience**
  - Since the beginning of the last school year (2008–2009), which of the following activities have you participated in?
• Math identity
  o I see myself as a math person.
  o Others see me as a math person.
• Math interest
  o I enjoy (Math) class very much.
  o I think (Math) class is a waste of time.
• Math utility – What I learn in this course ...
  o is useful for everyday life.
  o will be useful for college.
  o will be useful for a future career.
• Math efficacy
  o I am confident that I can do an excellent job on tests in this course.
  o I am certain that I understand the most difficult material presented in the textbook used in this course.
  o I am certain that I can master the skills being taught in this course.
  o I am confident that I can do an excellent job on assignments in this course.
• Math gender perception
  o In this course, how would you compare males and females in math?
    ▪ Females are much better.
    ▪ Females are somewhat better.
    ▪ Females and males are the same.
    ▪ Males are somewhat better.
    ▪ Males are much better.

Domain 4: Teacher-Level Characteristics
• Teacher demographic
  o What is your sex?
  o Which of the following choices best describes your race?
• Teacher quality
  o Highest degree earned
  o Type of math teaching certificate currently held by teacher
  o Math teacher held math-related job prior to becoming a teacher.
  o Years math teacher has taught high school math
• Teacher beliefs about teaching and learning. High school math teachers at this school… (teachers select (a) strongly agree, (b) agree, (c) disagree, or (d) strongly disagree for each option)
  o Set high standards for teaching.
  o Set high standards for student learning.
  o Believe all students can do well.
  o Have given up on some students.
  o Care only about smart students.
  o Expect very little from students.
  o Work hard to make sure that all students learn.
- Teacher self-efficacy
  - Are effective at teaching students mathematics
  - Feel responsible that all students learn
  - Feel responsible when students in this school fail
Appendix B. Algebraic Assessment Background Information

The following is information about the HSLS:09 follow-up Mathematics Assessment of Algebraic Reasoning taken from the Base-year Through First Follow-up. Taken from the HSLS:09 Instrumentation codebook (pp. 18 – 24).

Algebraic Reasoning Framework

This task entailed designing an assessment of student understanding, and growth in understanding, of key algebraic knowledge and skills in algebra as a measure of mathematical preparation for the study of science, preparation for further study within the mathematical science and statistics, and preparation for the requisite skills and expectations of the workplace. Accordingly, the framework was designed to assess a cross-section of understandings representative of the major domains of algebra and the key processes of algebra.

The test and item specifications describe six domains of algebraic content and four algebraic processes:

- Algebraic Content Domains:
  - The language of algebra
  - Proportional relationships and change
  - Linear equations, inequalities, and functions
  - Non-linear equations, inequalities and functions
  - System of equations
  - Sequences and recursive relationships
- Algebraic Processes:
  - Demonstrating algebraic skills
  - Using representations of algebraic ideas
Performing algebraic reasoning

Solving algebraic problems

Each item was coded to one of the Algebraic Content Domains and one of the Algebraic Processes.

Assessment Construct

The base-year administration of the HSLS:09 mathematics assessment was a two-stage adaptive assessment, composed of 73 unique items. Although 73 unique items were administered, owing to performance problems for one item, only 72 were scored, and the base-year scale has a range of 0 – 72. After scoring of the base year assessment, HSLS:09 decided to extend the assessment by developing additional higher difficulty items. Their rational was that this would guard against ceiling effects while more accurately measuring the full spectrum of algebraic knowledge and skills that is taught and learned in the first 3 years of high school. In the follow up, 20 new items were included.

As with the base year, the HSLS:09 first follow-up mathematics assessment was administered by computer, using a two stage design wherein each student completed a Stage 1 “router test” and then a Stage 2 test designated as {low, moderate, high} difficulty that was assigned on the basis of Stage 1 performance. In total, the first follow-up assessment consisted of 73 unique items, with 23 serving as linking items to the base-year assessment, with any given student receiving 40 items.

The administration design is as follows:

- Each student took a common 15-item Stage 1 router test that consisted of 11 base-year linking items and 4 unique to the first follow-up.
On the basis of Stage 1 performance, each student was routed to a low, moderate, or high Stage 2 test, each consisting of 25 items.

Items on the Stage 2 tests included 5 items linking the moderate and high tests; 12 base-year linking items were part of both the low and moderate Stage 2 test.

Students were aware that they were taking a 40-item test in two parts, a 15-item part and a 25-item part.

The computer-delivered design included an online scientific calculator and allowed students to skip and return to items within each stage and to identify items for review within each stage before submitting their answers as finished.

Of the 23 base-year items, 11 were included on the Stage 1 router, and 12 were included on both Stage 2 low and Stage 2 moderate levels. In addition to these items, 50 items were selected from the augmented field-test pool to comprise the first follow-up Stage 1 router and Stage 2 test based on the following criteria:

- Items needed to represent a balance across the six content domains and the four algebraic processes.
- The average difficulty of the 15 items allocated to the Stage 1 router test and to each set of 25 items on the Stage 2 tests was preset as follows on the basis of the difficulty parameter of the IRT model (Hambelton and Swaminathan, 1985) obtained using the updated field-test data:
  - Stage 1 router average difficulty = 1.6
  - Stage 2, low test average difficulty < -0.6
  - Stage 2, moderate test average difficulty = 1.6
  - Stage 2, high test average difficulty > 2.6
Additionally, students were assigned to the three Stage 2 tests on the basis of their Stage 1 router performance so that, based on field-test results, approximately 25 percent of students would be routed to the high form, 50 percent to the moderate form, and 25 percent to the low form.

**First Follow-up Scoring Procedures**

The assessment data were examined for possible indicators of lack of motivation to answer questions to the best of the student’s ability. Examples of possible indicators are missing responses and pattern marking (e.g. AAAAAAA or ABCDABCD).

The scores used to describe students’ performance on the mathematics assessment are based on IRT (Hambleton and Swaminathan 1985). The IRT model uses patterns of correct, incorrect, and omitted responses to obtain ability estimates that are comparable across the low-, moderate-, and high-difficulty test forms. One of the assumptions under the IRT model is unidimensionality of the test items. To verify that the items met the assumption, confirmatory factor analysis (CFA) was conducted based on each first follow-up test form.

Specifically, the IRT three-parameter logistic (3PL) model was used to calibrate the test items and estimate a student’s ability. The 3PL model is a mathematical model for estimating the probability that a person will respond correctly to an item. This probability is given as a function of one parameter characterizing the proficiency of a given student and three parameters characterizing the properties of a given item – the item’s difficulty, discriminating ability, and a guessing factor. The IRT model accounts for the three characteristics of each test question in estimating a student’s ability. BILOG-MG (Zimowski et al. 2003) was used in carrying out item calibration and student ability estimation. During item calibration, separate ability priors based on performance on the router test were used for each of the three subpopulations taking the
different second-stage tests (i.e., low, moderate, and high forms). The Bayesian estimation procedure was applied in estimating student proficiency.

Advantages of IRT

IRT scoring has several advantages over traditional raw number-correct scoring. First, IRT uses the overall response pattern of right and wrong answers to estimate ability and therefore can account for the guessing factor – a low ability student guessing several difficult items correctly. Specifically, if answers on several easy items are wrong, a correct difficulty item is assumed, in effect, to have been guessed. Second, unlike in raw number-correct scoring, where omitted (skipped) responses are treated as incorrect answers, IRT procedures number-correct treat the omitted responses as not administered and use the pattern of responses to estimate the probability of correct responses for all test questions. Therefore, omitted items are less likely to cause distortions of scores as long as enough items have been answered right and wrong to establish a consistent pattern.

Theta Algebraic (Ability) Score

Theta (ability) estimate provides that base scores for all the other summary statistics provided by HSLS:09 follow-up.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Range</th>
<th>Weighted mean</th>
<th>Weighted Standard Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>X2TXMTH</td>
<td>HSLS:09 first follow-up mathematics theta score</td>
<td>-2.60 – 4.50</td>
<td>0.55</td>
<td>1.134</td>
</tr>
</tbody>
</table>

Theta score estimate ability in a particular domain. The theta scores are on the same metric as the IRT item-level difficulty parameters. Therefore, the theta scores may be less intuitively interpretable than a score that is a transformation of theta, such as the estimated number-correct or the T-score. However, the theta scores tend to be more normally distributed than estimated
number-correct scores, because they are not dependent on the item difficulty parameters of the items within the scale score set. The standard error of measurement (SEM) is provided with the IRT theta.

The theta (ability) score provide a summary measure of achievement useful for correlational analysis with both status and educational process variables, such as demographics, school type, or behavioral measures (such as advanced mathematics taken). They may be used in multivariate models as well, and provide measures of gain in algebraic reasoning ability over time (value-added studies).
Appendix C. Psychometrics and Item Response Theory Modeling

General information regarding Item Response Theory (IRT) modeling

From Wikipedia,


Psychometrics is a field of study concerned with the theory and technique of psychological measurement. One part of the field is concerned with the objective measurement of skills and knowledge, abilities, attitudes, personality traits, and educational achievement. For example, some psychometric researchers have, thus far, concerned themselves with the construction and validation of assessment instruments such as questionnaires, tests, raters' judgments, and personality tests. Another part of the field is concerned with statistical research bearing on measurement theory (e.g., item response theory; intra-class correlation).

As a result of these focuses, psychometric research involves two major tasks: (i) the construction of instruments; and (ii) the development of procedures for measurement. Item response theory (IRT), also known as latent trait theory, strong true score theory, or modern mental test theory, is a paradigm for the design, analysis, and scoring of tests, questionnaires, and similar instruments measuring abilities, attitudes, or other variables. It is a theory of testing based on the relationship between individuals’ performances on a test item and the test takers’ levels of performance on an overall measure of the ability that item was designed to measure. Several different statistical models are used to represent both item and test taker characteristics. Unlike simpler alternatives for creating scales and evaluating questionnaire responses, it does not assume that each item is equally difficult. For example, questions can be varied according to low, medium, and high; these can be used to represent the student test taking ability. This
distinguishes IRT from, for instance, the assumption in Likert scaling that "All items are assumed to be replications of each other or in other words items are considered to be parallel instruments"[2] (p. 197). By contrast, item response theory treats the difficulty of each item, the item characteristic curve (ICC) as information to be incorporated in scaling items.

The name *item response theory* is due to the focus of the theory on the item, as opposed to the test-level focus of classical test theory. Thus IRT models the response of each examinee of a given ability to each item in the test. The term *item* is generic: covering all kinds of informative item. They might be multiple choice questions that have incorrect and correct responses, but are also commonly statements on questionnaires that allow respondents to indicate level of agreement (a rating or Likert scale), or patient symptoms scored as present/absent, or diagnostic information in complex systems.

IRT is based on the idea that the probability of a correct/keyed response to an item is a mathematical function of person and item parameters. The person parameter is construed as (usually) a single latent trait or dimension. Examples include general intelligence or the strength of an attitude. Parameters on which items are characterized include their difficulty (known as "location" for their location on the difficulty range), discrimination (slope or correlation) representing how steeply the rate of success of individuals varies with their ability, and a pseudo-guessing parameter, characterizing the (lower) asymptote at which even the least able persons will score due to guessing (for instance, 25% for pure chance on a multiple choice item with four possible responses). This model takes into account if the student omits or guesses a question into their ability score, thus improve reliability of the score.

IRT models are often referred to as *latent trait models*. The term *latent* is used to emphasize that discrete item responses are taken to be *observable manifestations* of hypothesized
traits, constructs, or attributes, not directly observed, but which must be inferred from the manifest responses. Latent trait models were developed in the field of sociology, but are virtually identical to IRT models.

IRT is generally claimed as an improvement over classical test theory (CTT). For tasks that can be accomplished using CTT, IRT generally brings greater flexibility and provides more sophisticated information. Some applications, such as computerized adaptive testing, are enabled by IRT and cannot reasonably be performed using only classical test theory. Another advantage of IRT over CTT is that the more sophisticated information IRT provides allows a researcher to improve the reliability of an assessment.

IRT entails three assumptions:

1. A unidimensional trait (theta)
2. Local independence of items;
3. The response of a person to an item can be modeled by a mathematical *item response function* (IRF).

The trait is further assumed to be measurable on a scale (the mere existence of a test assumes this), typically set to a standard scale with a mean of 0.0 and a standard deviation of 1.0. Uni-dimensionality should be interpreted as homogeneity, a quality that should be defined or empirically demonstrated in relation to a given purpose or use, but not a quantity that can be measured. 'Local independence' means (a) that the chance of one item being used is not related to any other item(s) being used and (b) that response to an item is each and every test-taker's independent decision, that is, there is no cheating or pair or group work. The topic of dimensionality is often investigated with factor analysis, while the IRF is the basic building block of IRT and is the center of much of the research and literature.
The IRF gives the probability that a person with a given ability level will answer correctly. Persons with lower ability have less of a chance, while persons with high ability are very likely to answer correctly; for example, students with higher math ability are more likely to get a math item correct. The exact value of the probability depends, in addition to ability, on a set of item parameters for the IRF.

The study in question uses the IRT three parameter logistic model (3PL) to calibrate the test items and estimate a student’s algebraic ability.

Figure 1: Example of 3PL IRF, with dotted lines overlaid to demonstrate parameters.

For example, in the three parameter logistic (3PL) model, the probability of a correct response to a dichotomous item $i$, usually a multiple-choice question, can be represented by the graph above where theta indicates that the person abilities are modeled as a sample from a normal distribution for the purpose of estimating the item parameters. After the item parameters have been
estimated, the abilities of individual person are estimated for reporting purposes. a, b, and c are the item parameters. These items are determined by the shape of the IRF. Figure 1 depicts an ideal 3PL ICC. The item parameters can be interpreted as changing the shape of the standard logistic function.

The parameters are described as follows:

- **b** – this is the most basic and normally comes first. This parameter normally refers to difficulty, item locations, this is where the slope is maximized.
- **a** – the discrimination, scale, slope: the maximum slope
- **c** – pseudo-guessing, chance, asymptotic minimum.

For b, note that this model scales the item's difficulty and the person's trait onto the same continuum (theta). Thus, it is valid to talk about an item being about as hard as Person A's trait level or of a person's trait level being about the same as Item Y's difficulty, in the sense that successful performance of the task involved with an item reflects a specific level of ability.

For c, note for items such as multiple-choice items, the parameter c, is used in attempt to account of the effect of guessing on the probability of a correct response. It indicates the probability that very low ability individuals will get this item correct by chance, mathematically represented as a lower asymptote. A four-option multiple choice item might have an IRF like the example item; there is a 1/4 chance of an extremely low ability candidate guessing the correct answer, so the “c” would be approximately 0.25. This approach assumes that all options are equally plausible, because if one option made no sense, even the lowest ability person would be able to discard it, so IRT parameter estimation methods take this into account and estimate a “c” based on the observed data.[5]

In general, IRT models can be divided into two families: unidimensional and
multidimensional.

a. Unidimensional models require a single trait (ability) dimension (theta).

b. Multidimensional IRT models model response data hypothesized to arise from multiple traits.

However, because of the greatly increased complexity, the majority of IRT research and applications utilize a unidimensional model. IRT models can also be categorized based on the number of scored responses. The typical multiple choice item is *dichotomous*; even though there may be four or five options, it is still scored only as correct/incorrect (right/wrong). Another class of models apply to *polytomous* outcomes, where each response has a different score value. A common example of this is Likert-type items, e.g., "Rate on a scale of 1 to 5."
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