Teacher Classroom Practices, Student Motivation, and Mathematics Achievement in High School: Evidence from HSLS: 09 Data

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Abstract

The present study explored the direct influences of teacher classroom practices, including teacher support, conceptual teaching, and procedural teaching, on 9th grade students' mathematics achievement, and the indirect influences of these teacher variables on student mathematics achievement through students' mathematics self-efficacy and interest in mathematics courses. The base year data of High School Longitudinal Study of 2009 (HSLS: 09) was used for this study. Structural equation modeling method was used to estimate the relationships among variables. Results showed that teacher classroom practices influenced student mathematics achievement in different ways. Conceptual teaching positively, whereas procedural teaching negatively, influenced student mathematics achievement. Teacher support influenced student mathematics achievement indirectly through students' mathematics self-efficacy. It also had powerful influence on students' interest in mathematics courses. In addition, family socioeconomic status (SES) and student prior achievement were associated with teacher classroom practices. Students with higher levels of family SES and prior achievement were more likely to have teachers who use conceptual teaching strategies. Students with higher prior achievement were more likely to perceive higher levels of teacher support.

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Chapter 1 Introduction

This dissertation aimed to explore the direct influences of teacher classroom practices on 9th grade students' mathematics achievement as well as the indirect influences mediated by student motivational beliefs, using an observational research design. This chapter explains the background, rationale, research questions, conceptual framework, an overview of the research methods, and the organization of the study.

Background

Mathematics achievement is an important research area in the U.S. because it is strongly related to students' future academic success, their choice of major in college, as well as the economic growth of the nation (Geiser & Santelices, 2007; Rose & Betts, 2004; Wang, 2013). Students' high school mathematics achievement influences their decisions to take advanced mathematics and science courses, their plans to enter the Science, Technology, Engineering, and Mathematics (STEM) majors in the college, and in turn affects their intentions to enter the STEM job market after graduation. The highly qualified engineers and scientists are key determinants of the economic growth of a nation. In order to maintain a leading role in the global economy, there is a need for more students with advanced mathematical skills in the U.S.

However, a large number of U.S. students are not mathematically proficient and lag behind in international studies. According to the 2013 National Assessment of Educational Progress (NAEP) report – the so-called National Report Card - only 34% of 4th grade students, 27% of 8th grade students, and 26% of the 12th grade students achieved the proficient level in mathematics assessment (National Center for Educational Statistics, 2013). In the 2011 Trends in International Mathematics and Science Study

(TIMSS), the U.S. students' average mathematics score at Grade 4 (541) was higher than the international average (500), but the average mathematics score of Grade 8 (509) was around the international average (500) (Provasnik et al., 2012). In addition, in the 2012 Program for International Student Assessment (PISA), only 9% of 15-year-old students scored at the proficiency level 5 or above in the mathematics assessment, which was lower than the international average of 13%, and the average score of the U.S. students (481) was lower than the international average (496) (Kelly, Nord, Jenkins, Chan, & Kastberg, 2013). These national and international studies indicate that U.S. secondary students were not mathematically proficient and lag behind their high-achieving peers in other countries.

Moreover, the achievement gap is a long-standing issue in the U.S. The achievement gap refers to the significant and persistent disparity of academic performance between the groups of Black and White, Hispanic and White, and recent immigrants and White students (Ladson-Billings, 2006). For example, according to the 2013 NAEP mathematics assessment results (National Center for Educational Statistics, 2013), in Grade 4, 54% of White students achieved proficiency, but only 18% of Black and 26% of Hispanic students achieved proficiency. In Grade 8, 45% of White students achieved proficiency while only 14% of Black and 21% of Hispanic students achieved proficiency. Furthermore, the achievement gap enlarged as students grew up. The White-Black gap averaged 26 points in 4th Grade, and 31 points in 8th Grade. The White-Hispanic gap averaged 19 points in 4th Grade, and 22 points in 8th Grade. In addition, researchers have compared students' mathematics achievement from 1990 to 2007, and found that Hispanic, Black, and White students made progress in their mathematics achievement, but the achievement gap did not change significantly (Hemphill & Vanneman, 2011; Vanneman, Hamilton, Baldwin Anderson, & Rahman, 2009).

High school years are particularly critical for students' future educational trajectory. Ninth grade students' mathematics achievement will influence students' beliefs about their mathematical capability and future choice of higher level mathematics courses in high school, which will further influence their postsecondary and occupational options. Students with higher mathematics achievement in high school are more confident about their capability in mathematics learning and more likely to choose STEM majors in college (Wang, 2013). Therefore, high school is a very important time for developing interest and positive attitudes toward math.

In conclusion, high school students' mathematics achievement is critical for their postsecondary pathways and occupational decisions. But U.S. high school students are not mathematically proficient, especially the students from disadvantaged groups. Therefore, there is a pressing need to explore how to improve high school students' mathematics achievement as well as to close the achievement gap.

Rationale

Three major groups of factors influence student academic achievement: student characteristics (e.g., student ability, self-efficacy, interest, and achievement goals), family environment (e.g., family socioeconomic status (SES) and parental involvement), and school context (e.g., teacher quality and school environment) (Borman, Hewes, Overman, & Brown, 2003; Fan & Chen, 2001; Geary, 2011; Middleton & Spanias, 1999; Singh, Granville, & Dika, 2002; Sirin, 2005; Wenglinsky, 2000). In recent years, school context has attracted more attention of researchers and policy makers because it can be manipulated by educational interventions, whereas student ability and family environment are outside the control of educators. Some educational reformers hold the assumption that the key to improve student performance lies in improving schools (Wenglinsky, 2002).

Among the school factors, improving teacher quality is one of the major approaches to increase student achievement, since teachers are the principal resource in the schools. In general, two types of teacher variables are related to student achievement: teacher qualifications (e.g., teacher certificate and teaching experience) and teacher classroom practices (e.g., instructional methods). No Child Left Behind Act of 2001(NCLB) underscores the important role that teacher qualifications play in student achievement. It states that all students should have equal and fair opportunities to obtain high quality teachers with (1) a bachelor's degree, (2) state certificate or licensure, and (3) competence in subject knowledge and teaching (NCLB, 2001). The logic behind the NCLB is that student learning will increase by improving teacher quality and holding teachers accountable for student test results. A large number of empirical studies examined the influences of teacher qualifications on student academic performance, for example, teacher experience, teacher preparation program and degrees, teacher certification, teachers' former coursework, and teachers' own test scores (Clotfelter, Ladd, & Vigdor, 2007; Rice, 2003; Wayne & Youngs, 2003). Some of the teacher characteristics make significant contribution to students' achievement. Teachers' content knowledge is one of these (Hill, Rowan, & Ball, 2005). But some teacher characteristics had no or very weak association with students' achievement, for example, teacher college ratings, teachers' test scores, teachers' degrees, and teaching experience (Hanushek & Rivkin, 2006; Wayne & Youngs, 2003).

However, there is a lack of research on teacher classroom practices on student learning. Teacher classroom practices—what teachers do in the classroom—are critical for student performance, since teaching and learning occur inside the classroom (Wenglinsky, 2000, 2002). The different components of teaching, for example, the emphasis teachers place on different goals, the time they allocate to different topics, the tasks they pose to students, the kinds of questions they ask, and the types of discussion they lead, influence the opportunities students have to learn, and in turn affect student achievement (Hiebert & Grouws, 2007; National Research Council, 2001). Some studies have investigated how the classroom social environment created by teachers influenced student achievement and found some important predictors, for example, teacher-student relationship, teacher support, and the practices of promoting interaction and mutual respect (Patrick, Ryan, & Kaplan, 2007; Ryan & Patrick, 2001). Some studies have compared teacher instructional practices in the U.S. and other high-achieving countries, such as Japan and Germany (Desimone, Smith, Baker, & Ueno, 2005; Hiebert et al., 2005; Stigler & Hiebert, 1997). These studies indicated that teacher classroom practices matter for student achievement.

Although some factors related to teacher classroom practices have been examined, there is still a lack of knowledge on teacher instructional practices. First, there are very few empirical studies on teacher pedagogy. In past decades, the major emphasis was on procedural fluency in the U.S. mathematics classrooms. Now many U.S. mathematics reforms have imported the conceptual teaching model from high-achieving countries, such as Japan and Singapore (Desimone et al., 2005; Hiebert et al., 2005; Stigler & Hiebert, 1997). In recent years, the mathematics education reforms placed a high priority on developing students' conceptual understanding of mathematical content and problem solving skills, for example, the standards-based mathematics and Common Core State Standards stress the importance of conceptual understanding in successful mathematics learning (Common Core State Standards Initiative, 2010; NCTM, 2000). However, very little research has examined how this focus on student conceptual understanding has been applied in the U.S. mathematics classrooms, and how this teaching method influences students' mathematics achievement.

Second, most of the existing literature on teacher classroom practices have either focused on the informal part (e.g., the social environment that teachers created) or the formal part (e.g., the instructional practices), and only a few studies have investigated their influences on student achievement jointly. Third, majority of the research on teacher classroom practices explored the direct effects of teacher practices on student learning outcomes, but little is known about the mechanism—how teacher practices impact student achievement. Fourth, since the majority of the studies on teacher classroom practices have been conducted in elementary and middle schools, much less is known about high school classrooms. The tendency to focus on younger populations reflects the importance of teachers' influence on elementary and middle school students, but we should expect teacher effects on student learning to change as students grow up (Anderman, Andrzejewski, &Allen, 2011).

In sum, teachers are important for improving student achievement. A substantial body of studies has explored the influences of teacher qualifications and personal characteristics in student learning and found important predictors, such as teacher content knowledge. But much less is known about the effects of teacher classroom practices. What teachers do in the classroom is essential for student learning, since the classroom is the primary place where students and teachers interact (Wenglinsky, 2002). Therefore, there is a need for more research to explore the effective teacher classroom practices.

Purpose Statement and Research Questions

In recognizing the lack of knowledge on teacher classroom practices, the current study aims to fill the gap in literature to investigate the influences of teacher classroom practices on student mathematics achievement in high school. First, this study investigates the influence of teacher support, conceptual teaching and procedural teaching methods on student mathematics achievement in high school. Teacher support represents the informal aspect of teacher classroom practices, and conceptual teaching and procedural teaching methods represent the formal aspect of teacher classroom practices. Second, this study explores how teacher practices influence student mathematics achievement, in particular, whether student self-efficacy and interest in mathematics mediate the relationships between teacher classroom practices and student mathematics achievement. The following two research questions guided this dissertation:

1. Do teacher support, conceptual teaching and procedural teaching influence students' mathematics achievement after controlling for family SES and student prior achievement?
2. Do students' mathematics self-efficacy and interest in mathematics courses mediate the relationships between teacher classroom practices (teacher support,

conceptual teaching, and procedural teaching) and student mathematics achievement?

Conceptual Framework

This study focuses on the relationships among teacher classroom practices, student motivation, and mathematics achievement. A reduced motivational model that includes the instructional context, motivation, and academic outcomes will guide this study (Skinner, Kindermann, Connell, & Wellborn, 2009). In this model, the instructional context facilitates the academic outcomes, and the motivational beliefs are hypothesized to mediate their effects (See Figure 1).

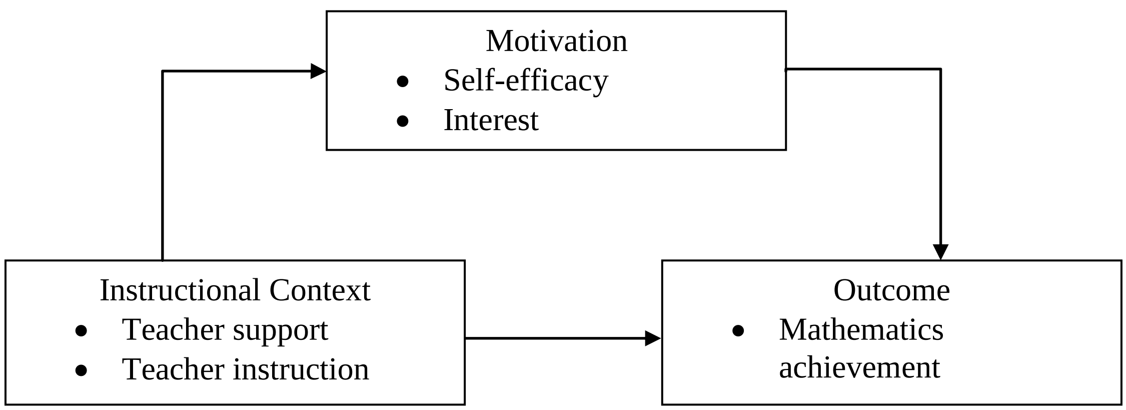

Figure 1. Conceptual Model

Instructional context has been variously studied as classroom environment, content area, and instructional activities that are related to learning (Turner & Meyer, 2000). This study specifically focuses on teacher support and instructional practices in the mathematics classroom. Students' perception of teacher support was related to positive changes in students' school adjustment, motivation, engagement, and achievement (Klem & Connell, 2004; Ryan & Patrick, 2001). Teacher instructional practices will impact students' opportunities to learn, which in turn may affect the academic outcomes (Hiebert & Grouws, 2007).

Various theoretical perspectives have focused on the different aspects of the intrapsychic processes of motivation, for example, students' achievement goals, self-efficacy, beliefs about their own intelligence, their attributions of success, interest, and so on. This study focuses on the motivational processes of self-efficacy and interest in the mathematics domain. Self-efficacy is the degree to which a student believes that he or she is capable of performing specific tasks (Bandura, 1986). Students with higher levels of self-efficacy are likely to have higher aspirations, make greater effort, and persist longer in their goals than those with lower levels of self-efficacy (Bandura, 1997). Interest is a relatively unique motivational construct with the feature of strong emphasis on the content of learning (Schiefele, 2009). Students' subject area interest is positively related to their achievement across grade level and subjects (Schiefele, Krapp, & Winteler, 1992). As students mature, their interest levels have more influence on student learning, for example, students with higher levels of interest choose more advanced courses in a subject, resulting in higher achievement (Köller, Baumert, & Schnabel, 2001).

In sum, this conceptual model describes how instructional context, student motivation, and student achievement are linked to each other. It highlights the interaction between teachers and students. Student motivation mediates the links between teacher practices and student achievement.

Overview of the Methodology

This study utilizes an observational design to explore the relationships between teacher classroom practices and student mathematics achievement. In observational designs, sampling and the controlling of confounding variables are critical to establish validity (Pedhazur & Schmelkin, 1991). In order to improve the validity, a nationally representative sample and statistical control will be used. First, the High School Longitudinal Study of 2009 dataset (HSLS: 09) with a nationally representative sample will be used for this study. The HSLS: 09 study utilized a two-stage sample design with primary sampling units defined as schools selected in the first stage and students randomly selected from the sampled schools within the second stage (Ingels et al., 2011). This method yielded a random sample of 25,206 eligible students from 944 participating schools. A total of 21,444 9th grade students completed a survey and mathematics ability assessment in the base year.

Second, the family SES and student prior achievement were controlled when exploring the influences of teacher classroom practices in student achievement because they are powerful predictors of student performance (Sirin, 2005; Wenglinsky, 2000). Family background influences student achievement directly through providing resources and indirectly through providing social capital that is necessary to succeed in school; for example, the students from affluent families are more likely to have access to highly qualified teachers (Sirin, 2005). Prior achievement represents all the factors that led to previous academic success and will continue to affect later success. Statistical controls would decrease the error term and increase the sensitivity of the analysis (Pedhazur & Schmelkin, 1991). After controlling for family SES and prior achievement, the estimation of the teacher effect will be more close to the true effect.

Structural equation modeling (SEM) method was used in data analyses for two reasons. First, student achievement has been hypothesized as the joint effects of teacher classroom practices, student motivational beliefs, and student background characteristics. SEM allows the complex phenomena of student achievement to be statistically modeled and tested (Schumacker & Lomax, 2012). Second, the measurement error is a major concern in this study because the teacher classroom practices and student characteristics are measured indirectly through multiple items. SEM method explicitly takes measurement error into account when statistically analyzing data (Schumacker & Lomax, 2012). The SEM allows the measurement error and the statistical analysis of the data to be treated separately by testing the measurement model first and testing the structural model second.

Organization of the Study

In chapter 2, a comprehensive literature review related to variables in the conceptual model is presented. Specifically, the theories and empirical studies on the relationships between teacher support, teacher instruction, and student self-efficacy and interest in mathematics courses are presented. A summary of the limitations of the reviewed literature is presented at the end of chapter 2. In chapter 3, the research methods are described in detail. It includes the information of the data source, sample, the measures of the variables, and data analysis strategies. In chapter 4, the preliminary data analysis results (descriptive and correlation matrix) are presented first. Then the measurement testing results follow. Lastly, the structural model results corresponding to the two research questions are presented. In chapter 5, the findings of the study are summarized. Then the discussion and implication of the results are presented. Finally, the limitations of the research and future research directions are addressed.

Chapter 2 Literature Review

In this chapter, the theoretical and empirical literature that supports the present study has been reviewed. The literature review is organized into seven sections. The first section explains the methods of literature review. The second section reviews the factors that influence student achievement and primarily focuses on teacher effects. The following four sections focus on the four main constructs in the proposed conceptual model: teacher support, teacher instructional practices, self-efficacy, and interest. In each section, the theories and empirical research on the relationships between these variables and student achievement are reviewed. Finally, a summary of the literature review is presented.

Methods of Literature Review

Following Cooper (1998), the literature review was conducted in three steps: identify goals of the literature review, search and select relevant articles, and integrate the research findings. The goal of the literature review was to gain a comprehensive understanding of the relationships between teacher support, teacher instruction, self-efficacy, interest, and student achievement. Additionally, the literature review identified the research gap—what is unclear in the associations among the variables in the present study.

An extensive search on the literature of teacher practices was conducted. An initial search was conducted in the following three databases: EBSCOhost, ERIC, and PsycINFO. The focus of the present study was teacher support, conceptual teaching, and procedural teaching methods, so the key search words included "teacher support", "teacher-student relationship", "mathematics instruction", "teaching for understanding", “conceptual understanding”, “high-order instruction”, and “cognitive instruction”. The records after 2000 with full text, focusing on the relationships between these variables and student mathematics achievement, were selected. In addition, the references of the selected articles were reviewed. Some additional articles were identified through this approach. One article in teacher instruction published before 2000 that had a significant impact in mathematics education has been included. Finally, 14 empirical articles on teacher support and eight articles on teacher instructional practices were identified.

A substantial body of research has examined the sources of self-efficacy and the relationship between self-efficacy and student achievement, and some synthesis studies have been conducted to summarize the findings of previous research. Therefore, four synthesis studies of self-efficacy and five recent studies of self-efficacy in the mathematics domain were reviewed. Additionally, a broad search has been conducted to identify the existing research on student interest in math, using the same approach as for teacher classroom practices, and as a result one meta-analysis and three empirical studies in the mathematics domain have been identified.

In the literature integration step, the purpose statement, theoretical framework, methods, research findings, contributions, and limitations of the identified articles have been studied. Different researchers used different research designs, applied different measures of teacher practices and student learning outcomes, and studied different groups of participants, so the research findings were not simply added up when exploring the patterns across studies. Instead, the research design, the measurement of variables, and the participant sample were described in order to accurately synthesize the research findings.

Academic Achievement and Teacher Effect

Hattie (2009) synthesized the findings of more than 800 meta-analysis studies on student achievement and summarized six categories of factors that influence student achievement: (1) student characteristics (e.g., student prior achievement, motivation, and engagement); (2) family (e.g., family SES, home environment and parental involvement); (3) school (e.g., school size, climate, and safe environment); (4) teacher (e.g., teacher training, teacher-student relationship and professional development); (5) curricula (e.g., the integrated curriculum program and mathematics program); (6) teaching approaches (e.g., concept mapping, mastery learning, and teacher feedback). Among these factors, personal ability and family environment are difficult to change and are outside of the control of educators. School environment, curriculum, teacher qualifications, and teaching approaches can be modified by educational interventions. Therefore, understanding the roles of these school and teacher factors on students' academic performance has attracted more attention in recent years.

Among the in-school factors, teachers offer the greatest opportunity for improving student achievement (Hattie, 2009; Stronge, 2010). Hattie (2003) claims that teachers account for approximately 30 percent of the variance in student achievement after reviewing extensive literature on teacher effects. Nevertheless, it is unclear that what particular teacher attributes make the difference between a successful teacher and an unsuccessful one. In past decades, the research on teacher quality mainly focused on two areas: teacher background qualifications (e.g., teacher's degree, certificate and teaching experience) and teacher classroom practices (e.g., teaching methods and teachers' attitude).

The research on teacher background characteristics has yielded mixed findings. Darling-Hammond (2000) examined the relationships between teacher qualifications and student achievement across states using multiple datasets. The results suggested that teacher preparation and certification are related to student achievement in reading and mathematics after controlling for student poverty and language status. Wayne and Youngs (2003) reviewed studies on teacher characteristics and found that high school students learn more mathematics from teachers with certifications in mathematics, degrees related to mathematics, and coursework related to mathematics. Rockoff (2004) examined the impact of teaching experience on student achievement using rigorous methods and found that teaching experience improved student reading achievement but failed to improve mathematics achievement. Harris and Sass (2011) studied the effects of various types of education and training on the productivity of teachers in promoting student achievement but failed to discover significant relationships between teachers' undergraduate training or college entrance exam scores and productivity. In sum, these studies found inconsistent results of the impact of teacher qualifications on student achievement.

Researchers have generally reported that teacher classroom practices have greater influence on student achievement than teacher background qualifications. Wenglinsky (2002) compared the influences of three aspects of teacher quality on 8th grade students' mathematics achievement using 1998 NAEP data: teacher classroom practices, professional development and pre-service characteristics. The results indicated that teacher classroom practices have the greatest influence on student achievement. Additionally, this study found that the total impact of teaching variables was comparable to that of family SES. Palardy and Rumberger (2008) investigated the importance of three general aspects of teacher effects—teacher background qualifications, attitudes, and instructional practices—to first grade student reading and mathematics achievement. The results indicated that compared with background qualifications, instructional practices have more robust associations with achievement gains. Stronge, Ward, Tucker, and Hindman (2007) identified that teacher instructional practices result in higher student gains by comparing the teaching practices between more effective and less effective teachers, which were categorized based on students' gains. Qualitative analyses of teachers' classroom practices have indicated that effective teachers attained higher scores in classroom instruction (e.g., instructional focus, planning and question), student assessment (e.g., monitoring student and differentiation), classroom management (organization and behavior expectations) and personal qualities (e.g., caring, respect and interaction with student) than less effective teachers. In total, teacher classroom practices matter more than teacher backgrounds.

Overall, teacher background qualifications and classroom practices are both related to student learning. But classroom practices play a more important role in improving student performance, which indicates that educational policies that merely rely on improving teacher background qualifications are insufficient to raise student achievement. More research will be needed to explore what kinds of teacher classroom practices are more effective in enhancing student achievement (Palardy & Rumberger, 2008).

Teacher Support

Definition of Teacher Support

Among the 14 reviewed articles, only three explicitly presented the definition of teacher support. Ryan and Patrick (2001) described it as "the extent to which students believe teachers value and establish personal relationships with them" (p.440). Klem and Connell (2004) suggested that teacher support included the components of teacher involvement, providing autonomy support, and providing structure. Patrick et al. (2007) defined teacher support as "students' perceptions that their teacher cares about and will help them" (p. 84). Although the definitions are slightly different, it can be concluded that teacher support generally involves the characteristics of caring, respect, understanding, and willingness to help.

Several constructs are related to or have certain degree of overlap with teacher support, for example, classroom social environment, teacher-student relationships, and pedagogical caring. The classroom social environment is a broad construct, including student support, teacher classroom management, and other components in addition to teacher support (Patrick et al., 2007; Ryan & Patrick, 2001). Teacher-student relationships have both positive (e.g., empathy, warmth, encouraging, etc.) and negative (e.g., conflict, neglect, rejection, etc.) aspects of teacher-student interaction (Roorda, Koomen, Spilt, & Oort, 2011) whereas teacher support mainly focuses on the positive relations. Pedagogical caring and teacher support share similar features. Pedagogical caring involves characteristics of caring about students, democratic communication styles, expectations for behavior, rule setting, and nurturance (Noddings, 1992; Wentzel, 1997).

Theory Related to Teacher Support

Self-determination theory provided the theoretical support to explain the importance of teacher support on students' motivation and engagement in mathematics learning. Deci and Ryan (2002) suggested that children have three kinds of basic psychological needs: relatedness, competence, and autonomy. Teacher support is related to the basic need of relatedness. Relatedness refers to the connection and sense of belonging with others (Martin & Dowson, 2009). Through showing involvement, for example, caring and expressing interest in the students, teachers can support students' needs of connectedness and sense of belonging with teachers. This sense of belonging provides the required emotional security that students need to actively explore and effectively deal with the learning activities (Martin & Dowson, 2009). The students with a strong sense of relatedness are more likely to have higher aspirations that motivate them, engage in learning activities, and take on challenges (Martin & Dowson, 2009).

Measurement of Teacher Support

The measures of teacher support varied in different studies. In some studies, it was unidimensional, measuring how much teachers care about, like, help, and are interested in students (Hughes, Luo, Kwok, & Loyd, 2008; Levpušček & Zupančič, 2009; Ryan & Patrick, 2001; Sakiz, Pape, & Hoy, 2012; Woolley, Kol, & Bowen, 2009; Yıldırım, 2012). In some research, teacher support was multidimensional. Patrick et al. (2007) measured it from two perspectives: emotional support (e.g., understanding students' feeling) and academic support (e.g., caring about how much students learn). Bru, Stornes, Munthe, and Thuen (2010) assessed teacher support using four sub-scales: academic support (e.g., explaining group work well), emotional support (e.g., know students' interest), managerial support (e.g., making sure students behave well), and autonomy support (e.g., student participating in decisions). Chen (2005) measured teacher support as three types: emotional (e.g., providing encouragement), instrumental (e.g., assisting with homework), and cognitive support (e.g., communicating the values of educational success).

The majority of the studies on teacher support have relied on student perception of teachers' attitudes and behaviors (Bru et al., 2010; Chen, 2005, 2008; Levpušček & Zupančič, 2009; Mercer, Nellis, Martínez, & Kirk, 2011; Patrick et al., 2007; Ryan & Patrick, 2001; Sakiz et al., 2012; Woolley et al., 2009; Yıldırım, 2012). Very few studies have included teachers' reports of their own beliefs and behaviors (Crosnoe et al., 2010; Hughes et al., 2008), or observations of actual interactions between teachers and students in the classroom (Estell & Perdue, 2013).

Relations of Teacher Support to Student Learning

The identified studies examined the impact of teacher support on student motivation, engagement, and achievement. However, these studies had inconsistent findings due to the different research designs. In some studies, teacher support was the unique independent variable. In other studies, teacher support was examined simultaneously with other variables such as parental support, peer support or teacher instruction.

Most of the studies, which included teacher support as a unique independent variable, examined the motivational processes of student learning, and found significant associations between teacher support and the outcome variables. For example, Sakiz et al. (2012) found that perceived teacher affective support had significant positive association with a sense of belonging, academic enjoyment, academic self-efficacy, and academic effort, and a negative correlation with academic hopelessness in middle school mathematics classrooms. By examining the relationship between students' classroom experiences and mathematics achievement of 15-year-old students in Turkey using the PISA 2003 data, Yıldırım (2012) found teacher support positively influenced the students' learning strategies in mathematics directly and indirectly through students' motivational beliefs. A longitudinal study found that second-grade effortful engagement mediated the associations between first-grade teacher-student relationships, including teacher support and conflict, and the third-grade reading and mathematics achievement, in a sample of academically at-risk children (Hughes et al., 2008). Klem and Connell (2004) noted that students who perceived teachers as creating a caring, well-structured learning environment are more likely to report engagement in school; in turn, the higher levels of engagement are associated with higher attendance and test scores. To sum up, when teacher support was examined individually, it showed significantly positive associations with students' motivational beliefs, engagement, and academic performance in both elementary and middle schools.

When teacher support was examined simultaneously with other variables (e.g., parental and peer support), the findings on the effects of teacher support were mixed. Some studies found the effect of teacher support was non-significant after controlling for other variables. For example, Mercer et al. (2011) simultaneously examined the influence of teacher support and academic self-efficacy on elementary students' academic growth, and found the perceived teacher support did not uniquely relate to students' initial performance or growth over years in either reading or math. But they found the interaction effect between academic self-efficacy and teacher support was significant in predicting mathematics skill growth. For students with higher levels of self-efficacy, the lower levels of teacher support were related to greater growth in mathematics skills. One explanation is that high-achieving students did not need high levels of perceived teacher support to maintain high rates of academic skill growth (Mercer et al., 2011). Estell and Perdue (2013) found that teacher support in fifth-grade had no significant association with students' affective and behavioral engagement in sixth-grade after controlling for students' gender, learning ability, and achievement. Levpušček and Zupančič (2009) revealed that teacher support had non-significant association with students' mathematics achievement in Slovene middle school after controlling for parental involvement, teacher academic challenge, and teachers' effort in developing students' mastery goal.

Some studies found a significant effect of teacher support on students' learning outcomes after accounting for other social contextual factors. Chen (2005, 2008) conducted two studies to examine the relation of academic support from parents, teachers, and peers to Hong Kong adolescents' (From 3-5, equivalent to Grade 9-11 in the U.S.) academic achievement and also to investigate the grade-level difference. The author found that students' academic engagement partially mediated the relationship between teacher support and student achievement. In addition, the strength of the relationship between teacher support and academic achievement was the strongest among the three social support systems—parents, teachers, and peers. When these relationships were examined in different grade levels, the author found that perceived teacher support was a significant predictor of academic achievement only for Form 3 students (equivalent to Grade 9 in the U.S.). The author explained that comparing with students in higher grade, 9th grade students are relying more on teachers for academic guidance (Chen, 2008). Another study found that teacher responsiveness, which was measured by similar items as teacher support, significantly predicted middle school students' academic achievement after controlling for family and other school factors (Marchant, Paulson, & Rothlisberg, 2001). The researchers explained that teacher support meets students' developmental needs, which are essentially important for academic success (Marchant et al., 2001).

Two studies examined the influence of classroom social environment—teacher support, promoting interaction, promoting mutual respect, and student support—on student motivation and engagement in elementary and middle school (Patrick et al., 2007; Ryan & Patrick, 2001). These two studies found that teacher support was significantly related to students' social efficacy with teachers, lower level of disruptive behavior, self-regulated learning strategies, and task related interaction, after controlling for student prior achievement and other components of classroom social environment (Patrick et al., 2007; Ryan & Patrick, 2001). Teachers' emotional and academic support developed students' competence or mastery orientation, which in turn improve student achievement (Patrick et al., 2007). Crosnoe et al. (2010) has investigated the joint effects of teacher support and teacher instruction on elementary school students' mathematics achievement in a longitudinal study, and found the inference-based instruction promoted the achievement gains of initially least skilled children when they did not have conflicting relations with their teachers. This finding indicates that both the formal instructional practices and informal teacher-student interaction are important for improving student achievement (Crosnoe et al., 2010).

Limitations of the Existing Research on Teacher Support

First, most of the reviewed studies on teacher support were in elementary or middle schools. Very little was known in high school. One reason that research focused on younger students is that they are more attached to their teachers. However, high school students still interact frequently with their teachers in a school day, as such they need to feel teachers are involved with them. This is important to support their academic motivation, engagement, achievement and psychological functioning. Second, majority of the studies used cross-sectional data, while few of them used longitudinal designs. A longitudinal design can help us to detect the possible causal relationships between teacher support and student learning outcomes. Third, a majority of the studies on teacher support have investigated this variable individually, or examined it simultaneously with other social support systems (e.g., parental support and peer support), very little research has examined the joint effects of teacher support and teacher instructional practices on student achievement. In addition, previous studies had inconsistent findings on the effects of teacher support in student learning, so more studies are needed to verify its effect on mathematics achievement.

Conceptual and Procedural Teaching

There has being a longstanding debate in mathematics education: should teachers emphasize the facts and procedures and then help students to apply these procedural skills to solve mathematical problems, or should teachers guide students to discover the principles behind mathematics and then help them to use the knowledge in real-life (Hoff, 2003)? These two methods are referred to as teaching for procedural fluency and teaching for conceptual understanding in mathematics instruction. For a long time, teaching primarily focused on procedural skills in mathematics classrooms in the U.S, but now many teachers have begun to emphasize conceptual understanding. The mathematics reforms in past decades influenced this pedagogical change in mathematics education.

A Brief History of Mathematics Reforms

Two mathematics reforms in the past three decades emphasized the importance of teaching for conceptual understanding. The standard-based math, which was launched by the National Council of Teacher s of Mathematics (NCTM) in 1990s, explicitly states the need to teach for conceptual understanding in K-12 mathematics classrooms. It calls for a de-emphasis on manual arithmetic and favors students' discovering their own knowledge and conceptual thinking (NCTM, 2000). Traditional mathematics emphasizes procedural skills, provides step-by-step examples with skill exercises, and focuses on the algorithm that leads to the right answer. By contrast, standard-based mathematics de-emphasizes algorithms. Students are suggested to use calculators to solve the arithmetic with more than two digits (Klein, 2003). The standard-based mathematics calls for teachers to challenge students to make sense of new mathematical ideas through explorations and projects in real contexts. The teaching and learning focuses on the process leading to a right answer rather than the answer itself. Five standards have been established for the teaching and learning process: problem solving, reasoning and proof, communication, connections, and representations (NCTM, 2000).

Another reform is Common Core State Standards, which was sponsored by the National Governors Association (NGA) and the Council of Chief State School Officers (CCSSO) in 2009. It places equal emphasis on conceptual understanding, procedural fluency and application of skills in problem solving. The Common Core seeks to establish consistent educational standards in mathematics for K-12 students (Common Core State Standards Initiative, 2010). It includes standards for mathematical practice and standards of mathematical content. The standards for mathematical practice include six principles: making sense of problems, reasoning abstractly and quantitatively, constructing viable arguments, modeling with mathematics, using appropriate tools strategically, attending to precision, making use of structure, and looking for and expressing regularity in repeated reasoning. These standards describe the expertise that educators should seek to develop in their students. The standards of mathematical content vary in different grade levels. Basically, they are balanced combinations of procedural fluency and conceptual understanding.

In sum, the standard-based mathematics and Common Core State Standards aim to improve American students' mathematics achievement by establishing high quality standards. They highlight the development of students' conceptual understanding and problem solving skills. Although the implementation of standard-based mathematics and Common Core received support from educators and policy makers, some still question the effectiveness of these reforms. Therefore, empirical studies will be needed to explore the influences of these reforms in improving student achievement in mathematics.

Definitions of Procedural Fluency and Conceptual Understanding

Procedural fluency refers to "knowledge of procedures, knowledge of when and how to use them appropriately, and skills in performing them flexibly, accurately, and efficiently" (National Research Council, 2001, p.121). Silver, Mesa, Morris, Star, and Benken (2009) explained the features of procedural skills teaching from two aspects: curriculum and pedagogy. First, the mathematics curriculum has been featured as focusing on numbers and operations, restricting students' opportunities to learn other interesting and important mathematics content. Second, students often focus on low-level tasks, work alone with little access to classmates and computational tools, and make little connection to the world outside of school. Hiebert and Grouws (2007) summarized that the teaching facilitating students' skill efficiency has the following characteristics: being rapidly paced, including teacher modeling with many teacher-directed product-type questions, and displaying a smooth transition from demonstration to substantial amounts of error free practice.

Conceptual understanding was defined as "an integrated and functional grasp of mathematical ideas" (National Research Council, 2001, p. 118). Students with conceptual understanding have the following characteristics:

> Students with conceptual understanding know more than isolated facts and methods. They understand why a mathematical idea is important and the kinds of contexts in which is it useful. They have organized their knowledge into a coherent whole, which enables them to learn new ideas by connecting those ideas to what they already know. (National Research Council, 2001, p. 118)

Silver et al. (2009) described the curriculum and pedagogy characteristics of teaching for conceptual understanding. First, the mathematical tasks are drawn from a broad array of mathematics domains, which are cognitively demanding. The teachers incorporate a broad range of topics in the curriculum, which could enrich students' exposure to more mathematical topics and promote students to establish connections among different content domains in mathematics. Second, the teachers who emphasize conceptual understanding utilize a broad range of strategies in mathematics teaching. They support collaboration among students, and engage students in mathematical reasoning and explanation, consideration of real-world application, and use of technology or physical models.

Conceptual understanding and procedural fluency have often been seen as competing (National Research Council, 2001; Willingham, 2009), but now the researchers have reached agreement that these two types of knowledge are critical and interwoven, with no trade-offs needed (Hiebert & Grouws, 2007; National Research Council, 2001; Rittle-Johnson & Alibali, 1999; Willingham, 2009). Conceptual understanding makes learning skills easier, and procedural fluency helps develop and strengthen the conceptual understanding. Even though these two types of knowledge are both important, the relative importance of them is still controversial in the field of mathematics instruction. For example, which type of knowledge should teachers place more emphasis in teaching, and the order in which students should learn them, are more open to debate (Willingham, 2009).

Theory that Supports Conceptual Teaching

The research findings from cognitive psychology have provided strong support for the importance of teaching for conceptual understanding. For example, researchers have explored the learning process of novices and experts in various fields and found significant differences. Compared to the isolated facts of novices' knowledge, experts' knowledge is well-organized information of concepts, principles, and procedures of inquiry (Bransford, Brown, & Cocking, 2000). In addition, knowledge transfer is more likely to occur when learners understand the underlying principles. Learners with conceptual understanding tend to transfer knowledge into new contexts whereas the learners with rote memories rarely transfer information (Bransford et al., 2000). These findings suggest that students should not only learn the factual or procedural knowledge but also develop conceptual understanding of the knowledge and establish connections between ideas. The National Mathematics Advisory Panel (2008) suggested that learning mathematics requires three types of knowledge: factual, procedural, and conceptual. A consensus is building around an integration of these three types of mathematics knowledge. The more challenging task is to translate this knowledge into classroom instruction and pedagogical practices.

Measurement of Teacher Instruction

The measurement of mathematics teaching largely depends on two strategies: observation of classroom teaching and teacher self-report data from surveys (Silver et al., 2009). Among the eight reviewed articles on conceptual teaching, three studies analyzed the video of the TIMSS data, one analyzed the portfolios submitted by teachers who are seeking certification, and other ones used teacher reported data.

Mathematics Teaching in the U.S. Secondary Classrooms

The literature on instructional practices has focused on two areas: what teaching methods were utilized in the U.S. mathematics classrooms and the associations between instructional practices and student achievement, particularly focusing on the effects of conceptual teaching. Five studies, which described the status of mathematics teaching in the U.S., have been reviewed. Three compared the U.S. teacher instruction with other countries using the TIMSS 1995 and 1999 8^{th} grade data, which presented the nationally representative samples of ordinary classroom practices. One study examined the portfolio entries submitted by the teachers who are seeking certification in the area of Early

Adolescence/Mathematics in 1998-1999, representing best practices of the highly accomplished teachers in the U.S. The last one studied the self-reported data of a national representative sample of K-12 mathematics teachers in 2012, which captured the new patterns of mathematics instruction in the U.S.

Stigler and Hiebert (1997) compared the pedagogical differences between 8^{th} grade teachers in Japan, Germany, and the U.S. using the 1994 TIMSS video. They found significant differences in mathematics content, teaching strategies, student tasks, teacher roles, and the goal of mathematics classes among these three countries. First, they found that deductive reasoning—an important component of critical thinking—was covered in 62% of the Japanese lessons, 21% of the German lessons, and 0% of the U.S. lessons. Second, they examined how mathematical concepts and procedures were taught, and found around 80% of the concepts and procedures were developed through examples, demonstrations, or discussion in Japan and Germany but only 20% were developed in a similar way in the U.S. Third, they found Japanese students spend more time on inventing, analyzing, and proving but less time on routine procedures whereas German and U.S. students spent almost all their time on routine procedures. Fourth, Japanese teachers spent more time on lecturing and had more control on the direction of lessons in subtle ways even though they give students time to work on challenging problems. Finally, Japanese teachers placed more emphasis on thinking while German and U.S. teachers placed more emphasis on skills. In short, these findings suggest that U.S. mathematics teachers did not emphasize higher-order thinking and conceptual understanding as the Japanese teachers did.

Hiebert et al. (2005) examined the 8th grade mathematics instruction in the U.S. and 6 high-achieving countries—Australia, Czech Republic, Hong Kong, Japan, Netherlands, and Switzerland— using the TIMSS 1999 video data. They found that the high-achieving countries balanced challenging content, procedural skills, and conceptual understanding in different ways. However, the U.S. teachers uniquely reinforced attention to lower-level mathematical skills.

Previous studies indicated that U.S. teachers used less conceptual teaching strategies in mathematics classrooms than the teachers in the high-achieving countries. Thus, Desimone et al. (2005) conducted a study to assess the barriers to conceptual teaching in mathematics classrooms in the U.S. and found little evidence for the existence of commonly perceived barriers to conceptual teaching in the U.S. such as teacher autonomy and class size. Only minor differences between the U.S. and higher-achieving countries were found. First, the U.S. teachers have differential instructions, using significantly less computation and more conceptual strategies for higher-achieving students whereas using more computation and less conceptual teaching strategies for lower-achieving students. In contrast, in the higher-achieving countries, such as Japan and Singapore, teachers used similar conceptual and computation strategies for lower-achieving as well as higher-achieving students. Second, in the U.S., the increased use of conceptual instruction is associated with more years of experience but not with possession of a mathematics degree. In high-achieving countries, such as Japan and Singapore, the increased use of conceptual instruction is associated with possession of a mathematics degree but not with teacher experience.

Silver et al. (2009) analyzed the mathematical and pedagogical features of the mathematics teaching, using the portfolio entries submitted by candidates seeking certification from the National Board for Professional Teaching Standards (NBPTS) in the area of Early Adolescence/Math. First, they found the portfolios contained a broad range of content topics (e.g., involving tasks situated in context outside mathematics itself, encouraging collaboration, and using technology and hand-on materials) rather than narrowly focused on cognitively low-demanding tasks. However, half of the teachers failed to include even a single task that was judged to be cognitively demanding in their portfolio entries. Second, they found teachers used tasks—such as hands-on activities or real-world contexts and technology—but rarely required students to provide explanations or demonstrate mathematical reasoning. The results were disappointing since the data analyzed in this study was the best practice of the highly accomplished teachers who are seeking certification in the U.S.

The 2012 National Survey of Science and Mathematics Education identified the trends of K-12 science and mathematics education in the U.S. (Banilower et al., 2013). A total of 7,752 science and mathematics teachers in grades K-12 in the U.S. participated in this survey. The analyses of mathematics teachers' report of the curriculum and instruction revealed that the mathematics teachers at all grade levels are fairly likely to emphasize reform-oriented instructional objectives, such as developing understanding of mathematical ideas, increasing student interest in the subject, and connecting what students are learning to real-life applications. Explanation of ideas and whole group discussion are very prominent in mathematics instruction although the frequency of use decreases as grade level increases. Student prior achievement is related to the objectives and instructions in the mathematics class. Classes with mostly high-achieving students are more likely to stress reform-oriented objectives than classes consisting of mostly low-achieving students.

Overall, these five studies present the pedagogical changes in the U.S. mathematics classrooms in last two decades. The earlier studies revealed that there was heavy emphasis on procedural fluency and little emphasis on conceptual understanding in 8^{th} grade mathematics classrooms, and the most recent study showed that K-12 mathematics teachers increased emphasis on conceptual understanding. The idea of developing students' conceptual understanding gradually penetrated the mathematics instruction in practice. However, we should not be over optimistic about the K-12 mathematics instructional practices in the U.S. because different methods were used to assess teachers' instructional practices in these five studies. The earlier three studies assessed teacher instructional practices by classroom observation, which is relatively objective because researchers studied teacher practices by watching videotapes. The latest study that reported positive changes in U.S. teacher practices used teachers' self-reported data; however, teachers may over state the use of conceptual teaching strategies—they do not use it as often as they report. That makes the assessment more subjective. Overall, some positive changes toward more conceptual teaching may have occurred but only in small ways. The reform practices and pedagogy are yet to be followed in most of the mathematics classrooms.

Effects of Conceptual Teaching on Mathematics Achievement

The research on mathematics teaching, which emphasizes high-order thinking skills and standards-based instruction, confirmed the importance of conceptual teaching in mathematics classrooms. Using 1996 NAEP data, Wenglinsky (2000) examined how teacher classroom practices were associated with student achievement after controlling for teacher education, experiences, and professional development using multilevel structural equation modeling method. The results revealed that the emphasis on higher-order thinking skills was associated with increased student performance.

McCaffrey et al. (2001) examined the relationship between the teacher practices and 10th grade students' mathematics achievement. The teacher practices that were examined in this study were aligned to the standards of NCTM. The results revealed that the use of standards-based practices was positively related to achievement for students who use reform-based curriculum, whereas the use of standards-based practices was unrelated to achievement for students who used traditional curriculum. The findings highlighted the needs that the changes in instruction may need to be coupled with changes in curriculum to realize effects on student achievement.

Hamilton et al. (2003) investigated the relationship between the standards-based instruction and student mathematics achievement in the National Science Foundation's Systemic Initiative (SI) program. The content goals of the standards-based practices included greater emphasis on conceptual understanding of mathematical concepts, the application of the knowledge to everyday situations, and the integration of concepts across subjects. The instruction of standards-based practices sought to engage students actively in their own learning, to be sensitive to students' learning styles, to increase the use of technology, and to utilize new forms of assessment for instructional planning. After controlling for student prior achievement and background characteristics, the regression analyses revealed small but consistent positive relationships between the use of reform practices and student achievement.

In sum, these three studies consistently support that standard-based instruction has a positive impact on student mathematics achievement. These studies suggest that the standard-based instruction will improve student achievement when used with the standard-based curriculum.

Limitations of the Existing Research on Teacher Instruction

First, the data for the research were collected almost two decades ago, for example, TIMSS 1995, TIMSS 1999, NAEP 1996, and NBPTS certification 1998-1999 data. Patterns of teaching and learning may have changed in significant ways in the ensuing years. Thus, the research on mathematics teaching and student achievement with more recent data will be needed. Second, most of the reviewed research examined the teacher instruction in middle school mathematics classrooms. The influences of teacher practices may be varied in different grade levels. Third, most of the existing studies used cross-sectional data. The limitation of the cross-sectional research is that the outcome occurs the same time as the factors that apparently influence them, raising the possibility that the outcome affect the factors rather than the reverse. Thus, longitudinal studies will be needed to establish a temporal relationship between the factors and the outcome. Fourth, some of the studies examined the influence of teacher practices on student achievement without controlling other important factors, such as student prior achievement. Student mathematics achievement is an outcome of the joint effects of student characteristics, family background, school factors, and teacher practices. Without the control of other important factors, the estimation of the teacher effect will be inflated.

Fifth, most of the researchers examined the direct effect of teacher practices on student mathematics achievement. Few studies examined the process how teacher practices influence student achievement and did not hypothesize the mediating effects of student characteristics such as self-efficacy and interest.

Self-Efficacy

Definition and Theory of Self-Efficacy

Self-efficacy refers to individuals' belief in their capacity to successfully carry out specific tasks (Bandura, 1986, 1997). Self-efficacy has been hypothesized to influence people's behavioral choices, effort, persistence in face of obstacles, and task performance (Bandura, 1986). Individuals with high levels of self-efficacy are more likely to have higher aspirations, stronger commitment to their goals, make greater effort, and persist longer on their goals than those with lower self-efficacy (Bandura, 1986, 1997; Fast et al., 2010). In addition, high levels of efficacy can also enhance one's ability to deal with challenging situations by influencing cognitive and emotional processes related to the situation (Bandura, 1986, 1997; Martin & Dowson, 2009; Zimmerman, Bandura, & Martinez-Pons, 1992).

Bandura (1997) proposed that people could gain a sense of self-efficacy through four main sources. The most effective way is previous performance—successful experiences build a strong belief of one's efficacy, whereas failures undermine it. The second way is through vicarious experiences of observing others. For example, watching peers who are similar to himself/herself succeed by persistent efforts raise the individual's belief that he/she has the potential to succeed on similar tasks. Verbal persuasion (e.g., encouragement from parents and teachers) is a third way of strengthening students' belief that they could perform well. People who are persuaded verbally that they have the capabilities to carry out certain tasks are likely to make an effort to take challenges rather than doubt their abilities when problems arise. Lastly, the interpretation of physiological states also influences people's judgment of their capabilities. For example, the positive emotions may promote individuals' perceived self-efficacy, whereas the stress reactions and negative emotions may undermine the sense of efficacy.

Measurement of Self-Efficacy

Self-efficacy is concerned with perceived capability. Therefore, the measurement of this concept should focus on what the individual *can do* rather than *will do* (Bandura, 2006). Self-efficacy is a situation-specific competence belief (Bandura, 1997). In academic settings, the measurement of self-efficacy is usually subject-specific. Researchers assessed students' self-efficacy beliefs by asking students to rate their confidence to solve specific problems, perform particular tasks, or engaging in certain self-regulatory strategies (Pajares, 1996). In the mathematics domain, self-efficacy has often been assessed by asking students whether they were capable of achieving certain outcomes in mathematics, such as "I am sure I can achieve high grades in mathematics" (Pietsch, Walker, & Chapman, 2003).

Factors that Influence Self-Efficacy

Usher and Pajares (2008) conducted a critical review of the empirical studies on sources of self-efficacy, and synthesized findings that how mastery experience, vicarious experience, social persuasion, and physiological states were related to student self-efficacy in academic settings. The results revealed that the mastery experience or previous attainment was the most influential source that students use to create and develop their self-efficacy beliefs. The correlations between vicarious experience and self-efficacy were inconsistent because of the difficulty of measuring vicarious experience. Most of the studies reported positive and significant correlations between social persuasions and self-efficacy, but the association was not significant when social persuasion was included in the regression models with other predictors. The emotional and physiological states have been found to negatively relate to self-efficacy. The inconsistent findings on the associations of self-efficacy to vicarious experience, social persuasion, and emotional and physical states may be due to the methodological reasons, such as poor reliability of items and multi-collinearity between variables (Usher & Pajares, 2008).

Effects of Self-efficacy on Academic Outcomes

Two meta-analysis studies synthesized the relations between self-efficacy and academic outcomes. Multon, Brown, and Lent (1991) conducted a meta-analysis study on the relationship between self-efficacy beliefs and academic outcomes. This study revealed statistically significant positive relationships between self-efficacy and performance with an effect size of .38 and positive relationship between self-efficacy and persistence with an effect size of .34. The findings were across various types of student samples, designs, and criterion measures. Self-efficacy explained approximately 14% of the variance in student academic performance and 12% variance in student academic persistence.

Valentine, DuBois, and Cooper (2004) specifically synthesized the findings of longitudinal studies on self-beliefs, including self-efficacy, self-esteem, and self-concept.

In this meta-analysis study, the researchers selected studies that measured the self-beliefs and achievement at two time points with at least 6 weeks gap, and controlled the influence of prior achievement. This study uncovered a small positive relationship between the self-beliefs and later achievement, with an average standardized path or regression coefficient of .08. In addition, the relation was stronger when the domain specific self-beliefs were measured.

In the mathematics domain, previous studies consistently reported positive relationships between mathematics self-efficacy and mathematics achievement. Hoffman and Spatariu (2008) found that self-efficacy increased undergraduate students' problem-solving performance and efficiency. Pietsch et al. (2003) found that compared to self-concept, self-efficacy had higher correlation with high school students' mathematics achievement. In addition, some studies uncovered that self-efficacy mediated the relationship between perceived classroom environment and students' mathematics achievement in elementary and middle school, which means that perceived classroom environment influenced student mathematics achievement indirectly through their self-efficacy (Fast et al., 2010; Jiang, Song, Lee, & Bong, 2014). In sum, studies consistently show a positive relationship between self-efficacy and achievement outcomes.

Limitations of Existing Research on Self-Efficacy

These studies suggested future research directions on self-efficacy. First, researchers suggested that additional sources of self-efficacy should be investigated (Pajares, 1996; Usher & Pajares, 2008). For example, will different teaching strategies improve students' self-efficacy in the mathematics domain? Second, gender and cultural difference in self-efficacy should be clarified (Usher & Pajares, 2008). Previous studies found that boys and girls reported different levels of self-efficacy in mathematics in middle and high schools (Pajares, 2005). Majority of the participants in self-efficacy studies are White and middle class. Thus, the self-efficacy in different demographic groups should be investigated in the future. Third, the causal inferences that self-efficacy has impacted later achievement, or a certain source has influenced the development of self-efficacy, could not be concluded from the cross-sectional designs. Longitudinal studies or experimental designs will be needed to assess accurately the effects and causes of self-efficacy (Usher & Pajares, 2008; Valentine et al., 2004).

Interest

Definition and Theory of Interest

Interest refers to the "psychological state of engaging or the predisposition to re-engage with particular classes of objects, events, or ideas over time" (Hidi & Renninger, 2006, p. 112). There are primarily two types of interest in educational research: situational interest and individual interest. Situational interest refers to the temporal state that is triggered by the environmental stimuli, which may or may not last over time; whereas individual interest refers to a relatively enduring affective and cognitive state toward certain subject areas or objects (Hidi & Renninger, 2006). In the present study, the interest in mathematics course could be an expression of individual interest in the mathematics domain.

Hidi and Renninger (2006) proposed a four-phase model to describe the stages of interest development, starting with a first experience of situational interest and resulting in a well-developed individual interest. The first phase is a triggered situational interest, which is described as the induction of attention and arousal for only a short term. For example, situational interest may be created by a vivid lesson containing surprising information (Schiefele, 2009). If the triggered situational interest repeatedly and persistently experienced, it will evolve into a maintained situational interest in the second phase, which potentially contributes to the development of long-term individual interest. The third phase was characterized by an emerging individual interest, which was developed from the maintained situational interest when value cognitions are involved and when these repeatedly occurring cognitions transform into enduring valence beliefs. The emerging individual interest can lead to the fourth phase, a well-developed individual interest, which is characterized by strong valence beliefs and more stored knowledge as compared to an emerging interest. The development of interest is a sequential process. The deepening of interest in the previous phase may lead to the development of a subsequent phase. This four-phase model offers a useful framework for research on the transition from situational interest to individual interest (Hidi & Renninger, 2006).

Measurement of Interest

Individual interests were usually assessed by means of questionnaires (Schiefele, 2009). Typical academic interest instrument were designed to assess individual interests in school subjects, such as mathematics and science. For example, the Study Interest Questionnaire measured academic interest from three perspectives: feeling-related valences (e.g., Being involved with the subject affects my mood positively.), value-related valences (e.g., It is important to study this subject.), and intrinsic character of valence beliefs (e.g., I chose my major because of the interesting subject matter involved). These three aspects of interest are not separate factors. Instead, the questionnaire items are highly homogeneous and consistent (Schiefele, 2009). In contrast, some researchers conceptualized interest in a school subject as multidimensional, which were defined by topic areas (Schiefele, 2009). For example, a biology interest questionnaire includes the dimensions of molecular biology and biotechnology, maintaining human health, etc. (Tamir & Gardner, 1989). Despite the fact different instruments were developed, many studies used self-constructed simple ratings of interest (Schiefele et al., 1992).

Development Trends of Interest

Krapp (2002) explored the general development trends of interest at different grade levels through synthesizing the findings of cross-sectional and longitudinal studies. First, the researcher found that the average interest in any subject tends to decrease at all grade levels in the school system. This finding is consistent with research showing that student motivation tends to deteriorate as they grow up (Gottfried, Marcoulides, Gottfried, Oliver, & Guerin, 2007; Schiefele, 2009). Second, the decrease of interest is mainly found in mathematics, physics, and chemistry and is less evident in biology. In addition, the negative trend is more obvious among girls than among boys. Some researchers proposed tentative explanations of the negative changes. For example, the mismatch between the needs of developing adolescents and the opportunities afforded them by the social environment may cause the decrease of interest in school (Eccles et al., 1993). However, very few empirical studies have been conducted to investigate the factors associated with the negative psychological change, so the reason of the negative trend is still unclear.

Factors that Influence Interest

By synthesizing the previous studies, Hidi and Renninger (2006) found that situational interest is typically but not exclusively externally supported, and individual interest is typically but not exclusively self-regulated. Instructional conditions or learning environment, such as cooperative group work and project-based learning, can enable the development of both situational and individual interest. External support, in the form of peers and teachers, could facilitate the development of individual interest.

These findings have implications for teachers. Hidi and Renninger (2006) suggested three strategies for teachers to improve students' interest in a school subject: helping students sustain attention for tasks even when tasks are challenging, providing opportunities for students to ask curiosity questions, and selecting or creating resources that promote problem solving and strategy generation. Schiefele (2009) suggested four types of strategies to foster individuals' interest: facilitating students' experience of competence, providing support for student self-determination, establishing and maintaining social relatedness with students, and addressing the meaningfulness of a given subject area. In sum, teachers could develop and maintain students' interest in a subject through different ways.

Effects of Interest on Student Achievement

Empirical studies generally reported positive associations between interest and academic achievement. A meta-analysis study reported that on average the interest in a subject area accounts for 10% of the observed achievement variance across different subject areas, types of study, and age groups (Schiefele et al., 1992). A longitudinal study in Germany revealed that interest in Grade 7 had no significant effects on student mathematics achievement in either Grade 10 or Grade 12, but the interest in Grade 10 significantly affected student mathematics achievement in Grade 12 directly and indirectly through course selection after controlling for Grade 10 mathematics achievement (Köller et al., 2001). The findings of this study suggested that interest is not a significant antecedent of student mathematics achievement in middle school level classes but it is a more influential factor in high school level mathematics classes. Fisher, Dobbs-Oates, Doctoroff, and Arnold (2012) investigated the relationship between mathematics interest and skill both concurrently and over time in a preschool sample. The regression analyses of concurrent relationships indicated that high levels of interest were related to strong mathematics skills. After controlling for initial mathematics skills, the early interest also correlated with later mathematics skills. However, another research in a middle school sample reported that students' prior math interest had no significant effect on subsequent math achievement (Marsh, Trautwein, Lüdtke, Köller, & Baumert, 2005).

Limitations of Existing Research on Interest

First, although theory has suggested that academic interest is a significant factor in cognitive development and learning, researchers have rarely examined the impact of interest in school achievement in the past two decades. More empirical studies will be needed to explore the role of interest in student learning. Second, Köller et al. (2001) revealed that interest in mathematics only predicted student achievement in a higher grade level but not in a lower grade level, suggesting that more studies will be needed to explore the impact of interest in student learning in different age groups. Third, teacher behaviors could influence student interest, but few studies examine this premise (Fisher et al., 2012). More studies will be needed to investigate the potential influence of teacher practices on student interest development.

Summary of Literature Review

The existing theories and empirical studies on teaching and learning indicate that teacher classroom practices—what teachers do in the classrooms—affect student self-efficacy, interest, and achievement. More specifically, the variables included in the present study have the following relationships: (1) family SES influences the opportunities that students have to access high-quality teachers as well as their achievement; (2) student prior achievement influences teacher classroom practices, student motivation, and student achievement; (3) teacher classroom practices, including teacher support, conceptual teaching, and procedural teaching in the present study, affect student motivation and achievement; (4) student motivation, including self-efficacy and interest in the present study, affects student achievement.

However, there are some limitations of the existing studies on the variables that are included in the present study. First, teacher classroom practices are important for student learning, but there is a lack of quantitative studies to support this argument. An extensive literature search has been conducted to identify studies on conceptual teaching in mathematics domain in last 15 years, but only 8 articles have been identified. Most of these studies used the datasets that were collected before 2000. The patterns of teacher classroom practices and student learning may change in the context of educational reforms. Therefore, studies using more recent data are needed to capture the new changes in mathematics teaching and learning.

Second, most of the studies on teacher classroom practices used cross-sectional data, for example, TIMSS and NAEP data, which raise the possibility that student achievement affects teacher classroom practices rather than the reverse. The limitation of cross-sectional datasets reduces the confidence in addressing possible causal relations. Longitudinal studies are needed to establish the temporal precedence of the variables of interest.

Third, the majority of research on teacher classroom practices investigated the direct effects of teacher practices on student achievement but rarely explored how the influence occurs. Motivational studies indicated that what teachers do in classrooms could trigger the changes in students' self-systems, for example, how students assess their ability and how they set goals for themselves. The attitudes, values, and beliefs about self are related to student achievement. Empirical studies are needed to test whether student motivational beliefs mediate the relationships between teacher classroom practices and student achievement.

Fourth, very few studies addressed the influence of student characteristics on teacher classroom practices. Teacher classroom practices influence and are influenced by student performance. It is reasonable to hypothesize that teachers are more likely to be interested in students who are more motivated, engaged, and achieving higher goals, and are more likely to use cognitively demanding strategies for these students. Demographic factors, such as family SES, could influence students' opportunities to access teachers with different levels of quality, so it is reasonable to hypothesize that family SES influences the opportunities that students have teachers who use conceptual teaching or procedural teaching strategies.

Based on the findings and suggested future research directions of existing studies, a hypothesized structural model has been developed to address the research questions of the present study. The hypothesized model is presented chapter 3.

Chapter 3 Methods

This study examined the relationships among teacher classroom practices, student motivation and mathematics achievement using an observational design. This chapter describes the methods of this study, including the data source and sample, measures of variables, and data analysis steps.

Data Source and Sample

The data for the present study came from the High School Longitudinal Study of 2009 (HSLS: 09), which was the fifth in a series of secondary longitudinal studies conducted by the National Center for Educational Statistics (NCES). The HSLS: 09 study was designed to track students' trajectories from the beginning of high school into the postsecondary education, the workforce, and beyond (Ingels et al., 2011). It focused on how students choose STEM courses, majors, and careers, as well as to explore the educational and social experiences that affect students' trajectories (Ingels et al., 2011). The HSLS: 09 study started with a nationally representative sample of high school freshmen in the 2009-2010 school year, and then followed with a survey in the spring of 2012 when most sample members were in the spring semester of their 11th grade. A brief follow-up data collection of students' postsecondary options and plans at the graduation year in 2013 is being processed now. The subsequent data collections are planned in 2016 to learn students' postsecondary experiences and in 2021 to learn students' occupational choices and decisions (Ingels et al., 2011).

The HSLS: 09 dataset has been selected mainly for four reasons. First, this is a nationally representative dataset, which is important to establish external validity, so the findings from this study can be generalized to all the 9^{th} grade students in the U.S.

Second, this dataset collected extensive information on student background, mathematics and science experiences, mathematics and science teacher characteristics and practices, and home and school information. Third, this is one of the most recent national dataset, which captures new changes in student achievement patterns and teachers' classroom practices. Since the focus of the present study is the relationship between mathematics teachers' classroom practices and student mathematics achievement, only the base year has been used for the present study. Mathematics teachers only took the base year survey, although HSLS: 09 is a longitudinal study.

The base year study of HSLS: 09 utilized a two-stage sample design with primary sampling units defined as schools selected in the first stage and students randomly selected from the sampled schools within the second stage (Ingels et al., 2011). This method yielded a random sample of 25,206 eligible students from 944 participating schools. A total of 21,444 students completed a survey and mathematics ability assessment in the base year. After excluding the cases with missing values on the variables of interest, 9,662 students were selected for the present study. The different school types, regions, localities, gender, and ethnicity groups represented by these 9,662 students are very close to the HSLS: 09 sample, so the sample of the present study is still nationally representative. For details of the sample distribution, see Table 1. Among the 9, 662 students, 5% were randomly selected for the exploratory factor analyses and the remaining 95% were used for the confirmatory factor analyses and structural model analyses.

Table 1
Distributions of the Sample of the HSLS: 09 Base-Year Data and the Sample of the Present Study

	Sample of the HSLS: 09 Base-Year Data	Sample of the Present Study
Total	21,444 (100%)	9,662 (100%)
School type		
Public	17,511 (81.7%)	7,611 (78.8%)
Private	3,933 (18.3%)	2,051 (21.2%)
Region		
Northeast	3,331 (15.5%)	1,386 (14.3%)
Midwest	5,695 (26.6%)	2,778 (28.8%)
South	8,705 (40.6%)	3,870 (40.1%)
West	3,713 (17.3%)	1,628 (16.8%)
Locale		
City	6,067(28.3%)	2,888(29.9%)
Suburban	7,636(35.6%)	3,283 (34.0%)
Town	2,580(12.0%)	1,238 (12.8%)
Rural	5,161(24.1%)	2,253 (23.3%)
Gender		
Male	10,887 (50.8%)	4,834 (50%)
Female	10,557 (49.2%)	4,828(50%)
Race		
Amer. Indian/Alaska Native, non-Hispanic	163 (.8%)	58 (.6%)
Asian, non-Hispanic	1,672 (7.8%)	722 (7.5%)
Black/African-American, non-Hispanic	2,218 (10.3%)	810 (8.4%)
Hispanic, no race specified	204 (1.0%)	75 (.8%)
Hispanic, race specified	3,311 (15.4%)	1,376 (14.2%)
More than one race, non-Hispanic	1,912 (8.9%)	861 (8.9%)
Native Hawaiian/Pacific Islander, non-Hispanic	110 (.5%)	40 (.4%)
White, non-Hispanic	11,854 (55.3%)	5,720 (59.2%)

Measures

This section describes the measures of variables that were included in the present study. This study includes six latent variables, which were measured by multiple items, and two observed variables, which were measured by a single item.

Family SES

The composite variable X1SES, which has been composed by NCES using parents' education, parents' occupation, and family income, was used to represent family SES in the present study. The higher value of X1SES represents a higher level of family socioeconomic status.

Prior Achievement

The final grades of students' most advanced mathematics and science courses in 8^{th} grade have been used to measure students' prior achievement. The scaling of the mathematics and science grade is 1=A, 2=B, 3=C, 4=D, and 5=Below D. In order to be consistent with the positive direction of all other variables, the scaling has been recoded as 1=Below D, 2=D, 3=C, 4=B, and 5=A.

Teacher Support

There are 9 items on students' perception of mathematics teachers' affective and academic support in the base year student survey. Students were asked to indicate their level of agreement on the following 9 items on a 4-point Likert scale with 1=strongly agree, 2=agree, 3=disagree, and 4=strongly disagree.

(1) The mathematics teacher values and listens to students' ideas.

(2) The mathematics teacher treats students with respect.

(3) The mathematics teacher treats every student fairly.

(4) The mathematics teacher thinks every student can be successful

(5) The mathematics teacher thinks mistakes are okay as long as all students learn.

(6) The mathematics teacher treats some kids better than other kids.

(7) The mathematics teacher makes mathematics interesting.

(8) The mathematics teacher treats males and females differently.

(9) The mathematics teacher makes mathematics easy to understand.

Except items 6 and 8, a lower score represents teachers' positive attitudes and behaviors toward students whereas a higher score represents negative attitudes and behaviors toward students. In order to keep items semantically in the positive direction, items 1, 2, 3, 4, 5, 7, and 9 have been reversely coded with 1= strongly disagree, 2=disagree, 3=agree, and 4=strongly agree. After recoding, a higher score represents students' perception of higher level of teacher support, and a lower score represents students' perception of lower level of teacher support.

Teacher Instructional Practices

Teachers reported on a list of objectives in the base year survey, which have been selected to measure their instructional practices. The mathematics teachers were asked to report the emphasis they placed on the following objectives on a 4-point Likert scale with 1=no emphasis, 2=minimal emphasis, 3=moderate emphasis, and 4=heavy emphasis. Exploratory factor analysis was conducted to identify which items are loaded on conceptual and procedural teaching respectively.

(1) Increasing students' interest in mathematics.

(2) Teaching students mathematical concepts.

(3) Teaching students mathematical algorithms or procedures.

(4) Developing students' computational skills.

(5) Developing students' problem solving skills.

(6) Teaching students to reason mathematically.

(7) Teaching students how mathematics ideas connect with one another.

(8) Preparing students for further study in mathematics.

(9) Teaching students the logical structure of mathematics.

(10) Teaching students about the history and nature of mathematics.

(11) Teaching students to explain ideas in mathematics effectively.

(12) Teaching students how to apply mathematics in business and industry.

(13) Teaching students to perform computations with speed and accuracy.

(14) Preparing students for standardized tests.

Mathematics Self-Efficacy

Four items on students' perception of their capabilities in mathematics learning in the base-year survey have been used to measure students' mathematics self-efficacy. The scaling of these items are: 1=strongly agree, 2=agree, 3=disagree, and 4=strongly disagree. These items have been reversely coded with 1= strongly disagree, 2=disagree, 3=agree, and 4=strongly agree. After recoding, a higher score represents students' perception of higher capabilities in math.

(1) You are certain that you can understand difficult mathematics material.

(2) You are certain that you can master mathematics skills.

(3) You are confident that you can do an excellent job on mathematics tests.

(4) You are confident that you can do an excellent job on mathematics assignments.

Interest in Mathematics Courses

Three items in the base-year survey were used to measure students' interest in mathematics courses. These items measure student attitudes toward mathematics courses on a 4-point Likert scale with 1=strongly agree, 2=agree, 3=disagree, and 4=strongly disagree. The first two items have been reversely coded with 1= strongly disagree, 2=disagree, 3=agree, and 4=strongly agree. After recoding, a higher score represents a higher level of interest in mathematics courses.

(1) You enjoy mathematics classes very much.

(2) You think mathematics classes are a waste of your time.

(3) You think mathematics classes are boring.

Mathematics Achievement

The mathematics Item Response Theory (IRT) score of the base-year assessment was used to measure students' mathematics achievement. IRT is a method of estimating achievement level by considering the pattern of right, wrong, and omitted responses on all items administered to an individual student (Ingels et al., 2011). The mathematics IRT score, represented by the estimated number of correct responses, is a criterion-referenced measure. In the HSLS: 09 study, the criterion is the set of skills defined by the base-year framework and represented by 72 items. Under IRT scoring, the estimated number of correct answers for mathematics is an estimate of the number of items students would have answered correctly to all 72 items in the item pool. IRT scoring has several advantages over traditional raw score scaling. First, IRT scoring can account for the guessing factor using the overall response pattern of right and wrong answers to estimate ability (Ingels et al., 2011). Second, omitted items are less likely to cause distortion of scores as long as enough items have been answered right and wrong to establish a consistent pattern (Ingels et al., 2011). Third, the IRT scoring makes it possible to obtain scores on the same scale for students who took harder or easier forms of the test (Ingels et al., 2011).

Data Analysis Steps

The data analysis was conducted in four steps. First, descriptive analysis was carried out to get a general profile of teacher practices, student motivation, and mathematics achievement. Second, exploratory factor analysis (EFA) was conducted to uncover the underlying structures of items on teacher support and instructional practices. Third, confirmatory factor analysis (CFA) was executed to test the relationships between latent variables and observed variables. Fourth, structural model was analyzed to examine the relationships between latent variables. The last two steps used structural equation modeling (SES) techniques. SPSS 21 was used to conduct the descriptive analyses and EFA (IBM Corp, 2012). LISREL 8.80 was applied to carry out the CFA and structural model analyses (Jöreskog & Sörbom, 2006).

Descriptive Analyses

First, descriptive statistics on teacher classroom practices, student motivation, and student mathematics achievement was conducted. The descriptive analyses provided a general profile of teacher classroom practices, student motivation, and mathematics achievement, and identified any variations in student achievement across student demographic status. In addition, correlations among the observed variables were examined.

Exploratory Factor Analyses

Nine items on teacher support have been identified in the HSLS: 09 dataset. According to the literature review in chapter 2, teacher support could be a unidimensional or multidimensional construct. Thus, EFA was conducted to determine how many factors could explain the interrelationships between these 9 items (Raykov & Marcoulides, 2012). In addition, 14 items have been identified on conceptual and procedural teaching approaches in the HSLS: 09 data set. EFA was conducted to uncover the underlying structure of these 14 items and reduce the number of observed indicators for each construct (Raykov & Marcoulides, 2012).

The EFA consisted of two main steps: factor extraction and factor rotation (Raykov & Marcoulides, 2012). The factor extraction was an initial step to explore the latent variables that are able to explain the interrelationships among a given set of observed variables. However, many times the initial solution is not easily interpretable in practice, for example, multiple variables have moderate loadings on several factors (Meyers, Gamst, & Guarino, 2006). In order to obtain an equivalently well-fitting solution, which is meaningfully interpretable in the substantive area, factor rotation is carried out in the second step. Although there are multiple choices for conducting factor extraction and factor rotation, it is general to choose the principal component and maximum likelihood methods for factor extraction and oblique method for factor rotation (Raykov & Marcoulides, 2012).

Two critical decisions were made regarding the selection of factor structure: how many factors can explain the interrelationships between variables and which variable is to be taken into account in interpreting the factors (Meyers et al., 2006). There is no one right way to select the factor solutions. Usually, the number of factors is decided based on the number of eigenvalues that are larger than 1. An observed variable will be taken into account to interpret a factor if the corresponding factor loading is larger or equal to .3. In addition, the theoretical and empirical background and the reasonableness of the factor structure was also considered (Meyers et al., 2006). After the EFA, reliability analysis was applied to examine the internal consistency of the variables loaded on the same factor, using Cronbach’s alpha.

Confirmatory Factor Analyses

In SEM, there are two major types of variables: latent variables and observed variables. Latent variables, sometimes called constructs or factors, are indirectly measured by sets of observed variables (Schumacker & Lomax, 2012). Observed variables (indicators) are a set of variables that are used to define or infer the latent variable or construct (Schumacker & Lomax, 2012). The use of observed variables assumes that all of the measured variables are perfectly valid and reliable, which is unlikely in practice. The advantage of using latent variables is that they take into account measurement error (Schumacker & Lomax, 2012). In the present study, the variables of prior achievement, teacher support, conceptual teaching, procedural teaching, mathematics self-efficacy, and interest in mathematics courses are measured by multiple items. CFA was conducted to examine the pattern of relations among the latent variables as well as those between them and the observed variables (Raykov & Marcoulides, 2012.

For models with latent variables, Anderson and Gerbing (1988) suggested a two-step approach to test the theoretical model—first test the measurement model (CFA) until the model achieves a good fit with the data and then test the structural model. The purpose of the measurement model estimation is to examine whether the latent variables are measured well by sets of observed variables (Raykov & Marcoulides, 2012). If the latent variables are measured well, then the structural model will be specified to indicate the relationships among the latent variables in the second step.

The CFA was conducted in five steps: model specification, model identification, model estimation, model testing, and model modification (Raykov & Marcoulides, 2012; Schumacker & Lomax, 2012). In model specification, the relationships among latent variables and the relationships between latent and observed variables were identified. In model identification, the order condition and rank condition were assessed. The order condition requires that the number of free parameters to be estimated should be less than or equal to the number of distinct values, which is equal to p*(p+1)/2 (p represents the number of observed variables). The rank condition requires that each parameter in the model can be estimated from the covariance matrix. The standard method of parameter estimation in SEM is maximum likelihood. In model testing, the fit indices and the convergent validity—factor loadings—were examined. If the model fit indices were acceptable, then the specified measurement model was supported by the data. Otherwise, model modifications were needed. In model modification, the parameters that were not statistically significant from 0 were eliminated, or additional parameters were included according to the modification indices.

Model testing is a critical step in structural modeling analysis. It assesses how well the measurement model fit with the data. Following Schumacker and Lomax (2012), several fit indices were examined, for example, chi-square (χ^2), root-mean-square error of approximation (RMSEA), goodness-of-fit indices (GFI), and standardized root mean square residual (SRMR). A significant chi-square value indicates that the theoretical model is not supported by the sample data (Hooper, Coughlan, & Mullen, 2008; Schumacker & Lomax, 2012). The value of RMSEA lower than .05 indicates good fit between the theoretical model and data, and the value lower than .08 indicates acceptable fit (Hooper et al., 2008). A cut-off value of .90 for GFI is acceptable and .95 is more appropriate (Hooper et al., 2008; Schumacker & Lomax, 2012). The value of SRMR less than .05 indicates a well fitted model and the value as high as .08 is acceptable (Hooper et al., 2008; Schumacker & Lomax, 2012).

Structural Model Analyses

The structural model was estimated after the measurement model achieved an acceptable level of fit with the data. In the full structural model analyses, the measurement and structural parts of the model were estimated simultaneously. Similar as in CFA, the structural model analysis was conducted in five steps: model specification, model identification, model estimation, model testing, and model modification (Schumacker & Lomax, 2012). The strategies for the last four steps are the same as in CFA. The following paragraphs present the first step of structural model analyses—model specification.

In order to address the two research questions, a hypothesized structural model in Figure 2 has been developed according to relevant theories and empirical studies on teacher classroom practices, student motivation, and student achievement, which were reviewed in chapter 2. The hypothesized model included 6 simultaneously estimated regression models: (1) family SES and prior achievement were related to students' perceptions of teacher support; (2) family SES and prior achievement were related to teachers' conceptual teaching approach in mathematics class; (3) family SES and prior achievement were related to teachers' procedural teaching approach in mathematics class; (4) student prior achievement, perception of teacher support, conceptual teaching, and procedural teaching were related to student mathematics self-efficacy; (5) student prior achievement, perception of teacher support, conceptual teaching, procedural teaching, and mathematics self-efficacy were related to students' interest in mathematics courses; (6) student family SES, prior achievement, perception of teacher support, conceptual teaching, procedural teaching, students' mathematics self-efficacy, and students' interest in mathematics courses were related to student mathematics achievement.

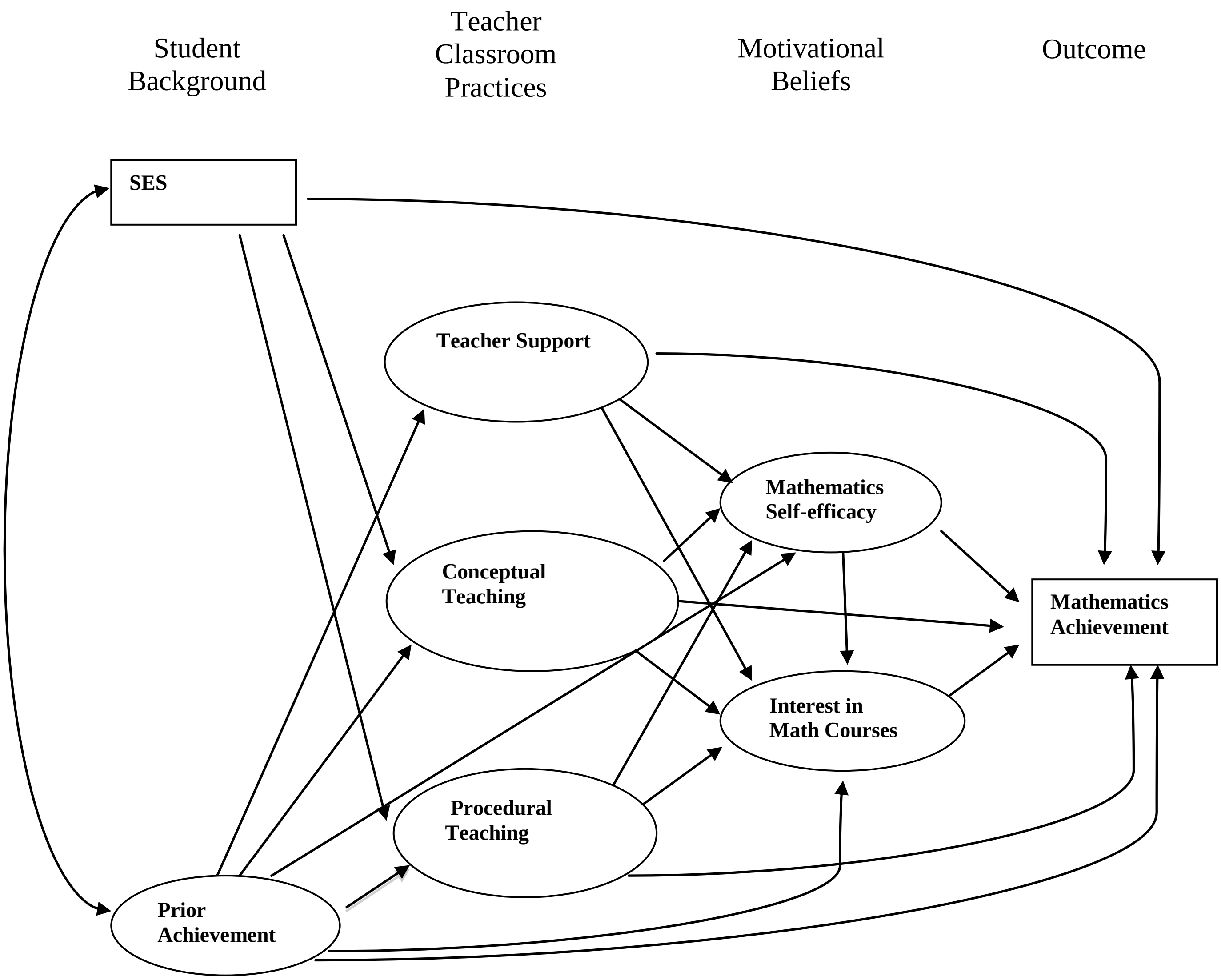

Figure 2. Hypothesized Structural Model

In structural model analyses, the direct, indirect, and total effects of teacher classroom practices on student achievement were estimated. First, the paths from teacher support, conceptual understanding, and procedural teaching to student mathematics achievements were examined. If the paths were significant, then the direct effects of these three variables on student achievement were significant after controlling for student background characteristics and student motivational beliefs. Second, the indirect effects of teacher classroom practices on student achievement were examined. Take the relationships among teacher support, mathematics self-efficacy, and mathematics achievement as an example, let ‘a’ represents the path coefficient from teacher support to mathematics self-efficacy and ‘b’ represents the path coefficient from mathematics self-efficacy to mathematics achievement, then ‘a*b’ represents the indirect effect from teacher support to student achievement. If ‘a*b’ is significantly different from 0, then the indirect effect is significant, indicating student mathematics self-efficacy mediated the association between teacher support and student achievement (Cole & Maxwell, 2003). Third, the total effects of teacher classroom practices on student achievement were estimated, which are the sum of direct and indirect effects.

Same as the CFA, the fit indices, such as χ^2, RMSEA, CFI, and SRMR, were reported to assess the overall fit of the hypothesized structural models (Schumacker & Lomax, 2012). If the hypothesized model was not supported by the data, then the non-significant paths were eliminated and additional paths were added to the model to arrive at a better-fitted model.

In summary, the structural model analyses addressed the two research questions in the present study. The analyses of the direct effects of teacher classroom practices on student achievement answered the first research question. The analyses of the indirect effects of teacher classroom practices on student achievement answered the second research question.

Chapter 4 Results

This chapter is divided in three sections: the descriptive statistics for each variable and correlations among them; the results of exploratory factor analyses; and the structural equation modeling analyses, including the measurement and structural model.

Descriptive Statistics

This section presents the descriptive statistics, including mean and standard deviation, for each variable in the hypothesized model. First, the descriptive statistics of mathematics achievement in the full sample and different gender, ethnicity, and SES groups were presented. Then the descriptive statistics of all the latent variables, including students' prior achievement, teacher support, teacher instruction, students' mathematics self-efficacy, and interest in mathematics courses are displayed.

Mathematics Achievement

In order to understand the patterns of student mathematics achievement, the mean and standard deviation of 9^{th} graders' mathematics IRT score in the full sample and different gender, ethnicity, and SES groups were computed (See Table 2). On average, students' mathematics IRT score was 40.45 in 9^{th} grade. Male and female students had very close mathematics IRT scores (M_{male}=40.54, M_{female}=40.37). In terms of ethnicity, Asian American students had the highest mean mathematics score (M_{Asian}=48.53); White students were the second (M_{White}=41.92); American Indian/Alaska Native and African American students had the lowest scores ($M_{Amer.Indian/Alaska\ Native}$=33.29; $M_{African\text{-}American}$=35.28). With regard to SES, students in the higher quintile SES groups attained higher mathematics IRT score than students from lower quintile groups.

Table 2
Descriptive Analysis of Student Mathematics Achievement in the Full Sample and Different Gender, Ethnicity, and SES groups

	Mathematics IRT Score	
	M	SD
Total	40.45	11.60
Gender		
Male	40.54	11.88
Female	40.37	11.33
Ethnicity		
Amer. Indian/Alaska Native, non-Hispanic	33.29	11.05
Asian, non-Hispanic	48.53	12.64
Black/African-American, non-Hispanic	35.28	10.84
Hispanic, no race specified	36.62	11.52
Hispanic, race specified	38.35	10.60
More than one race, non-Hispanic	39.97	11.13
Native Hawaiian/Pacific Islander, non-Hispanic	41.73	10.61
White, non-Hispanic	41.92	11.49
SES		
1^{st} quintile	34.71	10.27
2^{nd} quintile	36.14	10.99
3^{rd} quintile	39.17	10.59
4^{th} quintile	42.73	10.52
5^{th} quintile	47.42	10.82

Prior Achievement

Prior achievement was measured by two observed variables: the grades of the most advanced mathematics and science courses in 8^{th} grade. The measure of student mathematics and science grade ranged from 1 to 5, with 1 indicating the grade “below D” and 5 indicating the grade “A”. The mean mathematics grade was slightly lower than 4, and mean science grade was slightly higher than 4, indicating that on average students’ mathematics and science grades were around the level of grade “B” in 8^{th} grade. The correlation between students’ mathematics and science grades was .55, which is statistically significant at the .01 level. For details, see Table 3.

Table 3
Descriptive Statistics of Prior Achievement Items

	Item	M	SD	1	2
1	8^{th} grade mathematics grade	3.96	.96	1	
2	8^{th} grade science grade	4.07	.89	.55**	1

Note: *, p< .05; **, p< .01

Teacher Support

There are 9 items that pertain to students' perception of mathematics teacher's affective and academic support in the HSLS:09 study. These items were measured with a 4-point Likert scale with 1=strongly disagree and 4=strongly agree for items 1, 2, 3, 4, 5, 7, and 9. The mean score of items 1, 2, 3, 4, and 5 were slightly higher than 3 and the mean score of items 7 and 9 were slightly lower than 3, indicating that students tended to agree with these statements. Item 6 and 8 were measured by a 4-point Likert scale with 1=strongly agree and 4=strongly disagree. The mean score of these two items were slightly higher than 3, indicating that students tended to disagree with them. On average, students tended to agree that teachers provided affective and academic support to them during their 9^{th} grade mathematics class. The correlations between these items were moderate to high.

Table 4
Descriptive Statistics of Teacher Support Items

	Item	1	2	3	4	5
1	The mathematics teacher values and listens to students' ideas.	1				
2	The mathematics teacher treats students with respect.	.72**	1			
3	The mathematics teacher treats every student fairly.	.69**	.79**	1		
4	The mathematics teacher thinks every student can be successful	.62**	.68**	.67**	1	
5	The mathematics teacher thinks mistakes are okay as long as all students learn.	.56**	.58**	.56**	.57**	1
6	The mathematics teacher treats some kids better than other kids.	-.44**	-.48**	-.56**	-.43**	-.34**
7	The mathematics teacher makes mathematics interesting.	.60**	.53**	.55**	.50**	.46**
8	The mathematics teacher treats males and females differently.	-.31**	-.38**	-.40**	-.35**	-.28**
9	The mathematics teacher makes mathematics easy to understand.	.58**	.52**	.54**	.48**	.46**
	M	3.13	3.27	3.21	3.34	3.22
	SD	.73	.66	.73	.66	.69

Table 4
Descriptive Statistics of Teacher Support Items (continued)

	Item	6	7	8	9
6	The mathematics teacher treats some kids better than other kids.	1			
7	The mathematics teacher makes mathematics interesting.	-.37**	1		
8	The mathematics teacher treats males and females differently.	.59**	-.25**	1	
9	The mathematics teacher makes mathematics easy to understand.	-.38**	.69**	-.28**	1
	M	3.03	2.75	3.29	2.91
	SD	.86	.95	.74	.87

Note: *, p< .05; **, p< .01

Conceptual and Procedural Teaching

Fourteen items of teacher emphasis on different goals were used to measure their instructional practices in 9th grade mathematics classrooms. For details of the 14 items, see Table 5. The rating scale of these items ranged from 1= no emphasis to 4= heavy emphasis. Except the item, “emphasis on history and nature of math,” the mean score of other items were close to 3 or higher than 3, indicating that teachers had moderate to heavy emphasis on the those goals. The mean score of the item, “emphasis on history and nature of math,” was 2.25, indicating that teachers had lower emphasis on this goal. The 14 items had low to moderate correlation with each other.

Table 5
Descriptive Statistics of Teacher Instructional Practices Items

	Item	1	2	3	4	5	6	7
1	Emphasis on students’ interest	1						
2	Emphasis on teaching mathematics concepts	.18**	1					
3	Emphasis on teaching mathematics algorithm/procedures	.09**	.30**	1				
4	Emphasis on developing computing skills	.22**	.21**	.32**	1			
5	Emphasis on developing problem solving skills	.31**	.34**	.20**	.26**	1		
6	Emphasis on reasoning mathematically	.33**	.35**	.22**	.18**	.62**	1	
7	Emphasis on connecting mathematics ideas	.39**	.33**	.21**	.22**	.47**	.50**	1
8	Emphasis on preparation for future mathematics study	.36**	.29**	.20**	.19**	.33**	.31**	.39**
9	Emphasis on logic structure of mathematics	.38**	.30**	.27**	.20**	.39**	.47**	.48**
10	Emphasis on history and nature of math	.42**	.18**	.24**	.27**	.33**	.37**	.40**
11	Emphasis on effectively explain mathematics ideas	.32**	.26**	.23**	.25**	.44**	.46**	.45**
12	Emphasis on business/industry application of math	.37**	.15**	.13**	.23**	.35**	.31**	.38**
13	Emphasis on speedy/accurate computations	.23**	.15**	.22**	.52**	.25**	.21**	.23**
14	Emphasis on standardized test preparation	.10**	.09**	.19**	.22**	.11**	.10**	.10**
	M	3.21	3.84	3.41	3.28	3.63	3.63	3.50
	SD	.67	.39	.67	.73	.54	.55	.61

Table 5
Descriptive Statistics of Teacher Instructional Practices Items (continued)

	Item	8	9	10	11	12	13	14
8	Emphasis on preparation for future mathematics study	1						
9	Emphasis on logic structure of mathematics	.41**	1					
10	Emphasis on history and nature of math	.33**	.47**	1				
11	Emphasis on effectively explain mathematics ideas	.34**	.42**	.44**	1			
12	Emphasis on business/industry application of math	.24**	.32**	.47**	.37**	1		
13	Emphasis on speedy/accurate computations	.23**	.29**	.33**	.29**	.30**	1	
14	Emphasis on standardized test preparation	.11**	.15**	.17**	.13**	.19**	.27**	1
	M	3.50	3.29	2.25	3.27	2.81	2.99	3.26
	SD	.64	.71	.74	.69	.80	.77	.73

Note: *, p< .05; **, p< .01

Mathematics Self-Efficacy

Students' mathematics self-efficacy was measured by the items related to students' confidence in taking mathematics test, understanding mathematics textbooks, mastering skills in mathematics courses, and doing mathematics assignments. These items were measured on a 4-point Likert scale with 1=strongly disagree and 4=strongly agree. As shown in Table 6, the mean scores of these items ranged from 2.71 to 3.06, indicating that on average students were likely to agree with these statements. These four items were highly correlated with each other.

Table 6
Descriptive Statistics of Mathematics Self-efficacy Items

	Item	M	SD	1	2	3	4
1	9th grader confident in mathematics test	2.96	.77	1			
2	9th grader can understand mathematics textbook	2.71	.82	.68**	1		
3	9th grader can master skills in mathematics course	2.98	.73	.69**	.68**	1	
4	9th grader confident in mathematics assignments	3.06	.72	.75**	.65**	.73**	1

Note: *, p< .05; **, p< .01

Interest in Mathematics Courses

Interest in mathematics courses consisted of 3 items measuring students' attitude towards mathematics courses. The item "9th grader is enjoying mathematics courses" was measured by a 4-point Likert scale with 1= strongly disagree and 4=strongly agree. The mean score of this item was 2.76, indicating that students tended to agree with this statement. The items, "9th grader thinks mathematics course is a waste of time" and "9th grader thinks mathematics course is boring," were measured by a 4-point Likert scale with 1=strongly agree and 4=strongly disagree. The mean scores of these two items were 3.16 and 2.66, indicating that students tended to disagree with these two items. Overall, students tended to report that the 9th grade mathematics course is interesting. The correlations among these three items were moderate as shown in Table 7.

Table 7
Descriptive Statistics of Interest Items

	Item	M	SD	1	2	3	4	5
1	9th grader is enjoying mathematics course	2.76	.83	1				
2	9th grader thinks mathematics course is a waste of time	3.16	.79	.50**	1			
3	9th grader thinks mathematics course is boring	2.66	.90	.58**	.58**	1		

Note: *, p< .05; **, p< .01

Exploratory Factor Analyses

In the present study, there were nine items on teacher support and 14 items on teacher instructional practices. Exploratory factor analysis (EFA) was conducted to explore the underlying structure of the nine items that may explain teacher support and 14 items may explain instructional practices. The maximum likelihood method was used for factor extraction and direct oblimin method was selected for factor rotation in the present study (Meyers et al., 2006). Screen plots and total explained variance were used to determine the number of factors. Approximately 5% of the sample was used for the EFA (n=495).

Teacher Support

The initial factor analysis extracted two factors: the first factor had seven items and the second factor had two items loading on them. Generally a factor with fewer than three items is weak and unstable (Costello & Osborne, 2011), so the two items of the second factor — *mathematics teacher treats some kids better than other kids* and *mathematics teacher treats males and females differently*—was removed in the next round of analysis. Finally, one factor was extracted with seven items loaded on it. This factor explained 59.72% of the total variance in this scale. For the factor loadings of the seven items, see Table 8. The Cronbach's alpha coefficient of this scale was .89.

Table 8
EFA for Teacher Support Items

Number	Item	Factor loading
1	Mathematics teacher treats students with respect	.89
2	Mathematics teacher treats every student fairly	.85
3	Mathematics teacher values/listens to students' ideas	.84
4	Mathematics teacher thinks all student can be successful	.72
5	Mathematics teacher makes mathematics interesting	.72
6	Mathematics teacher makes mathematics easy to understand	.69
7	Mathematics teacher thinks mistakes OK if students learn	.67

Conceptual and Procedural Teaching

Two factors were extracted from the EFA. The first factor includes the items that indicate mathematics teacher emphasis on reasoning mathematically, connecting mathematics ideas, logical structure of mathematics, developing problem solving skills, effectively explaining mathematics ideas, preparation for future mathematics study, increasing students' interest in math, and teaching mathematics concepts. These items are the characteristics of teaching for conceptual understanding, so the first factor was named as conceptual teaching. The second factor includes the items that show mathematics teachers' emphasis on speedy/accurate computations, developing computational skills, test preparation, and teaching mathematics algorithms/procedures. These items are the characteristics of teaching for procedural fluency, so the second factor was named as procedural teaching. The first and second factors explained 29.10% and 7.33% of total variance respectively. The Cronbach's alpha coefficient of the first scale was .84 and the second scale was .63. For the factor loading of each item, see Table 9.

Table 9

EFA for Teacher Instructional Practices Items

	Item	Factors	
		Conceptual Teaching	Procedural Teaching
1	Math teacher's emphasis on reasoning mathematically	.78	
2	Math teacher's emphasis on connecting math ideas	.73	
3	Math teacher's emphasis on effectively explaining math ideas	.69	
4	Math teacher's emphasis on logical structure of math	.66	
5	Math teacher's emphasis on developing problem solving skills	.64	
6	Math teacher's emphasis on preparation for further math study	.51	
7	Math teacher's emphasis on history and nature of math	.51	
8	Math teacher's emphasis on increasing students' interest in math	.40	
9	Math teacher's emphasis on teaching math concepts	.36	
10	Math teacher's emphasis on speedy/accurate computations		.76
11	Math teacher's emphasis on developing computational skills		.75
12	Math teacher's emphasis on test preparation		.40
13	Math teacher's emphasis on teaching math algorithms/procedures		.38

Structural Equation Modeling Analyses

The structural equation modeling analyses were conducted in two steps. It began with the measurement analyses to assess the construct validity of the latent variables, followed by the structural model analyses showing the relationships among variables in the hypothesized model (Schumacker & Lomax, 2012). Approximately 95% of the sample has been used for the structural modeling analyses (n=9,167). According to Ingels et al. (2011), the mathematics course enrollee weight should be used when the analysis draws on mathematics teacher data (alone or in conjunction with student data, school characteristics, or administrator/counselor data). In the present study, we analyzed mathematics teacher and student data together, so all the structural equation modeling analyses are based on the weighted sample. The sample was weighted by the base year mathematics course enroll weight *w1mathtch*. The weight was used to account for the HSLS: 09 complex survey design to produce estimates for the target population of the HSLS: 09 study, with appropriate standards errors (Ingels et al., 2011).

Measurement Model

The measurement model analysis was also called confirmatory factor analysis (CFA), which is used to test whether a set of observed variables define a construct or factor (Schumacker & Lomax, 2012). In the present study, we aimed to test whether the data fit the hypothesized factor structure of the six latent variables: prior achievement, teacher support, conceptual teaching, procedural teaching, mathematics self-efficacy, and interest in mathematics courses. In the hypothesized measurement model, these six latent variables correlate with each other (See Figure 3). The measurement models were tested in two steps. First, the measurement model for each latent variable was analyzed. Second, the full measurement model was tested for all latent variables simultaneously.

Generally three to four good indicators are the best number for each latent variable (Schumacker & Lomax, 2012). In the present study, teacher support had seven indicators and conceptual teaching had nine indicators. In order to simplify and optimize the measurement model, three composite variables were created. The first composite variable was created by taking the average of three highly correlated indicators of teacher support—*mathematics teacher values/listens to students' ideas, mathematics teacher treats students with respect*, and *mathematics teacher treats every student fairly*. The second composite variable was created by taking the average of three highly correlated indicators of conceptual teaching—*mathematics teacher's emphasis on developing problem solving skills, mathematics teacher's emphasis on reasoning mathematically*, and *mathematics teacher's emphasis on connecting mathematics ideas*. The third composite variable was created by taking the average of two highly correlated indicators of conceptual teaching--*mathematics teacher's emphasis on logical structure of mathematics* and *mathematics teacher's emphasis on history and nature of math*. All the follow-up analyses were conducted, using composite variables.

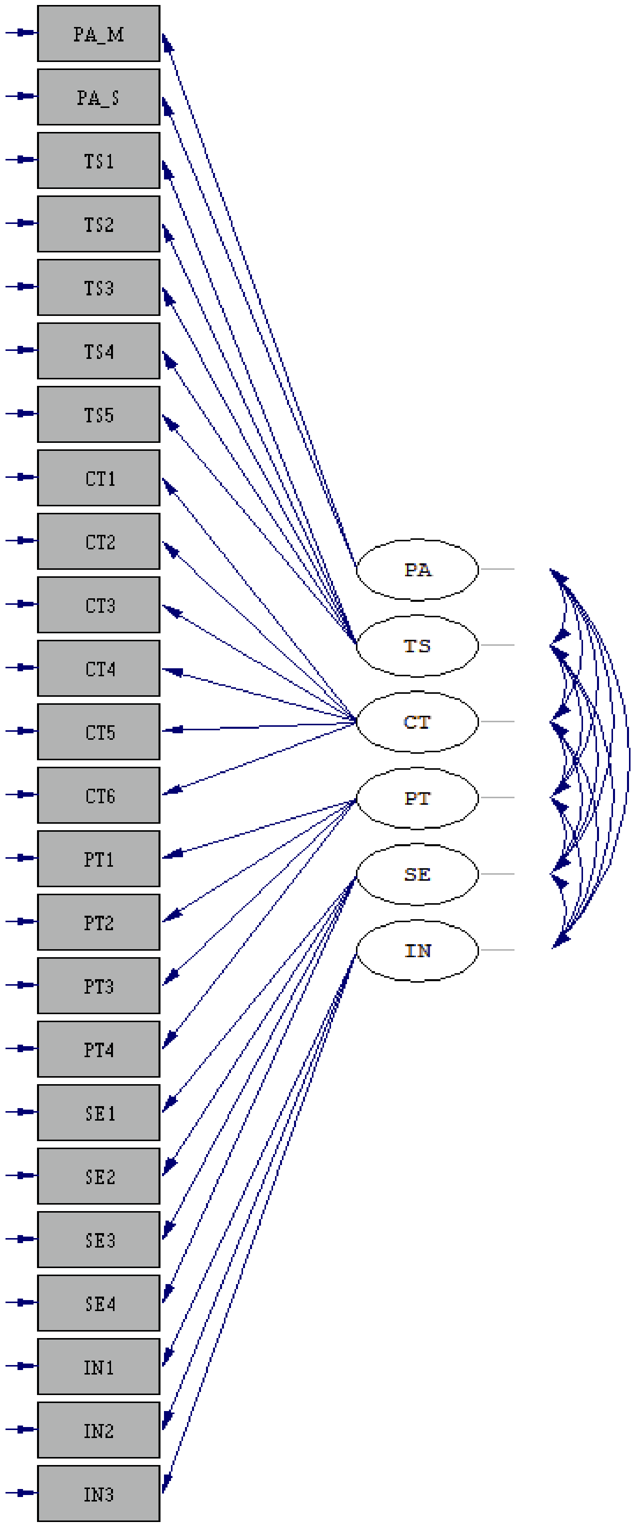

Figure 3. Hypothesized Measurement Model

Note: PA=prior achievement, TS=teacher support, CT=conceptual teaching, PT=procedural teaching, SE=mathematics self-efficacy, IN=interest in mathematics courses. For details of the indicators, see Table 11.

The hypothesized measurement model was constructed based on 24 observed variables, which loaded on 6 latent variables (See Figure 3). To get a better fitting model, three models have been tested in sequence. The model fit indices of the three measurement models are summarized in Table 10.

Base model. The chi-square of the base model was large and significantly different from 0 (χ^2=7730.19, df =237). The significant chi-square indicated that the input covariance matrix was not equal to the reproduced covariance matrix. This was largely due to the big sample size of the present study because the chi-square test is sensitive to the sample size. Other indices show that the base model had an acceptable fit with the data: comparative fit index (CFI) =.95, goodness of fit index (GFI) =.93, expected cross-validation index (ECVI) =.96, root mean square error of approximation (RMSEA) =.06, and standardized root mean square residual (SRMR) =.04. Usually, values above .95 for CFI, GFI, and AGFI indicate good fitting models (Schumacker & Lomax, 2012). The model having the smallest ECVI value is better (Browne & Cudeck, 1989). The values of RMSEA and SRMR below .05 indicate a desired fit (Schumacker & Lomax, 2012).

Although the base model was acceptable, the model modification indices showed that the fit of the model could be improved if some minor changes were made. The value of chi-square will decrease by 1288.84 if the error terms of the 4^{th} and 5^{th} indicators of teacher support were correlated. It is reasonable to correlate the error terms of these two items—*mathematics teacher makes mathematics interesting* and *mathematics teacher makes mathematics easy to understand*—because these two items may measure something in common other than the latent construct they are represented in this measurement model. Therefore, the error terms of the 4th and 5th indicators of teacher support were correlated in the next round of calculation (model 1).

Model 1. Chi-square difference test results indicated that model 1 was significantly improved compared to the base model ($\Delta\ \chi^2$=1329.12, df=1, p<.05). The fit indices were acceptable given χ^2=6401.07, df =236, CFI=.96, GFI=.94, ECVI=.72, RMSEA=.05, and SRMR=.04. The model modification indices showed that the chi-square value will decrease by 647.44 if the error terms of the 2nd and 3rd indicators of interest were correlated. It is reasonable to correlate the error terms of the two indicators, *9th grader thinks mathematics course is a waste of time* and *9th grader thinks mathematics course is boring,* because they are conceptually related, have some overlap of item content, and could possibly have something in common beyond the latent construct they are measuring. The change was made in the next round of analysis (final model).

Final model. Chi-square difference test showed that the final model was significantly better than model 1 ($\Delta\ \chi^2$=623.11, df=1, p<.05). Other model fit indices also indicated a good fit with the data (CFI=.97, GFI=.95, ECVI=.65, RMSEA=.05, and SRMR=.04). The final measurement model was considered well-fitting and acceptable. Compared to the hypothesized measurement model, the final measurement model has two changes: the error terms of the 4th and 5th indicators of teacher support were correlated, and the error terms of the 2nd and 3rd indicators of interest were correlated.

Table 10
Summary of Fit Statistics for the Measurement Models

	χ^2	df	$\Delta\ \chi^2$	Δdf	CFI	GFI	ECVI	RMSEA	SRMR
Base model	7730.19	237			.95	.93	.96	.06	.04
Model 1	6401.07	236	1329.12	1	.96	.94	.72	.05	.04
Final model	5779.74	235	621.33	1	.97	.95	.65	.05	.04

The standardized item loadings, t values and error variances of indicators, and the composite reliabilities of the latent variables are presented in Table 11. The standardized loadings ranged from .35 to .90 with t values ranging from 29.79 to 104.82, error variances ranged from .19 to .88, and composite reliabilities ranged from .62 to .90. Given the significant factor loadings, the model was retained as the final measurement model.

Table 11

Properties of the Final Measurement Model

Label	Observed variables	Standardized loading	t	Error	Reliability
	Prior achievement				.71
PA_M	8th grade mathematics grade	.88	59.09	.22	
PA_S	8th grade science grade	.63	48.53	.61	
	Teacher support				.86
TS1	Composite of mathematics teacher value/listen to students' ideas, treats students with respect, and treats every students fairly	.90	104.82	.19	
TS2	Mathematics teacher thinks all student can be successful	.78	85.78	.38	
TS3	Mathematics teacher thinks mistakes OK if students learn	.69	72.43	.52	
TS4	Mathematics teacher makes mathematics interesting	.69	72.09	.52	
TS5	Mathematics teacher makes mathematics easy to understand	.67	69.65	.55	
	Conceptual teaching				.78
CT1	Emphasis on increasing students' interest in math	.55	52.54	.70	
CT2	Emphasis on teaching mathematics concepts	.45	41.25	.80	
CT3	Composite of mathematics teacher's emphasis on developing problem solving skills, reasoning mathematically, and connecting mathematics ideas	.77	80.66	.40	
CT4	Emphasis on preparing for future mathematics study	.56	53.68	.69	
CT5	Composite of mathematics teacher's emphasis on logical structural of mathematics, and history and nature of math	.76	79.17	.42	
CT6	Emphasis on effectively explaining mathematics ideas	.66	65.75	.56	
	Procedural teaching				.62
PT1	Emphasis on teaching mathematics algorithms/procedures	.42	36.26	.82	
PT1	Emphasis on developing computational skills	.71	62.45	.49	
PT3	Emphasis on speedy/accurate computations	.70	61.76	.51	
PT4	Emphasis on standardized test preparation	.35	29.79	.88	
	Mathematics Self-efficacy				.90
SE1	Can do excellent job on fall 2009 mathematics tests	.86	99.69	.27	
SE2	Can understand mathematics textbook	.79	87.37	.38	
SE3	Can master skills in mathematics course	.84	95.87	.30	
SE4	Can do excellent job on mathematics assignments	.87	101.57	.25	
	Interest in mathematics courses				.79
IN1	Enjoys fall 2009 mathematics course very much	.86	87.57	.23	
IN2	Thinks mathematics course is a waste of time	.59	55.38	.65	
IN3	Thinks mathematics course is boring	.66	63.52	.57	

Structural Equation Models

In the structural models, the measurement part of the model was established based on the final measurement model, as described earlier. The structural part was tested in such a way that the hypothesized structural model was first tested. Then the model was modified according to the model modification indices and t-test results. Table 12 presents the overall correlation matrix of all the observed variables in the model. Figure 3 presents the hypothesized structural model.

Table 12
Overall Item Correlation Matrix

		1	2	3	4	5	6	7	8	9	10	11	12	13
1	SES	1.00												
2	PA_M	.26	1.00											
3	PA_S	.29	.55	1.00										
4	TS1	.05	.11	.12	1.00									
5	TS2	.01	.07	.09	.72	1.00								
6	TS3	.03	.09	.11	.63	.57	1.00							
7	TS4	-.02	.11	.07	.61	.50	.46	1.00						
8	TS5	.02	.11	.06	.60	.48	.46	.69	1.00					
9	CT1	.06	.08	.08	.01	.02	.04	.04	.03	1.00				
10	CT2	.10	.09	.09	.00	.00	.01	-.02	.01	.18	1.00			
11	CT3	.10	.15	.14	.01	.01	.02	.03	.02	.41	.42	1.00		
12	CT4	.11	.13	.14	-.01	-.02	-.01	.00	.01	.36	.29	.41	1.00	
13	CT5	.10	.14	.14	-.02	-.01	.01	-.01	.00	.47	.28	.57	.43	1.00
14	CT6	.07	.09	.10	.00	.02	.02	.00	-.01	.32	.26	.54	.34	.51
15	PT1	.03	.04	.04	-.03	-.01	-.04	-.03	-.01	.09	.30	.26	.20	.30
16	PT2	-.02	.00	-.01	-.07	-.03	-.05	-.04	-.01	.22	.20	.27	.19	.27
17	PT3	.01	.01	.01	-.03	-.03	-.02	-.02	-.01	.23	.15	.27	.22	.36
18	PT4	-.13	-.02	-.07	-.05	-.03	-.03	-.03	-.02	.10	.09	.12	.11	.18
19	SE1	.11	.33	.19	.21	.18	.19	.27	.38	.01	.02	.06	.05	.04
20	SE2	.12	.29	.19	.21	.16	.19	.25	.36	.05	.02	.05	.05	.05
21	SE3	.13	.33	.22	.23	.19	.21	.26	.33	.06	.04	.06	.05	.06
22	SE4	.12	.34	.23	.25	.23	.23	.29	.37	.04	.00	.04	.05	.04
23	IN1	.03	.23	.14	.41	.33	.30	.54	.51	.03	.01	.05	.03	.02
24	IN2	.07	.18	.15	.33	.29	.24	.36	.34	.03	.00	.03	.00	.02
25	IN3	.02	.17	.13	.35	.29	.24	.51	.41	.05	.00	.05	.03	.01
26	IRT	.41	.43	.43	.12	.07	.10	.05	.08	.08	.11	.19	.17	.17

Table 12
Overall Item Correlation Matrix (continued)

		14	15	16	17	18	19	20	21	22	23	24	25	26
14	CT6	1.00												
15	PT1	.23	1.00											
16	PT2	.26	.32	1.00										
17	PT3	.29	.22	.52	1.00									
18	PT4	.13	.19	.22	.26	1.00								
19	SE1	.05	.03	-.01	-.02	-.012	1.000							
20	SE2	.03	.01	-.02	.00	-.03	.69	1.00						
21	SE3	.05	.03	-.02	-.01	-.02	.69	.68	1.00					
22	SE4	.04	.03	-.01	.00	-.03	.75	.65	.73	1.00				
23	IN1	.02	.02	-.01	-.01	-.01	.50	.45	.46	.49	1.00			
24	IN2	.03	-.02	-.03	-.01	-.03	.29	.25	.31	.33	.51	1.00		
25	IN3	.02	-.03	-.03	-.02	-.03	.30	.27	.30	.32	.58	.58	1.00	
26	IRT	.15	.05	-.06	.00	-.08	.29	.26	.30	.29	.18	.18	.13	1.00

Note: SES=family SES, IRT=mathematics achievement. For descriptions of other items, see table 11.

Base model. The hypothesized model in Figure 3 was first tested. The goodness fit indices in Table 13 demonstrated acceptable fit of the base model (χ^2=8442.43, df=277, CFI=.95, GFI=.94, ECVI=.92, RMSEA=.06, SRMR=.07). According to the model modification indices, if the error terms of conceptual and procedural teaching were correlated, the value of chi-square will decrease by 1754.91. These two teaching methods were closely related to each other, so a covariance between conceptual and procedural teaching was added in the next round of calculation.

Model 1. After the covariance between error terms of conceptual and procedural teaching was set free, model 1 displayed a model fit of χ^2=6429.72, df=276, CFI=.97, GFI=.95, ECVI=.73, RMSEA=.05, SRMR=.04. The chi-square difference test indicated that model 1 was significantly improved compared to the base model ($\Delta\chi^2$=2012.71, Δ df=1, p<.05). Structural equation coefficients and t-test statistics indicated that nine paths were not significant: SES to procedural teaching, prior achievement to procedural teaching, prior achievement to interest, teacher support to mathematics achievement, conceptual teaching to mathematics self-efficacy, conceptual teaching to interest, procedural teaching to mathematics self-efficacy, procedural teaching to interest, and interest to mathematics achievement. These nine paths were removed one by one in the next round of analyses.

Final model. After removing the nine insignificant paths, the final model shows a good fit with the data given χ^2=6441.64, df=285, CFI=.97, GFI=.95, ECVI=.73, RMSEA=.05, SRMR=.04. The chi-square difference test results showed that there was no significant difference between model 1 and final model in model fit ($\Delta\chi^2$=11.92, Δdf=9, $p>.05$). However, the final model was more parsimonious, so the final model was optimal. The final model is shown in Figure 4.

Table 13
Summary of Fit Statistics for the Structural Models

	χ^2	df	$\Delta\chi^2$	Δdf	CFI	GFI	ECVI	RMSEA	SRMR
Base model	8442.43	277			.95	.94	.92	.06	.07
Model 1	6429.72	276	2012.71	1	.97	.95	.73	.05	.04
Final model	6441.64	285	11.92	9	.97	.95	.73	.05	.04

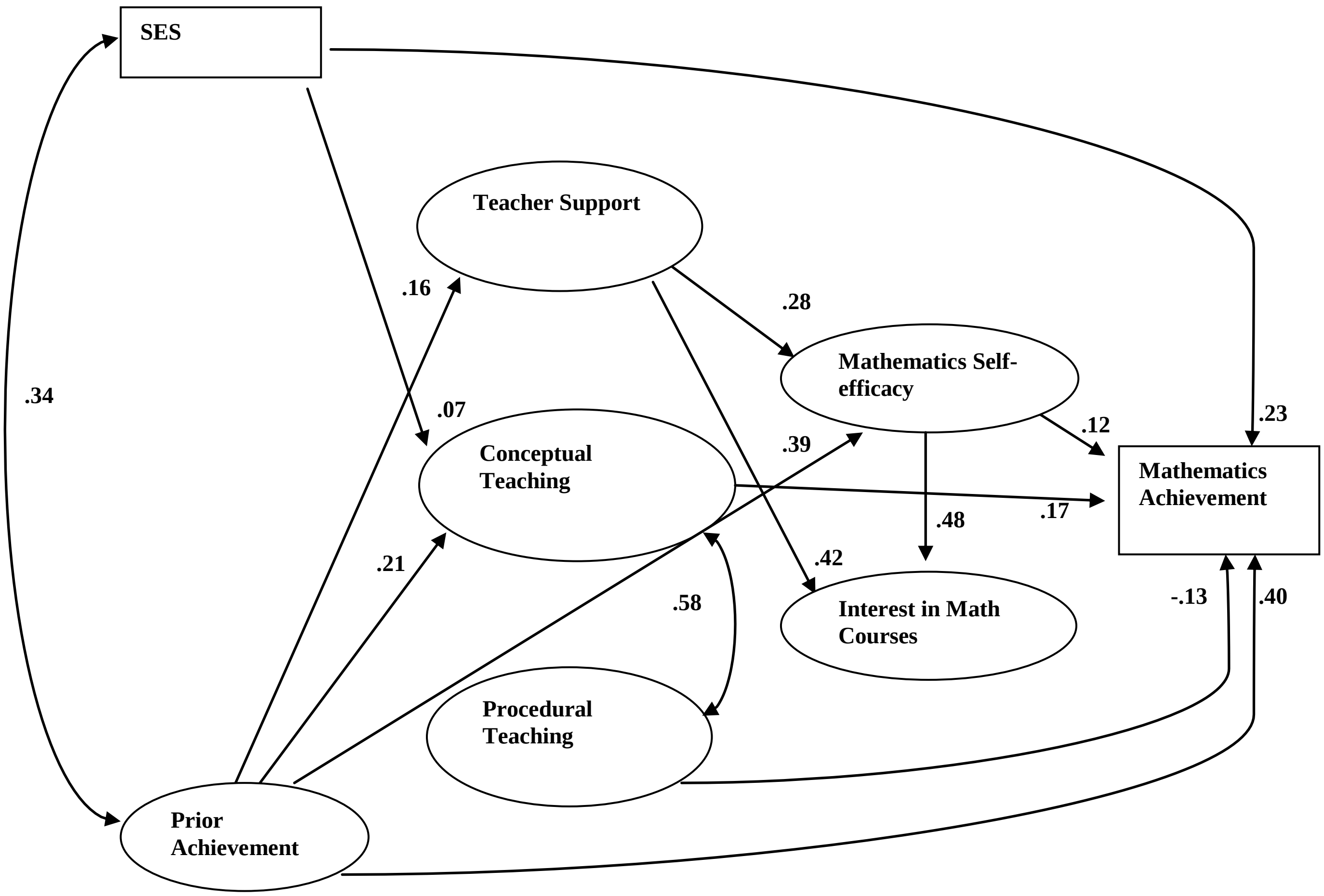

Figure 4. Final Structural Model

The results of the relationships between teacher classroom practices, student motivation, and student mathematics achievement are summarized in three parts: the effects of student background (including SES and prior achievement), the effects of teacher classroom practices (including teacher support, conceptual teaching, and procedural teaching), and the effects of student motivation (mathematics self-efficacy and interest). The path coefficients are presented in Table 14.

Effects of SES and prior achievement. As shown in Figure 4, SES had significant positive influences on conceptual teaching (β=.07) and student mathematics achievement (β=.23). The results indicate that students with higher level of SES were more likely to have teachers who emphasize conceptual understanding of mathematics content. Students with higher level of family SES were also more likely to attain higher mathematics achievement in 9^{th} grade. Prior achievement was positively related to teacher support (β=.16), conceptual teaching (β=.21), mathematics self-efficacy (β=.39) and mathematics achievement (β=.40). These results indicate that students who obtained higher mathematics and science achievement in 8^{th} grade were more likely to perceive higher levels of teacher support and were more likely to have a mathematics teachers who emphasize conceptual understanding in 9^{th} grade mathematics classroom. They also tended to have higher levels of mathematics self-efficacy, and gained higher mathematics achievement in 9^{th} grade.

Effects of teacher support, conceptual teaching, and procedural teaching. As shown in Figure 4, teacher support had substantial influence on student mathematics self-efficacy (β=.28) and interest (β=.42), but no significant direct effect on mathematics achievement. Nevertheless, teacher support influenced student mathematics achievement indirectly through mathematics self-efficacy. The indirect effect of teacher support on student mathematics achievement was .03.

Conceptual and procedural teaching had no significant influence on student mathematics self-efficacy and interest, but they influenced student mathematics achievement significantly. After controlling for family SES, prior achievement, teacher support, self-efficacy, and interest in mathematics courses, conceptual teaching had positive influence on student mathematics achievement (β=.17) while procedural teaching had negative influence on student mathematics achievement (β=-.13).

Effects of mathematics self-efficacy and interest. After controlling for SES, prior achievement, conceptual and procedural teaching, mathematics self-efficacy had significant positive influences on student mathematics achievement (β=.11) and interest in mathematics courses (β=.48). Interest had no significant influence on mathematics achievement. The results indicated that students with higher levels of mathematics self-efficacy were more likely to attain higher mathematics achievement and have higher levels of interest in mathematics courses.

Table 14
Standardized Path Coefficients for the Final Structural Model

Parameters	Coefficient	t-statistic
SES—Conceptual teaching	.07*	5.79
SES—Mathematics achievement	.23*	23.99
Prior achievement—Teacher support	.16*	12.83
Prior achievement— Conceptual teaching	.21*	15.57
Prior achievement— Mathematics self-efficacy	.39*	30.14
Prior achievement— Mathematics achievement	.40*	27.08
Teacher support—Mathematics self-efficacy	.28*	25.32
Teacher support—Interest	.42*	39.65
Conceptual teaching— Mathematics achievement	.17*	12.06
Procedural teaching— Mathematics achievement	-.13*	-8.93
Mathematics self-efficacy—Interest	.48*	45.37
Mathematics self-efficacy— Mathematics achievement	.12*	11.68

Note: *, p< .05

In summary, there are three notable findings of the present study. First, teacher support had substantial influence on student mathematics self-efficacy and interest in mathematics courses. It also had slightly indirect influence on mathematics achievement through mathematics self-efficacy. Second, conceptual teaching had a slightly *positive* influence, while procedural teaching had a small *negative* influence, on student mathematics achievement. Third, family SES and student prior achievement were associated with teacher classroom practices. Students with higher levels of family SES and prior achievement were more likely to have teachers who used conceptual teaching strategies. Students with higher prior achievement were more likely to perceive higher levels of teacher support.

Chapter 5 Discussion and Conclusion

The purpose of this study was to examine the influences of teacher classroom practices on 9th grade students' mathematics achievement, and the mediation effects of self-efficacy and interest on the relationships between teacher classroom practices and student achievement. Structural equation modeling method was used to analyze the relationships among variables. This chapter presents the summary of findings, discussion, implications, significance of the study, limitations, directions for future research, and conclusions.

Summary of Findings

The present study presented a complex model of mathematics achievement, which includes both teacher classroom practices and student characteristics. A two-step structural equation modeling approach was used to estimate the hypothesized model. In the first step, the measurement model was tested to examine how the latent variables were measured by sets of items. Six latent variables were included in the hypothesized measurement model: student prior achievement, teacher support, conceptual teaching approach, procedural teaching approach, mathematics self-efficacy, and interest in mathematics courses. Results showed that these latent variables were adequately reliable and valid.

In the second step, the structural model was tested to estimate the path coefficients in the hypothesized model and examine how the model fit with the data. The structural model analyses started with a very saturated model, indicating a somewhat exploratory nature of the study. Many prior studies have shown some patterns of relationships among personal, psychological, and school variables. The initial hypothesized model was based on relationships shown in earlier studies, and thus showed all hypothesized relationships. The initial model was conceived with all earlier exogenous and endogenous latent variables assumed to affect the later endogenous variables. Some post hoc changes were made which were theoretically acceptable. These changes although theoretical acceptable, should be tested further with new data. These points are further elaborated in the discussion section.

Results showed that teacher classroom practices influenced student mathematics achievement in different ways. First, teacher support positively and indirectly influenced student mathematics achievement through student mathematics self-efficacy. Conceptual teaching approach had a direct positive influence, while procedural teaching approach had a direct negative influence, on student mathematics achievement. Moreover, teacher support had a substantial positive influence on student mathematics self-efficacy and interest in mathematics courses. In addition, family SES and student prior achievement were associated with teacher classroom practices. Students with higher levels of family SES and prior achievement were more likely to have teachers who use conceptual teaching strategies. Students with higher achievement levels in 8^{th} grade were more likely to perceive higher levels of teacher support in 9^{th} grade.

Discussion of Findings

The findings of this study are organized in three parts and presented in the sequential order of the constructs in the model: effects of family SES and student prior achievement, effects of teacher support, conceptual and procedural teaching, and effects of mathematics self-efficacy and interest in mathematics courses.

Effects of family SES and prior achievement

Family SES. Family SES is an important background variable in student learning (Sirin, 2005). Because of SES's persuasive and persistent effects on student achievement, one of the hypotheses of this study is that students with higher levels of family SES are more likely to have effective teachers. The results showed that there was slight but significant association between SES and conceptual teaching. On the other hand, there was no significant relationship between SES and procedural teaching. This result confirms earlier findings about unequal educational opportunities for students based on family SES (Akiba, LeTendre, & Scribner, 2007; Darling-Hammond, 2006; Lubienski, 2000, 2002; Lubienski & Shelley, 2003). Despite various reform efforts of several decades, the achievement gap between different ethnicity and SES groups has persisted. As many other studies have suggested, this gap is related to unequal distribution of opportunities to learn and unequal number of effective teachers that students in lower SES schools have to access (Sirin, 2005). This finding supports the argument that SES determines the kinds of school and classroom environment to which students have access. The present study shows an observed association between SES and the type of teaching a student is exposed to and confirms that students have differential opportunities to learn mathematics. Several studies showed that the opportunities students have to access high quality teachers varied by SES (Akiba et al., 2007; Reynolds & Walberg, 1992; Wenglinsky, 2002).

Another hypothesis of this study is that students with higher family SES were more likely to attain higher mathematics achievement. The results of the present study confirmed this hypothesis in 9th grade mathematics classroom. Family SES influences students' academic performance in many ways. First, parents provide learning resources that are necessary for students to succeed in school, for example, family literacy and learning activities (Hattie, 2009). Second, parents' expectations for their children facilitate student motivation, aspiration, and engagement in learning (Davis-Kean, 2005). Third, parental involvement in everyday academic life also enhances student achievement (Hong & Ho, 2005). This study confirms the continued positive effects of family background on student achievement (Sirin, 2005). Thus, family SES has a direct effect on mathematics achievement due to family activities and interactions. It also determines the extent to which students have the opportunities to learn mathematics in school. This finding provides a reasonable explanation of a very large gap in mathematics achievement based on family resources and racial background.

Prior achievement. The strongest explanatory variable in any model of achievement is the previous achievement (Hattie, 2009). Prior achievement encapsulates all the factors that led to previous success and will continue to affect later success. Same factors (e.g., family resources, personal characteristics, and school contexts) that led to previous academic success will continue to affect later success. In the present study, prior achievement was hypothesized to influence the perception of teacher support, the opportunities to have mathematics teachers who use conceptual or procedural teaching strategies, student mathematics self-efficacy, interest in mathematics courses, and mathematics achievement. Prior achievement was measured by the final grades of students' most advanced mathematics and science courses in 8^{th} grade.

First, the results showed that as hypothesized, prior achievement had significant and positive influence on students' perception of teacher support. Students who had higher academic performance in 8^{th} grade generally were more likely to report higher levels of teacher support in 9^{th} grade. It is possible that students who had higher previous achievement were more likely to have positive views of teachers due to earlier positive interactions with teachers. It is expected that good students tend to develop good relationships with teachers and teachers are likely to respond more positively to good students in the classroom. Additionally, just as teacher practices influence student performance, student performance also influences teacher attitude and pedagogy. Previous studies reported that student performance could influence teacher practices in elementary school and preschool. For example, Skinner and Belmont (1993) found reciprocal effects between teacher behavior and student engagement in elementary school—teacher behaviors of structure, autonomy support, and involvement influence student behavior and emotional engagement, which in turn also affects subsequent teacher involvement, structure, and autonomy support behaviors. Curby, Downer, and Booren (2014) reported that there is a bidirectional relationship between teacher support and student engagement in preschool. The present study confirmed that student performance could influence teacher practices in high school.

Second, this study found that there was positive relationship between students' prior achievement and teachers' conceptual teaching strategies. It is possible that good students in advanced mathematics courses are assigned to good teachers. Another reason is that students who attained higher grades in 8^{th} grade had high-quality teachers in middle school, and they continued to have high-quality teachers in high school. It is also possible that teachers are more likely to focus on conceptual understanding and high-order thinking skills for high-achieving students. Previous studies found that teachers use conceptual instruction more with high-achieving students than with low-achieving students (Desimone et al., 2005). The present study provides empirical support for the relationship between student achievement and types of pedagogy a teacher is likely to use in the classroom.

Third, prior achievement had a significant positive influence on students' mathematics self-efficacy. Specifically, students who obtained high grades in 8^{th} grade mathematics and science courses tended to have higher levels of mathematics self-efficacy in 9^{th} grade. This result was well expected since the social cognitive theory has explained the role of past performance in developing individuals' self-efficacy (Bandura, 1997). The development of efficacy in a specific subject is highly related to previous achievement (Usher & Pajares, 2008). The prior success in mathematics provides the basis for later efficacy in mathematics. If students have learned mathematics successfully in the past, they are going to have stronger beliefs in their ability to learn mathematics. They probably will believe that they have the capability to understand the mathematics textbook, master skills in mathematics courses, and excel in mathematics assignment and exams. Previous studies repeatedly reported that prior success or mastery experience could boost student self-efficacy (Britner & Pajares, 2006; Lent, Lopez, & Bieschke, 1991; Usher & Pajares, 2008).

Fourth, the present study found an indirect effect of prior achievement on students' interest in mathematics courses. High-achieving students had more positive perceptions of teaching and higher levels of mathematics self-efficacy. In turn, positive perceptions of teaching and self-efficacy improved students' interest in mathematics learning. Previous studies found significant positive associations between student performance and attitudes toward mathematics in preschool and high school (Fisher et al., 2012; Ma, 1997). But the reasons why student ability influences the subject-related interest were not well studied. The present study provides one explanation of the process—teacher support and self-efficacy mediated the relationship between student performance and interest in mathematics courses. This finding is consistent with previous research in Australia that the influence of prior mathematics achievement on students' interest in statistical literacy was mediated by student self-efficacy (Carmichael, Callingham, Hay, & Watson, 2010).

In addition, the 8th grade mathematics and science achievement had substantial and positive influence on students' 9th grade mathematics achievement. It is consistent with previous research findings that student ability or previous performance is a significant predictor of future academic success (Casillas et al., 2012; Harackiewicz, Barron, Tauer, & Elliot, 2002; McKenzie & Schweitzer, 2001). As family SES and student ability are powerful predictors of student academic performance, we examined the effects of teacher classroom practices on student 9th grade mathematics achievement after controlling for students' prior performance and family SES.

Effects of Teacher Classroom Practices

Teacher support. In the present study, the three teaching related variables were teacher support, and conceptual and procedural teaching approaches. Teacher support was conceptualized as the emotional content of the relationships and interactions between students and teachers while the conceptual and procedural teaching approaches captured the classroom pedagogy and instructional strategies of mathematics teaching. Teacher support was hypothesized to influence student mathematics self-efficacy, interest in mathematics courses and mathematics achievement. Teacher support was measured by the following items: teachers value and listen to students' ideas, treat students with respect, think all students can be successful, think mistakes are fine as long as students learn, make mathematics interesting, and make mathematics easy to understand.

The results showed that teacher support had strong and positive influence on students' mathematics self-efficacy and interest in mathematics courses, but no significant direct effect on student mathematics achievement. The significant link between the perceived teacher support and mathematics self-efficacy supports the premise that the social environment significantly influences the development of self-efficacy (Bandura, 1997). When students are in a teaching-learning environment that supports their cognitive development, provides emotional support for mastering challenging materials, and treats them with respect, they are more likely to have control over their learning and have a strong sense of their mathematics abilities. This finding is also aligned with the self-determination theory and attachment theory. These theories indicate that supportive teacher-student relationships satisfy students' basic need of relatedness and enable students to feel safe and secure in the learning environment (Bowlby, 1988; Ryan & Deci, 2000). When students feel related to teachers and have secure relationships, they are more likely to explore the learning environment and take challenges with confidence. In addition, this finding is consistent with the previous research on teacher support that was conducted in elementary and middle schools in the U.S. (Patrick et al., 2007; Sakiz et al., 2012).

Teacher support was also found to have powerful influence on student interest in mathematics courses. In a supportive classroom environment where students are encouraged to think critically and their ideas are valued, they are more likely to develop interest in learning the course content. On the other hand, if students perceived their mathematics teachers as unsupportive and felt marginalized by the classroom climate, it is more likely that their interest in mathematics courses would be eroded. Hidi and Renninger (2006) proposed that external support from peers and teachers could facilitate the development of individual interest. The present study provided evidence that the affective and academic support from mathematics teachers develop students' interest in high school mathematics courses. Plenty of studies have reported the influence of teacher support on student engagement, school adjustment, subjective well-being and motivation (Klem & Connell, 2004; Reddy, Rhodes, & Mulhall, 2003; Wentzel, 1998). But little is known on the relationship between teacher support and students' subject-related interest. The present study extended our understanding of how teachers facilitated the development of student interest in mathematics courses.

Although teacher support did not influence student mathematics achievement directly, it influenced mathematics achievement indirectly through mathematics self-efficacy. This study identified the mechanism of how teacher support influences mathematics achievement. The finding shows positive teacher-student relationship helps to build the mathematics self-efficacy of students, which in turn influences mathematics learning of students. The positive interaction between teacher and students will lead to students' stronger beliefs in their cognitive capability to master the course content, which in turn supports their achievement in mathematics. This finding confirms Bandura's (1997) theory that verbal persuasion supports the development of self-efficacy, which in turn influences people's task performance. Similar findings were reported in previous studies. For example, Patrick et al. (2007) found that teacher emotional support influenced elementary school students' engagement indirectly through academic self-efficacy. More specifically, when students felt a strong sense of emotional support from their teachers, academic support from their peers, and encouragement from their teachers to discuss their work, they were more likely to have mastery goals, strong beliefs of their capabilities in learning, and improved social efficacy; consequently, they had more task-related interactions with teachers and peers, and finally had higher levels of achievement (Patrick et al., 2007).

Conceptual and procedural teaching. One of the important questions this study explored was the relative influence of conceptual and procedural approaches to mathematics teaching. In the past 25 years, the teaching of mathematics became the subject of heated controversies in the U.S., which was known as the mathematics wars (Schoenfeld, 2004). The mathematics war was triggered by the standard-based mathematics launched by NCTM in 1989 (Schoenfeld, 2004). Standard-based mathematics was significantly different from traditional mathematics in both mathematical content and instructional approaches (Klein, 2003). It had a strong call for developing students' conceptual thinking and de-emphasizing manual arithmetic, while traditional mathematics was in favor of developing students' procedural fluency (Klein, 2003). The recent Common Core State Standards takes a more balanced view—conceptual understanding, problem solving, and procedural fluency are all critical to mathematical proficiency (Common Core State Standards Initiative, 2010). Although the instruction that emphasized conceptual thinking and problem solving skills was supported by policy makers and researchers, it was criticized by the public (Klein, 2003). Parents worried their children were getting unsound education from the math reform.   Therefore, empirical research was needed to examine whether the new teaching method could improve students' mathematics achievement. In view of the current debate on the sound pedagogical approaches to teach and improve math learning, the present study posed an important question about the relative influence of conceptual and procedural approaches on mathematics learning in high school.

In the present study, conceptual and procedural teaching approaches were hypothesized to influence students' mathematics self-efficacy, interest in mathematics courses, and mathematics achievement. Conceptual teaching was assessed by mathematics teachers' report of their emphasis on a set of instructional goals, for example, students' interest, mathematics concepts, and developing problem-solving skills. Procedural teaching was measured by mathematics teachers' emphasis on another set of teaching goals, for example, mathematics algorithms, procedures, and computing skills.

The results of this study showed that conceptual teaching had a significant positive correlation with student mathematics achievement while procedural teaching had significant negative correlation with student mathematics achievement after controlling for family SES, student prior achievement, teacher support, self-efficacy and interest. This is an important finding both for theoretical and practical reasons. Based on the nationally representative recent data, this study supports the importance of conceptual approach to mathematics teaching. It also builds a framework for further theoretical thinking on how and why emphasis on conceptual understanding supports and scaffolds learning in mathematics, and how the two approaches are interwoven. It further poses new questions such as how conceptual understanding works to improve mathematical skill building and problem solving.

When teachers place more emphasis on developing problem solving skills, reasoning mathematically, connecting mathematics ideas, understanding logical structure of mathematics, and explaining mathematics ideas effectively in 9^{th} grade classrooms, students were more likely to attain higher grades in mathematics exams. On the contrary, when teachers focused on students' speedy and accurate computation, computation skills, standardized test preparation, mathematics algorithms and procedures, students were likely to obtain lower grades. It is important to note that a conceptual approach to mathematics teaching is not mutually exclusive to necessary skill building in mathematics learning. It is more of a matter of overall framework and approach to mathematics teaching. This finding is consistent with the results of previous international studies. In the countries where teachers used conceptual teaching strategies (e.g., Japan), 8^{th} grade students achieved higher grades in mathematics exams. In the countries where teachers used procedural teaching methods (e.g., the U.S.), students achieved lower grades in mathematics exams (Desimone et al., 2005; Stigler & Hiebert, 1997).

In the U.S., a majority of students took algebra I or geometry courses in 9^{th} grade. According to the Common Core State Standards Initiative (2010), these two courses require students to have a deep understanding of mathematical contents, master procedural skills, and attain problem solving ability. For example, the algebra course requires students to understand the logic and structure of expressions, perform arithmetic operations with polynomials and rational functions, reason with equations and inequalities, and solve practical mathematics problems. In order to achieve these standards, students need to be challenged to make sense of mathematical ideas through explorations and projects. Focusing on low-level skills, such as computational skills, is not effective in improving student mathematical proficiency and test grades in high school (Richland, Stigler, & Holyoak, 2012).

Conceptual understanding and procedural proficiency are critical components of mathematics proficiency (National Research Council, 2001). The development of these two competencies are interwoven (National Research Council, 2001). Conceptual understanding makes skill learning easier. Procedural skills deepen the understanding of mathematical ideas and help in solving mathematical problems (National Research Council, 2001). The present study found that there was a moderate but significant correlation between conceptual teaching and procedural teaching approaches, which indicates that these two teaching methods were not isolated in teaching practices. Although the present study found negative correlation between procedural teaching and student mathematics achievement, it does not indicate that procedural teaching is unimportant. It indicates that the type of teaching, which is solely focused on procedural skills, was detrimental for 9^{th} grade students. The procedural skills should be taught on the foundation of understanding of key mathematical concepts, making connections between mathematical ideas, and mastering of mathematical reasoning skills (NCTM, 2014).

The present study brings important empirical evidence in support of conceptual approach to mathematics teaching. Not only that, this finding also supports that the current shift in the mathematics community towards a more broader framework of teaching with focus on promoting students' conceptual thinking and problem solving skills is a step in the positive direction (Common Core State Standards Initiative, 2010; NCTM, 2000). This study shows that students are likely to have a better grasp of mathematical ideas and have higher mathematics achievement when teachers focus on students' conceptual understanding of the mathematics content.

However, the present study did not confirm the assumptions that conceptual and procedural teaching approaches influenced students' mathematics self-efficacy and interest in mathematics courses. There was no significant relationship between these two teaching methods and student mathematics self-efficacy or between the two teaching methods and interest in mathematics courses. One reason for the insignificant correlations is that the constructs were reported by different groups: conceptual and procedural teaching were reported by mathematics teachers; mathematics self-efficacy and interest in mathematics courses were reported by students. Usually measures from different groups have lower association than measures from the same group. Although teachers reported that they emphasize conceptual understanding in practice, they may not do it as well in practice as they reported in the survey. Another explanation is that the effect of mathematics instruction on students' motivational beliefs may take some time to become apparent. In this study, we used cross-sectional data, so the long-term effects of conceptual and procedural teaching were not obvious.

Effects of Mathematics Self-efficacy and Interest in Mathematics Courses

Mathematics self-efficacy. Self-efficacy refers to people's beliefs of their ability in achieving a goal or outcome (Bandura, 1977). It determines whether coping behavior will be initiated, how much effort will be expended, and how long it will be persisted in the face of difficulties (Bandura, 1977). In general self-efficacy has been associated with task performance in both short and long term studies (Multon et al., 1991; Valentine et al., 2004). In the present study, mathematics self-efficacy was hypothesized to influence student interest in mathematics courses and their mathematics achievement. The following items measured self-efficacy in the present study: students believe that they can do well in mathematics assignments and tests, understand mathematics textbooks, and master skills in mathematics courses.

The results indicated that students' mathematics self-efficacy had strong influence on students' interest in mathematics courses. Students who expected that they could do well in mathematics were more interested in mathematics courses than students who did not. This is an interesting finding with implication for pedagogy. The pedagogical strategies that could foster students' self-efficacy in mathematics will finally improve their interest in mathematics courses. Bandura (1997) proposed that self-efficacy influences the development of academic interest; at least a moderate perceived efficacy is required to generate and sustain interest in an activity. In the present study, most students showed moderate or high levels of confidence in their capabilities in mathematics. They also had moderate levels of interest in mathematics courses. Research in vocational psychology has repeatedly shown that there is moderate correlation between vocational self-efficacy and interest (Lent, Brown, & Hackett, 1994; Rottinghaus, Larson, & Borgen, 2003). But few studies have been conducted in educational psychology to investigate the relationship between self-efficacy and interest in a specific subject. The present study extended our understanding of the relationship between these two important constructs that are related to mathematics achievement in direct and indirect ways.

Consistent with expectation, students who reported greater level of mathematics self-efficacy were likely to obtain higher achievement in mathematics. This finding is in accordance with previous research that subject-specific self-efficacy had a positive relation with student academic achievement (Pajares, 1996). Students with higher self-efficacy are more likely to choose challenging activities, make more effort to succeed, and persist longer on difficult tasks. Those learning behaviors lead to overall higher achievement (Bandura, 1997).

Interest. Interest is a relational construct that consists of a more or less enduring relationship between a person and an object (Krapp, 2002). Two types of interest have been suggested by scholars: situational and individual interest (Schiefele, 2009). Situational interest is a temporary state that is aroused by an object, task, or situation. On the contrary, individual interest is a relatively stable orientation towards certain domain (Schiefele, 2009). In the present study, interest in mathematics courses is a relative enduring affective and cognitive orientation towards mathematics courses. It was measured by the items that students enjoy mathematics courses, think mathematics course is a waste of time, and think mathematics course is boring.

Interest was hypothesized to influence mathematics achievement positively. However, the present study found that the correlation between interest and achievement was insignificant after controlling for SES, prior achievement, teacher support, conceptual teaching, procedural teaching, and mathematics self-efficacy. One possible reason is that interest may influence student achievement indirectly through other variables, such as engagement in learning activities. Previous studies showed that interest is not a direct predictor of achievement rather it influences student performance through mediating variables, such as course selection and mastery goals (Harackiewicz, Durik, Barron, Linnenbrink-Garcia, & Tauer, 2008; Köller, Baumert, & Schnabel, 2001). Moreover, two items on interest were negatively worded—*student thinks mathematics course is a waste of time* and *student thinks mathematics course is boring*. These items may not have fully captured the construct of interest.

Another possible reason is that the relationship between interest and academic achievement has been affected by other factors. For example, when students' learning behaviors are primarily driven by external values, such as exams, interest becomes a less important antecedent of mathematics achievement (Köller et al., 2001). The accountability system places high value of standardized test on student learning in recent years. For example, the NCLB Act requires states to test students from 3rd to 8th grade in reading and math, and once again in high school (No Child Left Behind, 2002). These standardized tests were used to measure student progress. When these standardized tests motivate students to learn and become important factors in teaching through the school year, there is no room for interest to initiate and maintain learning behaviors.

Interest is an important variable that may have some reciprocal effects with other personal and school context variables, such as self-efficacy, self-regulation, and classroom practices (Rottinghaus et al., 2003). These interesting relationships should be investigated in future research.

In summary, the findings of the present study highlighted the roles of teachers played in students' success in mathematics. Teachers' affective and academic support could improve students' mathematics achievement indirectly through enhancing students' beliefs about their mathematical capabilities. Conceptual teaching approach could improve 9th grade students' mathematics achievement. The teaching that purely focused on students' procedural fluency was detrimental to 9th grade students' mathematics achievement. Family SES and prior achievement were associated with the opportunities that students had to access high quality teachers.

Implications

The findings of the present study have both theoretical and practical implications. First, the findings support that mathematics learning is a complex process, which is mediated by many personal, psychological and school level of factors. The present study confirms some previous findings: family SES and prior achievement are strong predictors of student academic achievement; prior achievement and teacher support are significant sources of self-efficacy; self-efficacy predicts student achievement. More important, this study also provides some new insights in mathematics learning: family SES and prior achievement affect the chance of exposure to conceptual teaching environment. This finding in line with other studies that have explored opportunities to learn (OTL) based on differences in SES and race. The present study also found the importance of teacher-student relationship and pedagogy in mathematics learning: conceptual teaching approach influences student mathematics achievement positively while procedural teaching approach influences student mathematics achievement negatively; teacher support and self-efficacy facilitate the development of interest in mathematics course. These findings clarify and support a stronger theory of mathematics learning, and create a better framework for understanding mathematics learning. The study findings highlight some important practical and theoretical implications.

Second, the findings support the current pedagogical changes in mathematics education. For a long time the mathematics instruction in the U.S. was described as "a mile wide and an inch deep". Teachers tried to cover too many topics and focused on the practice of procedures in the mathematics classrooms. This kind of learning environment made it hard for students to gain a deep understanding of the mathematical content. International studies found that in high-achieving countries, teachers covered fewer topics and focused on developing students' high-order thinking skills. Therefore, the U.S. math reforms imported the "conceptual teaching" models from high-achieving countries. The "conceptual teaching" models called for teachers to develop students' conceptual understanding and problem solving skills (Common Core State Standards Initiative, 2010; NCTM, 2000). Although the math reform was supported by the policy makers and researchers, it has been criticized by the public (Klein, 2003). The present study provides empirical evidence that the pedagogical change is beneficial for student mathematics learning. When the teaching focused on the understanding of key concepts, problem-solving skills, mathematical reasoning, connecting mathematical ideas, logical structure of mathematics, history and nature of mathematics, and explaining mathematics ideas effectively, students' mathematics achievement improved. This finding suggests that teacher professional development programs could help teachers to develop conceptual teaching skills.

Third, the present study suggests potential strategies for motivating students in mathematics. Motivation is key to academic success. Students with strong motivation are likely to engage in mathematics activities, take challenges, make an effort, and persist longer when facing difficulties. However, many U.S. students view mathematics as hard, boring and irrelevant, and do not have sufficient motivation in learning mathematics. In this case, how to improve student motivation for learning mathematics is a challenge for teachers. This study found that teacher support had substantial influences on student mathematics self-efficacy and interest in mathematics courses. When teachers respect students, value and listen to students' ideas, treat students fairly, expect students to be successful, think mistakes are fine as long as students learn, and make mathematics interesting and easy to understand, students will feel confident about their ability and be interested in mathematics courses. This finding has implications for the practice of improving student motivation in mathematics.

Significance of the Study

This study makes a significant contribution to the literature on mathematics achievement in high school. First, it confirms some of the previous findings with more rigorous methods. More specifically, it highlights the role of teacher support in improving student achievement. Teacher support was a strong predictor of student mathematics self-efficacy and interest in mathematics courses, and mathematics self-efficacy subsequently affected student mathematics performance. It also provides empirical evidence for the importance of conceptual teaching, which was positively related to student achievement. Moreover, it suggests the probable reciprocal relationship between teacher instructional practices and student achievement. Students with higher prior achievement were more likely to have teachers who use conceptual teaching strategies. Often more effective and experienced teachers were assigned to students with high abilities and achievement. The better teaching further improved achievement, creating a positive cycle. In addition, this study explains one way how family SES influences student achievement. Students from families with higher SES were more likely to be concentrated in schools with better resources and more effective teachers. Effective teachers further improved students' achievement.

Second, the HSLS: 09 data has a nationally representative sample. It is one of the most recent dataset, which captures new changes in student achievement patterns and teacher classroom practices. Therefore, the findings of the study have significant implications for practice, and are relevant to the current debate in mathematics teaching and learning. The present study provides a dynamic picture of the process of mathematics achievement, showing an interaction of many family, personal, and school effects. This study has two major practical implications: stronger conceptual approach to mathematics teaching, and positive classroom environment of caring and respect to increase student motivation. This study provides support for a theoretical model of mathematics learning—a complex process with interlinks between opportunity to learn, family background, and personal characteristics with many interacting and reciprocal effects. These findings further clarify how supportive relationships affect achievement and can enhance student interest in mathematics courses.

Third, we incorporated factors that influence student mathematics achievement from two domains: teacher practices and student psychological characteristics. Often the achievement models either focused on student characteristics or school and classroom variables. The model in the current study hypothesized the relationships among the two domains and mediation effects of student characteristics on the links between teaching practices and student achievement. Thus, the model presented a more complex view of achievement, including both teacher variables and student characteristics. The study has both theoretical and practical significance.

Limitations of the Study

Along with the significance, there were several limitations of this study. First, the self-reported data by teachers on teaching goals and instructional practices is likely to contain desirability bias. Although mathematics teachers reported that they placed moderate to high emphasis on conceptual understanding and problem solving goals, they may assign different meanings and interpret the conceptual and procedural approaches differently, and thus their reporting may be biased.

Second, the variables that are included in the hypothesized model were reported by different groups. Conceptual and procedural teaching approaches were reported by mathematics teachers. Perception of teacher support, mathematics self-efficacy and interest in mathematics courses were reported by students. The associations between variables that were reported by different groups often are not as strong as the associations between the measures from the same group. Despite this limitation of the data, results showed significant relationships in the expected direction. It is probable that data from same units will exhibit higher correlations and stronger effects.

Third, the present study used cross-sectional data, so a strong inference cannot be made for the likely casual relationships between variables. It may be that teacher classroom practices influence student mathematics achievement, or it may be that teachers were more likely to support students and use conceptual teaching when they have high-achieving students. The direction of influence is hard to determine statistically using cross-sectional data, except on the basis of theory. Despite the strengths of the conceptual model presented in the current study, only tentative causal inferences can be drawn based on cross-sectional data. Cross-sectional data provides a snapshot while longitudinal data can show patterns of growth and change.

Fourth, this study used extant data. The extant data often provides limited or one-dimensional measurement of complex constructs. For example, the conceptualization of interest in this data was one-dimensional, students' feeling about mathematics course. More complex conceptualization and operationalization of interest could provide better understanding of the relationship of interest to learning. Many educational studies have a very small or non-significant relationship of interest to achievement, which is probably because of the one-dimensional items used to measure interest.

Directions for Future Research

This study provides some directions for future study. First, hierarchical linear modeling method could be used to analyze the data with hierarchical structures. The data used for the present study (HSLS: 09) has a nested structure—the outcome variable student mathematics achievement was measured at the individual level, and the key explanatory variables conceptual and procedural teaching were measured at the classroom level. However, no student-teacher link variable was provided in the HSLS:09 data, so we cannot use the hierarchical linear modeling method to decompose the relationship between variables into separate student and class level components (Raudenbush & Bryk, 2002). Hierarchal linear modeling methods could be used to take into account within-classroom variability and between-classroom variability in explaining student academic performance in future studies (Raudenbush & Bryk, 2002).

Second, longitudinal studies could be conducted to examine the effects of teacher classroom practices on student motivation and achievement over time. In the present study, teacher classroom practices and student motivation were measured at the same time period. A significant relationship between conceptual teaching and student motivation was not evident. The effects of instructional practices on student motivation may take time to become apparent. So, future studies could measure teaching strategies and student motivation at different time points to explore the long-term influences of instructional practices on student motivation.

Third, subject-related interest is usually considered to be an important antecedent of academic success. However, student interest in mathematics courses did not show significant influence on student mathematics achievement in the present study. The relationship between interest and student learning is very complicated. Some potential moderators may influence the relationship between interest and performance such as the instructional context (Köller et al., 2001). Future studies could examine the relationship between interest and academic performance in different contexts, such as traditional lecture classes and active learning classes.

Fourth, the relationships in the model should be investigated further, using different samples and different groups based on SES, race, and gender. Previous research suggested that there are persistent achievement gaps among different ethnic and SES groups (Hemphill, & Vanneman, 2011; Vanneman, Hamilton, Baldwin Anderson, &Rahman, 2009), so the comparison of hypothesized models across different ethnic groups should be conducted in future studies.

Fifth, it would be important to further explore these relationships within classrooms where objective measures of classroom teaching are available. In this study, the insignificant associations between conceptual teaching approach and self-efficacy/interest may be due to the subjective measure of teacher classroom practices. Observations of actual classroom activities may yield different findings.

Conclusions

A large number of U.S. students are not mathematically proficient (NCES, 2013). How to improve student mathematics achievement is a national concern. The mathematics reforms call for changes in both mathematics curriculum and pedagogy. The present study explored the influences of teacher classroom practices on 9^{th} grade students' mathematics achievement, specifically focusing on teacher support and two instructional methods—conceptual and procedural teaching. The results revealed that teacher support played an important role in influencing student mathematics self-efficacy and interest in mathematics courses. Teacher support also influenced student mathematics achievement indirectly through student mathematics self-efficacy. With respect to instructional practices, the findings highlighted the importance of conceptual approach to mathematics teaching. In addition, family SES and prior achievement were associated with teacher classroom practices.

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