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Relationships of home, student, school, and classroom variables with mathematics achievement

By

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Relationships of home, student, school, and classroom variables with mathematics achievement

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This study used the TIMSS 2011 International Database to investigate predictors of 8th-grade mathematics achievement across three countries that represent a wide range of cultures and levels of mathematics achievement: Chinese Taipei, Ghana, and the United States. A review of literature on predictors of mathematics achievement yielded variables in four major contexts of learning—a student's home, beliefs, school, and classroom. The variables of home that were investigated are home possessions for learning, parent education, and parents' expectations and involvement in their children's education. The variables of student beliefs were self-confidence in mathematics and the value of mathematics. The variables of school were school climate, school resources, administrator leadership, and school socioeconomic status. Finally, the variables of the classroom are access and equity, curriculum, tools and technology, assessment, and teacher professionalism.

A 2-level hierarchical linear model was used to investigate relationships between the predictors for learning mathematics and 8th-grade mathematics achievement. Level 1

represented the relationships among the student-level variables, and Level 2 represented the school-level variables.

In Chinese Taipei, statistically significant predictors of mathematics achievement in the final model included variables from the domains of home resources, student beliefs, school climate, and school socioeconomic status. In Ghana, both student-beliefs variables had statistically significant relationships with mathematics achievement, and one school climate and one school socioeconomic status variable each was found statistically significant. The U.S. had statistically significant predictors in the domains of home resources, student beliefs, school socioeconomic status, classroom-level access and equity, classroom assessment, and teacher professionalism.

This study extends previous research in several ways. It includes a review of classic and recent literature regarding predictors of mathematics achievement; 17 scales using the Rasch partial credit model were developed to measure predictors of mathematics achievement; and the results of this study may be used to examine the relationships between the independent variables of this study and middle-grades mathematics achievement in countries similar to the 3 in this study to reinforce and support variables that contribute to student achievement.

DEDICATION

My most fulfilling roles in life have been being a wife to Andy and mother to Bethany and Jonathan. From a child's age, I wanted to be a minister's wife because of the fulfilling life I enjoyed growing up in a minister's family. It did come to pass that I found a man with whom I wanted to spend my life, and he became a minister of the gospel. Andy and I were just two of us for our first four years of marriage, and then we were four for a couple of decades, loving and teaching Bethany and Jonathan to hopefully become fruitful adults. As a ministering couple, we dedicated our lives to serving those in need and encouraging all.

As our nest became less populated with children grown and moved away, I worked part time as an afterschool lead teacher and began a master's program with the goal of supervising teacher interns. When I graduated with a master's degree two years later, I had a fulltime university staff position which included supervising teacher interns, but I immediately began a doctoral program with the new goal of being a university professor or whatever other opportunity a Ph.D. might provide. Even without children at home, life was busier for Andy and me, more focused on things other than each other than we had intended at this point in our marriage. We had looked forward to having more time to enjoy just being together with an empty nest than we were experiencing.

I shared our background in this document to lead to this: through seven years of my spending nights and weekends on coursework, research, and writing in addition to working part- or full-time, Andy never once complained about how my time and focus on graduate school affected his life or expectations. He cleaned and maintained the house, maintained the yard, did laundry, prepared meals when I couldn’t, cleaned and maintained my car, shopped for groceries, and so much more. He has only supported my efforts physically, mentally, emotionally, and spiritually.

Life does not pause for dissertations. It would be helpful at times if it did. Holidays, anniversaries, and birthdays come and go. Ball games, concerts, and movies are not even a consideration. Children move, get married, and change life directions. Parents age and pass into eternity. This dissertation is dedicated to the man, Andy Miller, who has been my support in my job, ministry, graduate courses, research, and family matters so that this work could be completed.

ACKNOWLEDGEMENTS

In my seven years of graduate work, I have benefitted from the support and encouragement of faculty, family, fellow students, and colleagues. Dr. Dana Franz recruited me for both my master's and doctoral programs. Throughout my graduate education, she has served as my advisor, professor, graduate coordinator, dissertation chair, and walking partner. Dr. David Morse served as my statistics professor and a member of my dissertation committee, but that description belies the impact he has had on my teaching, research, and writing. He knows he has been my *critiquer*, because I've asked him to review my large writing projects; he may not know I have looked to him as a research and teaching mentor. Dr. Dwight Hare served on my dissertation committee and was an exceptional professor/mentor for me and many others until his unexpected, but peaceful, passing from this life. Dr. Devon Brenner was an outstanding professor, department head, and dissertation committee member, always helpful, gentle, and kind while making me grow and be better. Dr. Sean Owen served as my manager and accepted my request to serve on my dissertation committee when Dr. Brenner accepted a position as an education policy fellow for the U.S. Senate. Dr. Jessica Ivy, as a new faculty member, accepted my request that she serve on my committee before she knew me personally.

Because most everything else in my life took a backseat to my job and school for the past seven years, my family and our gatherings received less attention from me than I wanted to give them. Holidays were more rushed and without my full attention. Extended family weddings and funerals were missed. Phone conversations were shortened. Cards and letters did not get written, much less sent. I appreciate my family's understanding and patience, and I now look forward to being fully present with them this Thanksgiving and beyond.

I had several schoolmates without whom statistics classes would have been much more difficult, and mathematics classes would have been impassable. Lina Trullinger, Sammy Sullivan, and I got through Dr. Morse's statistics courses with weekly study groups and shared Dropbox folders. Dr. Elizabeth Repsher and I got through mathematics courses with purposive scheduling, late night and weekend study sessions, and the class curve.

I'm glad to count many of my colleagues among my friends. In addition to those who have been mentioned already, Dr. David Shaw, Dr. Lori Bruce, Dr. John Giesemann, and Ashley Brown have been especially supportive to me in my coursework and research.

The one who I must acknowledge is the Lord. He has gotten me through every homework assignment, test, paper, project, course, and this dissertation. Even though I declined many opportunities for relaxation, companionship, and enjoyment in the last seven years, I made a personal commitment to the Lord that I would not decline an opportunity to serve him through serving others if confronted with it, and I would trust that he would not let me fail in my schoolwork because of it. It is a testimony to his faithfulness that I am submitting this completed dissertation.

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CHAPTER I

INTRODUCTION

Statement of Problem

Students should be provided opportunities to experience the elegance and richness of mathematics and to appreciate it as a valuable human capability. However, learning mathematics for its own sake is only one of the compelling reasons for its place in school curricula across cultures. Another major reason for mathematics' place as a fundamental component of education is the increasing demand for mathematical knowledge and skill in society and work. The demand for proficiency in mathematics or mathematical thinking in the workplace has surged with the advances of technology and global connectivity (Mullis, Martin, Ruddock, Sullivan, & Preuschoff, 2009).

Preparing students to excel in mathematics is one of the fundamental goals for education in countries around the world. Learning mathematics in the primary years of schooling prepares children to succeed in future educational endeavors and eventually in daily life and the workforce. Effective participation in society increasingly requires understanding of mathematics to make informed decisions about issues concerning personal well-being such as health and finance as well as about issues concerning public policy such as the environment and economy (Mullis et al., 2009).

What then are effective contexts and practices for facilitating the learning of mathematics from country to country? Are the contexts and practices universal, do they all vary from country to country, or are some stable across countries while others are variable?

Conceptual Framework

Because we are in an age of international comparisons of academic achievement worldwide and an era of emphasis on local school and teacher accountability for student achievement in the United States, this dissertation study sought to construct a model for three different countries to explain variation in mathematics achievement of their students that incorporates as many of the major contexts and predictors for learning as feasible. This study is framed on the conception that contributions to student achievement in mathematics come from four major sources: (a) students' families/homes, (b) the cultures in which students live and are educated, (c) the beliefs and engagement of the students themselves, and (d) the educational systems composed of schools, teachers, and learning environments with which students are associated (Carroll, 1963; Creemers, 1996; Schneider, 1985). Data from the Trends in Mathematics and Science Study (TIMSS) 2011 were analyzed to construct models for predicting achievement in eighth-grade mathematics in a range of cultures.

Previous studies have incorporated some combination of the sources of contributions to student achievement that this study incorporated (Goldhaber & Brewer, 2000; Wang, Osterlind, & Bergin, 2012). Using TIMSS 2003 data, Phan (2008) analyzed hierarchical linear models representing student variables, home variables, teacher variables, instructional practices, and school variables for predicting eighth-grade mathematics achievement in two developed countries and two developing countries. Results from that study indicated that an instructional practices model worked the best for the United States, a teacher background model was the most efficient model for predicting mathematics achievement in Egypt, and a combination model was the most efficient for predicting mathematics achievement in Canada and South Africa. Phan concluded that no one model best predicts mathematics achievement for every country and that policymakers and educators should use their country-specific findings to support their educational decisions. Preuschoff (2011) reported four global indicators of effective learning environments using data from TIMSS and Progress in International Reading Literacy Study (PIRLS) 2011: (a) effective school environments for learning to read, (b) effective home environments for learning to read, (c) effective classroom environments for learning mathematics, and (d) students' motivation to learn mathematics.

The conceptual framework of this dissertation study is based on the four contexts for learning and the 14 domains related to those contexts that were found in the review of literature. These 14 domains are measured by a total of 30 variables derived from TIMSS 2011 questionnaire items. Twelve of the 30 independent variables had previously been empirically derived and scaled from TIMSS 2011 questionnaire items that the author had selected to represent those constructs. Using principle components analyses (PCA), the author derived variables for the remaining 18 constructs from questionnaire items that had been selected to represent the constructs found in the review of literature. The pre-existing composite variables and the author-derived variables were scaled using the one-parameter IRT (Rasch) model and its extension, the Partial Credit Model (Bond & Fox, 2007). ConQuest Generalized Item Response Modeling Software (Wu, Adams, Wilson, & Haldane, 2007) was used to derive individual student scores for each latent variable.

In TIMSS 2011, students were nested within schools, a hierarchical structure. Therefore, two-level modeling with HLM 7 software was used to analyze the data. The four research questions were addressed for each of the three countries in the study.

The hierarchical linear modeling (HLM) began with an unconditional model (Model 1) with none of the independent variables included. Second, each of the three variables related to the context of the student's home were entered separately to construct Models 2-4. Third, Model 5 was constructed with all of the statistically significant home-related variables. Fourth, each of the two variables related to students' beliefs was entered separately to the unconditional model to construct Models 6 and 7. If both student-beliefs variables are indicated to be statistically significant, then a Model 8 was constructed with both the variables. All of the statistically significant variables at the student level (variables related to students' homes and beliefs) were included to construct Model 9, the full Level 1 (student level) model.

The Level 2 model was constructed by entering separately each of the nine school-related variables representing domains of school climate, school resources, administrator leadership, and school socioeconomic status to each country's full Level-1 model composed of all the statistically significant Level-1 predictors to examine the extent to which these school-related variables accounted for variance in students' mathematics achievement. First, the three school climate variables were entered separately into Model 9, creating Models 10-12. Then, all of the statistically significant school climate variables were entered into Model 9 to construct a combined school climate variables model (Model 13). The three school resources variables were entered separately into Model 9, creating Models 14-16. Then, all of the statistically significant school resources variables were entered into Model 9 to construct a combined school resources variables model (Model 17). Administrator leadership was measured with one variable, and it was entered singularly into Model 9 to create an administrator leadership model (Model 18). The three school socioeconomic status variables were entered separately into Model 9, creating Models 19 and 20. Then, all of the statistically significant school socioeconomic status variables were entered into Model 9 to construct a combined school socioeconomic status variables model (Model 21).Then, all of the statistically significant school-related variables were added to the full Level 1 model together to construct a combined school-related variables model (Model 22).

The 12 teacher- and classroom-related variables representing five domains of access and equity, curriculum, tools and technology, assessment, and teacher professionalism were entered into each country's full Level 1 model composed of all the statistically significant Level 1 predictors to examine the extent to which these teacher-related variables accounted for variance in students' mathematics achievement. The two access and equity variables were entered separately into Model 9, creating Models 23 and 24. Then, if both access and equity variables were statistically significant, they were entered into Model 9 to construct a combined access and equity variables model (Model 25). The two curriculum variables were entered separately into Model 9, creating Models 26 and 27. Then, if both the curriculum variables were statistically significant, they were entered into Model 9 to construct a combined curriculum variables model (Model 28).

Variables in the domain of tools and technology were not included in the HLM because questionnaire items comprising the two variables in the domain of tools and technology had a majority of non-responses in each country of this study. Because HLM uses complete cases, the sample size for each country would be reduced by more than half if these two variables were included in the HLM analyses. Therefore, those two variables were examined in separate exploratory models rather than being included in the HLM models of this study.

The two classroom assessment variables were entered separately into Model 9, creating Models 29 and 30. Then, if both classroom assessment variables were statistically significant, they were entered into Model 9 to construct a combined classroom assessment variables model (Model 31). The six teacher professionalism variables were entered separately into Model 9, creating Models 32-37. Then, all of the statistically significant teacher professionalism variables were entered into Model 9 to construct a combined teacher professionalism variables model (Model 38). Model 39 was constructed by entering all the statistically significant teacher-related variables to the full Level 1 model. All the statistically significant Level-2 school- and teacher-related variables were then entered into Model 9 to construct Model 40, the final two-level model.

Because these procedures were conducted for each of the three countries selected for the study, the models for each country provide valuable information for making decisions to improve learning and effective teaching for those three countries in particular, and perhaps other countries with characteristics similar to the three that represent a range of cultures, socioeconomic development, and mathematics achievement.

Research Questions

To extend the research to date in addressing the overarching questions of effective contexts and practices for learning mathematics, this dissertation study investigated four questions across three countries representing a wide range of cultures and levels of mathematics achievement:

1. To what extent do home-related variables (home possessions for learning, parents' education, and parents' expectations for and involvement in their children's education) predict eighth-grade mathematics achievement in each country?
2. To what extent do student beliefs (self-confidence in mathematics, value of mathematics) predict eighth-grade mathematics achievement in each country?
3. To what extent do school-related variables (school climate, school resources, administrator leadership, and school socioeconomic status) predict eighth-grade mathematics achievement in each country?
4. To what extent do teaching-related variables (access and equity, curriculum, tools and technology, assessment, and teacher professionalism) predict eighth-grade mathematics achievement in each country?

Rationale for Study

TIMSS has the specific goal of increasing understanding of the effects of educational policies and practices within and across countries. TIMSS 2011 international database is a resource for investigating variables in students' homes, national cultures, personal beliefs, schools, and classrooms which might explain differences in eighth-grade mathematics achievement (Mullis, Martin, Minnich, et al., 2012).

Even though data from multiple administrations of the TIMSS have been made publicly available for all participating countries, relatively few of these countries have been included in published studies of large international databases of student achievement. Researchers have tended to focus on countries with higher performance and higher socio-economic status such as Japan, Korea, Singapore, Finland, and the United States. A neglect of research of student mathematics achievement in lower-performing countries has resulted in at least some of these countries making educational policy decisions or implementing educational reform projects based on research findings and educational models of countries with higher socioeconomic status and achievement (Riddell, 1997). Countries differ in cultures, and an educational model that is effective in some countries may not yield the same results in others (Bryan et al., 2007). Research of student achievement on an international level that samples a greater diversity of countries (e.g., ranges of culture, socioeconomic status, and achievement) and that yields findings specific to each country is needed so that policy makers and educators from underserved countries can use research findings relating to their own countries to inform their educational decisions.

Definitions of Terms

Achievement behavior: behavior directed at developing or demonstrating high rather than low ability

Assessment: the process of gathering evidence about a student's knowledge of, ability to use, and disposition toward, mathematics and of making inferences from that evidence for a variety of purposes (National Council of Teachers of Mathematics (NCTM), 1995)

Content knowledge: understanding not only the facts and concepts of a subject area but the structures, that is the ways in which the concepts of the discipline are organized, as well (Shulman, 1986)

Culture: the values, traditions, and beliefs mediating the behaviors of a particular social group (American Psychological Association, 2002)

Curriculum: the program used to help students meet the standards, including instructional materials, activities, tasks, units, lessons, and assessments—distinct from both textbooks and standards (Leinwand et al., 2014)

Instruction: everything that teachers do to support the learning of their students (Ball, Thames, & Phelps, 2008)

Pedagogical content knowledge: content knowledge for teaching—the ways of representing the content that make it comprehensible to others (Shulman, 1986)

Self-efficacy: beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments (Bandura, 1997)

Socioeconomic status: an individual's or group's ranking on a scale according to access to or control over some combination of valued commodities such as wealth, power, and social status (Meuller & Parcel, 1981)

Standards: statements of what students are expected to learn

Teacher qualifications: the credentials, knowledge, and experiences that a teacher brings to the job (Goe & Stickler, 2008)

Teacher practices: the ways in which teachers interact with students and the teaching strategies they use to accomplish specific teaching tasks (Goe & Stickler, 2008)

CHAPTER II

REVIEW OF LITERATURE

This dissertation study was an investigation of effective contexts and practices for facilitating the learning of mathematics across three countries. A review was conducted of both classic and recent literature to synthesize the major contexts for learning mathematics and salient variables related to those contexts. The literature review yielded a finding of five major contexts for learning mathematics. An initial context for children’s learning of mathematics is their family or home environment. Another early context for learning mathematics is the culture in which a student lives and is educated. A third context is students’ beliefs regarding their abilities in mathematics and the value of the mathematics. Fourth, the context of the school affects student achievement. Finally, the context of students’ teachers and classrooms affects their mathematics achievement. This chapter will describe findings from the review of literature regarding the effects that each of these contexts have on student achievement, especially in mathematics. Salient variables related to the five contexts for learning were also identified in the literature and will be described in the discussion of each context for learning.

Family/Home

Children's homes or families are contexts for their early experiences and learning of mathematics. Learning in the context of the home emerges from children's interactions with other household members, materials, or experiences. Variables related to early experiences in the home context have been significantly associated with student achievement by their effect on cognitive readiness which appears to be stable throughout a child's schooling and influence achievement over the long term (Goldhaber & Brewer, 2000; Henderson, 1987; Reynolds, 1991).

The Coleman (1966) Report, a study of access to education in the United States, found that home-related variables such as home possessions for learning, parent educational attainment, and parent expectations and involvement in their children's education have significant effects on student achievement. That report triggered a string of studies of the effects of both home and school contexts related to student achievement on an international level.

Prompted by the findings of the Coleman Report, Comber and Keeves (1973) and Loxley and Heyneman (1982, 1983) investigated the effects of home- and school-related variables on student achievement in science across the same 18 countries. Comber and Keeves first found that teacher- and school-related variables contributed stronger effects on student achievement than home-related variables did across the countries in their study. Loxley and Heyneman, building on Comber and Keeves' study, found that in countries with lower incomes, the teacher- and school-related variables had greater effect on student achievement than the home, and in countries with higher incomes, home-related variables had greater effect on student achievement than teacher and school.

Following on Comber and Keeves and Loxley and Heyneman's studies, Fuller (1987) found in a meta-analysis that schools, including those with limited resources, had a stronger effect on student achievement within countries of lower socioeconomic status than within countries of higher socioeconomic status, regardless of students' home-related variables. In contrast to the previous follow-up studies to the Coleman Report, Baker et al. (2002), using TIMSS 1995 data, found that the relationships among home and school contexts and student achievement were similar across countries, regardless of national income. The researchers attributed their different results to changes in macro-social conditions since the publishing of the previous studies.

The relationship of the context of home and family to student achievement across countries is far from settled. Further research is needed. Because the home contexts for learning and parents' contributions to children's learning are difficult to observe and measure directly, researchers often use a composite of proxy variables such as resources in the home, parents' level of educational attainment, and parents' expectations of their children's academic achievement to measure the contribution of home-related variables to academic achievement (Sirin, 2005). The following paragraphs describe the most salient variables related to the family and home that were found in the literature to explain variation in student achievement in mathematics.

Home Possessions for Learning

Educational resources in students' homes such as computers, calculators, desks, and dictionaries have been found to be significant predictors of higher achievement in mathematics in many countries, (Mullis, Martin, Gonzalez, & Chrostowski, 2004). Parents with lower socioeconomic status are less likely to possess reading and learning materials for their children, take their children to educational and cultural events, and limit the amount of television their children watch. This lack of access to educational resources and experiences is associated with students' increased behavior problems in school and lower academic achievement (Bradley & Corwyn, 2002).

Parents' Education

Parents' educational attainment has been found to be a stable indicator of the home educational context and to have a medium to strong relationship with student achievement (Goldhaber & Brewer, 1996; Reynolds, 1991; Sirin, 2005). Zuzovsky and Tamir (1989) found that parents' educational attainment explained twice the variance in student achievement in science that teacher instruction did. Multiple studies have found complex relationships between parents' education and student achievement; for example, parent education has been found to be less predictive of student achievement for students of minority races (effect size = .17) than White students (effect size = .27; Sirin, 2005). In addition, the greater a country's level of socioeconomic inequality, the greater the relationship parent education level tends to have with student achievement in mathematics (Martins & Veiga, 2010).

Parent Expectations and Involvement

Parent expectations and involvement related to their children's education have been found to have strong, positive associations with student achievement (Fan & Chen, 2001; Hong & Ho, 2005). Parent expectations tend to be demonstrated by parents' communication of the importance of academic achievement to their children, and then children often adopt their parents' expectations regarding their academic achievement for themselves. Lee, Bryk, and Smith (1993) found that parents' expectations for their children's academic achievement are significantly related to academic achievement, even after accounting for socioeconomic status.

Parent involvement includes behaviors such as monitoring and planning children's educational experiences. DePlanty, Coulter-Kern, and Duchane (2007) found that parent involvement in academics at home explains 36% of variation in student achievement while parent involvement at school explains 30 %; however, the literature overall regarding parent involvement and student achievement is largely qualitative and non-empirical (Fan & Chen, 2001). More research, then, especially quantitative, is needed to better understand the relationship between parents' involvement in their children's education and students' achievement.

Buchmann (2002) listed several reasons for controlling for the home context for learning in international comparative studies of education. Reasons included understanding: (a) the interaction of effects of school contexts for learning with home contexts for learning; (b) how the context of the home affects student ability and motivation to achieve academically; and (c) the distribution of academic achievement across social and cultural contexts. If home contexts for learning are found to be significantly related to student achievement, then stakeholders in education should include the home contexts for learning in their plans for support and improvement of children's education.

Culture

The American Psychological Association (2002) defined culture as the belief systems and value orientations that influence customs, norms, practices, and social institutions of a particular social group. Differences in cultures, operationalized in this study by countries (Porter & Gamoran, 2002), have been found to explain variance in student achievement. For example, students in East Asia tend to outperform students from other countries in mathematics (Liou, 2010; Wang, 2008). Variations in mathematics achievement between countries, especially between Eastern and Western cultures, have been shown to be associated with (a) student beliefs about learning such as self-efficacy and the value of mathematics and (b) variables related to teaching such as access and equity, curriculum, and instructional practices. For example, levels and effects of student self-confidence in learning mathematics vary across countries. Student self-confidence in mathematics is positively associated with mathematics achievement within many countries, particularly in the Western hemisphere (House, 2006; Pajeres & Graham, 1999). In other countries, particularly in Asia, self-efficacy in learning mathematics has been reported to have a negative relationship with mathematics achievement. Countries with the lowest levels of self-confidence in learning mathematics such as Japan, Taiwan, Hong Kong, and South Korea had high average mathematics achievement. Mullis et al. (2004) explained this relationship by suggesting that the cultures in these Asian countries encourage modesty in students such that students tend to rate themselves low in self-efficacy in learning mathematics while they perform successfully in mathematics assessments.

Cross-national studies of student achievement have indicated that teaching-related variables are also associated with variation in student achievement between countries. For example, Japanese students are expected to assume greater responsibility for their own learning than American students are. In Japan, interest and success are responsibilities of the student rather than the teacher. In the United States, on the other hand, teachers are expected to make instruction interesting and appealing, and students are less likely to be held responsible for disengaging if the topic is personally unappealing (Hess & Azuma, 1991). Also, educational literature in Western cultures conceptualizes a dichotomy between competition and cooperation in learning. This dichotomy is irrelevant to student learning in the Chinese culture. The Western dichotomy between memorization and conceptual understanding is also irrelevant in the Chinese culture. The most significant predictors in student achievement in Chinese culture are the effects of effort and persistence (Ho, Kong, & Hau, 2008).

School and classroom variables that foster student achievement in some countries may not yield the same results in other countries. Porter and Gamoran (2002) have called for more cross-national and -cultural research of educational practices and policies to investigate differences in student achievement among countries. Further, cross-national research of cultural differences and mathematics achievement has been primarily qualitative (LeTendre, 2002); therefore, more quantitative investigation is needed to study how predictors of student achievement vary across countries and how the variables of culture are associated with student achievement.

Student Beliefs

Vygotsky (1978) theorized that learning is one’s construction of meaning as a result of connecting new information or experiences to one’s prior knowledge or experiences. Learning requires some engagement with the content through text, direct experiences, teachers, peers, parents, etc. Student engagement in learning has been established as a predictor of student achievement in many studies and is a component of the TIMSS 2011 assessment framework (Mullis, Martin, Foy, & Arora, 2012). In this dissertation study, achievement attributable to the student is quantified by two variables of student beliefs regarding mathematics: their self-confidence in mathematics and the value of mathematics. Student beliefs regarding mathematics tend to be stable, long-term, and generally set by about the seventh grade of school (Bransford, Derry, Berliner, Hammerness, & Beckett, 2005; Middleton & Jansen, 2011). Using TIMSS 2007 data, Choi, Choi, & McAninch (2012) found that high achieving students have self-confidence in learning mathematics and value mathematics more than their peers without high achievement in mathematics. Inversely, Stipek (1995) concluded that students are unlikely to make efforts to achieve when they expect to fail or when they do not value the success it may bring.

House conducted a series of within-country studies using data from the TIMSS. First, House (2003) found significant relationships between beliefs about learning mathematics and mathematics achievement of students in Hong Kong using data from TIMSS 1999. Students who indicated that they value the enjoyment and importance of mathematics and who believe that hard work along with natural talent are required to do well in mathematics in school achieved higher scores in mathematics than others. Inversely, those who felt that mathematics was boring had lower mathematics achievement. The combined set of beliefs about mathematics explained 12 % of the variance in mathematics test scores.

In a similar study with eighth-grade students of Japan, House (2006) reported that students who enjoyed learning mathematics and felt mathematics was easy achieved higher scores in mathematics, and students who attributed success in mathematics to external factors such as luck achieved lower scores. The combination of these mathematical beliefs explained 13% of the variance in mathematics achievement scores for students in Japan. In a second analysis with students of Japan, House and Telese (2006) examined instructional activities and student beliefs as predictors of achievement in algebra. Results indicated that even after considering the effects of instructional practices, student beliefs associated with mathematics were significantly related to algebra achievement. As in his previous studies, House found that students who enjoyed learning mathematics achieved higher scores in mathematics, and students with negative attitudes scored lower.

Continuing his studies of the relationship between student beliefs about mathematics and mathematics achievement, House (2009) used TIMSS 2003 data with eighth-grade Native American students. Results again indicated a significant relationship between student beliefs and student achievement. Students who indicated enjoying learning mathematics and felt that they do well in mathematics tended to achieve higher mathematics scores, and students who had negative beliefs and lacked in self-confidence in mathematics had lower mathematics scores. The complete set of mathematics beliefs explained 27% of the variance in mathematics achievement for the sample of Native American students.

Self-Confidence in Mathematics

Competence, defined as effective interaction with one’s environment, produces a positive sense of self-confidence (White, 1959). Bandura (1997) defined self-efficacy as belief in one’s capability to organize and execute the courses of action required to attain a goal. Greater self-confidence in mathematics is significantly associated with higher mathematics achievement in adolescent students (Akey, 2006; House, 2006; Pajeres & Graham, 1999). Liou (2010) investigated relationships between student beliefs of mathematics and mathematics achievement at both the individual level and national level. Self-confidence was the most consistent and important predictor of mathematics achievement at the individual level; however, at the national level, the relationship was negative.

Self-confidence in mathematics and value of mathematics, though distinct, are related. If a task is more challenging, success has greater meaning and provides a sense of accomplishment. Inversely, if a mathematics task is too easy, students will not value success with it. When students expect to be successful in a moderately challenging task, they tend to expend more effort. Effort yields a greater chance of success, and success tends to yield even more success. Inversely, an expectation of failure often leads to low effort levels, or worse, an exertion of effort to avoid the activity. Acting out, withdrawing, and other task avoidance behaviors tend to lead to failure, and just as success yields even more success, failure tends to yield even more failure. Challenge implies that all will not be successful in every task. A healthy attitude, therefore, toward not always being successful is crucial for developing persistence and achieving greater success (Middleton & Jansen, 2011).

Value of Mathematics

Though self-confidence is necessary for students to be motivated to approach a challenging task, it is not sufficient by itself. Students must see a challenging task as valuable in some way, such as being enjoyable or having perceived utility. A challenge must also be at an appropriate level—within one’s zone of proximal development

(Vygotsky, 1978)—so that the student experiences success, but not so easily that the task is trivial to the student. When students value a task, they will persevere through small frustrations or setbacks to attain a solution and understanding; however, if accomplishing a task is so beyond the student's current understanding and skill that even great effort won't result in success, self-confidence will be diminished to the point of resistance to the task (Middleton & Jansen, 2011).

An essential element for taking an interest in a subject or task is that it must be something that one values (Cushman, 2010). Atkinson (1964) proposed that academic effort arises from the desirability or value of the achievement goal and that students are not likely to persist in a task if there is no perceived value in completing it, even if one expects to be successful in it. Brophy and Good (1986) concluded that the effort one is willing to expend on a task is determined by the expectation that participation in the task will result in successful outcomes, mediated by how much the individual values either participation in the task itself or the rewards associated with success in the task. Primary school children tend to acknowledge that mathematics is useful and that understanding it is important for scientific reasoning, financial dealings, and other applications; but as students approach the middle grades, they state that they don't want to take anymore mathematics courses. They seem to comprehend mathematics' value but have no desire to pursue it (Middleton & Jansen, 2011).

In a between-country analysis of eighth-grade mathematics achievement across the United States, the Russian Federation, Singapore, and South Africa using TIMSS 2003 data, Wang (2008) found that self-confidence in learning mathematics contributed the greatest effect to eighth-graders' mathematics achievement in all four countries. The effects of students' other motivational beliefs, parent educational attainment, teachers' and principals' perceptions, and other teacher- and school-related variables differed across countries.

School

The context of school has a strong influence on student learning internationally, and in poorer countries the impact of school on student achievement is even more powerful than it is in wealthier countries (Heyneman & Loxley, 1983). variables related to school that were found in the review of literature to be salient predictors of student achievement are school climate, school resources, administrator leadership, and school socioeconomic status.

School Climate

Operationalization of school climate varies in the literature but typically includes variables associated with school safety, student attendance and behavior, and teacher morale (Austin & Bailey, 2008; Freiberg, 1999; Johnson & Stevens, 2006; Koth, Bradshaw, & Leaf, 2008; Lubienski, Lubienski, & Crane, 2008; Reynolds & Teddlie, 2000; Schunk, Pintrich & Meece, 2008). Indicators of school climate include both negative aspects such as discipline and attendance problems and positive aspects such as support for academic achievement (Mullis et al., 2009). Even though school climate has been operationalized with various indicators among studies, associations between general school climate and student achievement have been found in multiple studies.

Teddlie (2010) found several characteristics under the umbrella of school climate associated with higher student achievement including effective instruction, a viable curriculum, opportunity to learn, high expectations for students and staff, parental involvement, and responsibility of students. In an analysis of six indicators of school climate—the learning and working environment, school norms and standards, staff-student relationships, student behaviors, school safety, and levels of substance abuse—Austin and Bailey (2008) found positive associations between positive school climate and student achievement. Additionally, the quality of school climate was found to decline consistently across all indicators from elementary to high school. Johnson and Stevens (2006) measured teachers’ perceptions of school climate operationalized with affiliation among teachers, atmosphere of innovation, involvement of teachers in decision-making, adequate school resources, and cooperative students. Results indicated a positive relationship between teachers’ perceptions of school climate and student achievement, with school climate explaining 95% of the variance in student achievement. School climate was mediated, however, by school socioeconomic status. Specifically, the influence of school climate on student achievement was greater in schools with higher socioeconomic indicators than it was in schools with lower socioeconomic indicators. Stanco (2012) used TIMSS 2007 data to examine the relationship of school climate and achievement in both mathematics and science, controlling for student home resources. Results across three countries indicated that absence of discipline and attendance problems and a school climate supportive of academic success were strong predictors of student achievement.

School Resources

Results of analyses using TIMSS 2007 data have indicated that adequate school resources are generally positively associated with achievement in eighth-grade mathematics across countries. Schools with resources such as facilities and general resources for learning such as books, computers, technological support, and supplies are likely to have higher-achieving students (Mullis, Martin, & Foy, 2008; Martin, Mullis, & Foy, 2008; Patnam, 2007). Schreiber (2002) found a significant positive relationship between school resources and advanced mathematics achievement at the school level using data from TIMSS 1995. School resources in that study included both resources for general instruction such as instructional materials, money for supplies, school buildings, heating and lighting systems, and instructional space as well as resources for mathematics instruction such as computers, computer software, calculators, and audio-visual technology. The TIMSS 2011 assessment framework has included a set of indicators of school resources that has been shown to differentiate among schools including well-prepared teachers, resources for general instruction, and resources for mathematics instruction (Mullis et al., 2009; Stanco, 2012).

Administrator Leadership

School administrators are responsible for allocating school time and resources and enacting and implementing policies to ensure that all students in the school have access to the learning opportunities and supports that they need to achieve. Effective administrators use their knowledge about their students' families and communities to support their teachers in selecting and providing instructional practices and resources to help students learn mathematics. They support multiple methods of assessment to both monitor student progress and inform modification of instruction. School administrators must fully understand effective mathematics instructional practices so that they can support teachers in planning and implementing them. To support these goals, NCTM (Leinwand et al.,

2014) has recommended research-based practices for school administrators to foster student achievement in mathematics:

- Provide for sustained professional development for teachers in mathematical content knowledge, pedagogical content knowledge, and the availability and use of technology to foster student achievement.
- Allocate time and resources for teachers to collaborate in planning lessons and studying the school's curriculum at, above, and below their assigned grade levels or courses.
- Ensure that mathematics curricula and instructional materials support effective mathematical practices, conceptual understanding, procedural fluency, and solving problems.
- Provide and support effective use of appropriate tools and technology for learning mathematics.
- Establish a school climate with high expectations for academic achievement.
- Ensure that the process of selecting instructional materials is a collaborative process that includes careful examination of the degree to which the materials not only align with the standards but also develop topics coherently within and across grades, promote mathematical practices, and support effective mathematics instruction.

School Socioeconomic Status

Socioeconomic status is defined as an individual's or group's ranking on a scale according to access to or control over some combination of valued commodities such as wealth, power, and social status (Meuller & Parcel, 1981). Socioeconomic status at the school level has been found to be positively associated with student achievement. For example, Coleman, et al. (1966) found that when students from lower socioeconomic backgrounds in the United States were placed in schools with students from higher socioeconomic backgrounds, their achievement was likely to increase. In a study using TIMSS 1999 data, Mokshein (2002) found that socioeconomic indicators explained about 50% of the variation in science achievement of eighth-graders at the school level in Malaysia. Hill and Lubienski (2007) found that schools with higher percentages of students in poverty had teachers who scored lower in teacher knowledge than teachers in more affluent schools. Literature cited in the following section indicates that teachers with greater knowledge of mathematics are associated with higher-achieving students in mathematics; hence, these results indicate that problems inherent for schools that have students from lower socioeconomic backgrounds are compounded by the likelihood of having teachers with less mathematics content knowledge.

Classroom

Variables related to the context of the classroom such as access to academic content and professionalism of the teachers have been found to have significant impact on student achievement across countries (Alexander & Simmon, 1975; Heyneman & Loxley, 1983). Nye, Konstantopoulos, and Hedges (2004) found that the context of the classroom has a much larger effect on student achievement in mathematics than in reading. In this study, the context of the classroom is framed by the five essential elements of teaching and learning mathematics as described by NCTM (Leinwand et al., 2014):

- a commitment to access and equity,
- a powerful curriculum,

- appropriate tools and technology,
- meaningful and aligned assessment, and
- a culture of professionalism.

Access and Equity

Access and equity in the mathematics classroom refer to the opportunity for all students to engage successfully in mathematics content and learn challenging mathematics. The mathematics curriculum, instructional materials, and instructional practices are all associated with students' access to learning (Mullis et al., 2009). To ensure access and equity in the mathematics classroom, teachers must know and understand the cultures and communities from which their students come and design and select meaningful learning opportunities that build on students' prior knowledge and experiences. Teachers must monitor student progress and make needed accommodations by collaborating with colleagues, including teachers of special education, gifted education, and second-language learners. Teachers must also work collaboratively with parents and community members to ensure that all students have the support that they need to maximize their mathematics achievement (Leinwand et al., 2014).

Instructional time also has a significant impact on student access to learning mathematics. Instructional time can be difficult to analyze, however, because multiple variables confound its effectiveness such as the quality of the curriculum and instructional practices. In addition, the relationship between instructional time and student achievement is highly dependent on the effectiveness of the educational system. If an education system is ineffective overall, increasing the amount of instruction time has diminishing returns. Finally, most countries set policies for instructional times across their educational systems, so any variation in instructional time is unintended and not relatable to achievement (Mullis, Martin, Foy, et al., 2012).

Curriculum

Curriculum is the content of teaching and learning (Stein, Remillard, & Smith, 2007). Curriculum includes (a) the standards that state what students are intended to learn; (b) instructional materials such as textbooks that teachers use as resources and with which students interact; and (c) instruction, defined as everything that teachers do to support the learning of their students (Ball, Thames, & Phelps, 2008).

The development of a curriculum begins with the knowledge, understanding, and skills that are valued by the students and their communities, formalized as standards (Mullis et al., 2009). Analyses of TIMSS 2003 data have indicated that countries with rigorous curricula that are aligned with standards and coherent across grade levels have high student achievement in mathematics (Mullis & Martin, 2007; Stanco, 2012).

The use of a research-based curriculum—research-based instructional materials and practices aligned with research-based standards—has been found to have a significant effect on student achievement; however, a transition from the use of a more traditional mathematics curriculum to a research-based curriculum takes sustained efforts, at least two years, to yield higher student achievement compared to the use of other curricula (Reys, Reys, Lapan, Holliday, & Wasman, 2003). McCaffrey et al. (2001) investigated the relationship between teachers' use of research-based curricula and student achievement after controlling for student-background variables and prior achievement. Instructional practices aligned with research-based standards such as those developed by NCTM was positively related to achievement for students in courses with standards-based instructional materials, yet it was unrelated to achievement in courses with more traditional instructional materials. The researchers concluded that changes to instructional practices may need to be coupled with changes in instructional materials to yield effects on student achievement. The following sections describe the literature related to the components of mathematics curricula—standards, instructional materials, and instructional practices.

Standards. Standards are statements of what students are expected to learn, and coherence in a set of standards has been found to be an important trait of high-quality standards. A set of standards is coherent if the sequence and depth of topics to be studied both within grades and across grades follow the logical structure of the discipline (Schmidt, Wang, & McKnight, 2005). In a study of the coherence of the mathematics standards of the six highest-achieving countries in the 1995 TIMSS, Schmidt, Wang, and McKnight found that coherence in the structure of standards was evident in the highest-achieving countries. New topics were gradually introduced, remained a part of instruction for a few grades, and then typically left the curriculum. In contrast, they found in the structure of NCTM standards in the United States that topics entered and lingered in the curriculum for more grades than in the high-achieving countries. In addition, U.S. standards addressed many more topics in a grade than was typical of the six high-achieving countries. Not having a coherent set of standards was found to be associated with instruction focused on rote memorization of procedures and neglect of the deeper understanding of concepts. The researchers recommended that U.S. policymakers develop coherent and rigorous mathematics standards at the national level like the top-achieving countries.

Teachers' understanding of the learning standards is positively associated with student achievement (Marzano, 2009). Black and Wiliam (1998) found that teachers who communicated student-friendly versions of the standards resulted in students' valuing and understanding the purpose of their work. When teachers communicate learning standards, students become more engaged and better able to assess their own learning (Clarke, Timperley, and Hattie, 2004; Zimmerman, 2001).

Instructional materials. Instructional materials influence what is taught and emphasized by teachers in the classroom (Schmidt, Houang, & Cogan, 2002; Tarr et al. 2008) and have a significant effect on what students learn and how they learn it (Stein, Remillard, & Smith, 2007). High quality instructional materials are those that align with standards and support teachers in effective instruction and students in mathematical practices (Bush et al., 2011).

Instructional materials designed with problem-solving tasks appropriate for group collaboration in each lesson provide greater support for teachers' implementation of research-based instructional practices than more traditional materials designed with drill sets for individuals to practice algorithms. McCaffrey et al. (2001) found that the relationship between use of research-based instructional practices and student achievement is moderated by the instructional materials. Specifically, results indicated that research-based practices are more effective when they are used in conjunction with standards-based instructional materials. For example, Tarr et al. (2008) examined student achievement in relation to the use of instructional materials and found that student achievement was positively impacted by standards-based instructional materials when coupled with research-based instructional practices.

Instruction. Instruction is defined as everything that teachers do to support the learning of their students (Ball, Thames, & Phelps, 2008). Instruction that consistently fosters higher-level thinking and reasoning is associated with the highest student achievement, and instructional tasks that are routinely procedural in nature are associated with the lowest student achievement (Boaler & Staples, 2008; Hiebert & Wearne, 1993; Stein & Lane, 1996). Instruction that fosters high-level thinking includes problems that allow multiple entry points, representations, tools, and strategies, and explanation of student thinking (Leinwand et al., 2014; Stein & Lane, 1996).

An instructional environment in which students work cooperatively in problem-solving and reasoning and using multiple representations is significantly related to higher mathematics achievement, engagement, and motivation. Student cooperation can be effectively accomplished in pairs, small-groups, and whole-class environments (Akey, 2006; Ginsburg-Block & Fantuzzo, 1998; Leinwand et al., 2014).

Making connections among mathematical representations such as tables, graphs, equations, and words deepens understanding of mathematics and can be used as tools for problem solving (Mayer, 2005; NCTM, 2000), so substantial instructional time should be allocated for students to use, discuss, and make connections among representations. Purposefully designed questions can be used to facilitate students' explanations and to advance their connections among various representations (Leinwand et al., 2014).

Instruction that balances development of conceptual understanding and procedural fluency is also associated with student achievement in mathematics (National Mathematics Advisory Panel, 2008; National Research Council 2001). Conceptual understanding leads to procedural fluency by developing skills in students to use their own reasoning strategies and methods for solving problems (Leinwand et al., 2014).

Tools and Technology

Mathematical tools and technology, when used to help students make sense of mathematical concepts, reason mathematically, and communicate their mathematical thinking, have been associated with higher student achievement (Leinwand et al., 2014; Marzano, 1998). Tools and technologies for teaching, learning, and doing mathematics have been in use since approximately 300 B.C. with the Chinese abacus as both a procedural tool and conceptual model of arithmetic (Fauvel & Maanen, 2000). Astrolabes, mechanical calculators for computing time and solving problems related to positions of the sun and stars, were used in both education and navigation in the fifth century A.D. (Morrison, 2007). In the first half of the 17th century, William Oughtred developed a circular slide rule from two logarithmic rulers so that could numbers could be rapidly multiplied and divided.

The development of calculators and computers in the latter half of the 20th century then made the slide rule largely obsolete. Texas Instruments released the four-function calculator in 1965 and then the scientific calculator in 1976. Casio produced the first graphing calculator, and since, various companies have been developing palm-sized devices that continue to extend capabilities of calculation, visualization, and connectivity. Electronic computers were being developed about the same time as handheld calculators. The first connections of what would become today's worldwide web were made at the end of the 1960s. Apple and IBM desktop computers debuted in the late 1970s and early 1980s and developed into the current mobile types of electronic devices such as tablets and smartphones in the early 21st century. These devices are used to both teach and do mathematics (Greenwald & Thomley, 2012).

Some technologies in mathematics classrooms such as calculators and graphing calculators were designed specifically for doing mathematics. Four-function and scientific calculators are typically used to simplify time-consuming computations, and graphing calculators are used in secondary grades to develop students' conceptual understanding of mathematical functions and foster spatial visualization (Ellington, 2003; Kaput, Hegedus, & Lesh, 2007). Software such as computer algebra systems (CAS) for manipulating algebraic statements and dynamic geometry systems for manipulating geometric constructions are also widely used in secondary mathematics classrooms.

More general technologies that are not mathematics specific can also be used in the mathematics classroom. Interactive whiteboards and various mobile, laptop, and desktop devices are used in classrooms to help students make sense of mathematics, engage in mathematical reasoning, and communicate mathematically. Smartphones and tablets can be used to gather data, conduct real-time formative assessment, perform calculations, run simulations, and foster visualization. Spreadsheet applications are used to perform calculations and create graphs and charts from tables. Word processing and presentation software are used to foster student engagement in mathematics tasks. Students might collaborate on mathematical projects using social media, blogs, or wikis within a school or with students in other states or countries (Leinwand et al., 2014).

Tools in modern mathematics classrooms used for fostering understanding of arithmetic and geometric concepts include manipulatives such as counters, snap-cubes, base-ten blocks, and pattern blocks in elementary grades, and algebra tiles, geoboards, protractors, compasses, and geometric solids in secondary grades (Varelas & Becker, 1997). Physical and virtual manipulative materials provide physical and visual models of mathematical concepts which help students explore new mathematics concepts and practice applying them (Roschelle et al., 2010). Examples of manipulatives include base-ten blocks that help younger students to visualize multi-digit multiplication and algebra tiles that help older students make sense of completing the square.

How tools and technology are used in the classroom determines their effectiveness. Teachers may merely teach students procedures for using tools or technology to solve problems without providing them opportunities to make sense of the problems or to connect the procedures with more formal mathematical reasoning. These practices with tools and technology may inhibit students' mathematical fluency and understanding. For example, a teacher may instruct students how to use base-ten blocks to solve multi-digit addition problems without offering them opportunities to use the blocks to explore the mathematical meaning behind procedures for multi-digit addition (Erlwanger, 1973).

Variables outside the classroom also have an impact on the effective use of tools and technology. Some schools, especially those with students with lower socioeconomic status, may not have reliable access to technology and other tools. In addition, teachers may not have adequate training in the use of tools or technologies to effectively foster students' mathematical learning. Technology and tools may sit unused, or they may be used in unproductive ways. Some schools have adequate computers but have unreliable internet connections. Finally, policies may limit the use of tools and technology for purposes such as assessment and, as a result, teachers may be reluctant to allow students to use technology that will not be allowed on the assessments (Leinwand et al., 2014).

Technology is currently an integral part of nearly all students' lives and is likely to be in their careers as adults. Mathematics classrooms should reflect this reality by incorporating technology as an integral part of instruction. Use of technology such as calculators has been shown to not inhibit students' learning of mathematics, contrary to the arguments of some. In a meta-analysis, Ronau et al. (2011) found that the use of calculators in the teaching and learning of mathematics does not contribute to any negative outcomes for skill development or procedural proficiency, but instead enhances the understanding of mathematics concepts and student orientation toward mathematics. Teachers need to be able to effectively use tools and technology for teaching and doing mathematics such investigating mathematical ideas, generating multiple representations of mathematical concepts, and solving mathematics problems (Leinwand et al., 2014).

Assessment

Assessment in mathematics refers to the process of gathering evidence about students' knowledge, skills, and dispositions in mathematics and of making inferences from that evidence. Assessment in school mathematics is useful for

- monitoring students' progress to promote student learning;
- informing modification of instruction to facilitate student learning;
- evaluating students' demonstrated understanding at a particular moment in time to summarize and report; and
- informing evaluation of programs for their improvement and future use (NCTM, 1995).

Frequent assessment accompanied by prompt corrective feedback to attain the standards is significantly related to student achievement across all grade levels, socioeconomic levels, races, and community types (Lysakowski & Walberg, 1982; Stiggins, 2007). Assessment supports student achievement when it is integrated into instruction such that students at any given time know what they are intended to be learning, how their success will be measured, and how they are progressing toward that standard (Wiliam, 2007). Effective integration of assessment and instruction to support student learning includes having students assess their own work as the owners of their learning and providing feedback that extends student thinking and learning (Leahy, Lyon, Thompson, & Wiliam, 2005).

Teacher Professionalism

Many studies have reported positive relationships between measures of teacher professionalism and student achievement (Coleman et al., 1966; Goldhaber, Goldschmidt, Sylling, & Tseng, 2011; Hanushek, Kain, O'Brien, & Rivkin, 2005; Hanushek & Rivkin, 2010; Heyneman & Loxley, 1983; Sanders & Rivers, 1996). Variables related to teacher professionalism that were found in this review of literature to be salient predictors of student achievement are the extent of their professional development, collaboration with colleagues, teaching experience, knowledge of both content and pedagogy, preparation, and self-efficacy (Darling-Hammond, 2000; Mullis, Martin, Foy, et al., 2012; Smyth, 2001). The following sections describe the literature related to these elements of teacher professionalism.

Professional development. Effective teachers of mathematics continue to develop professionally both individually and collectively with their colleagues (Leinwand et al., 2014). Mathematics teachers' participation in sustained professional development based on content-specific pedagogy linked to their curricula has been associated with improved student achievement (Blank & de las Alas, 2009; Darling-Hammond, 2000). Cohen and Hill (2000) investigated both curriculum-centered professional development and professional development based on discrete topics. Results indicated the professional development in which teachers worked with their research-based mathematics curriculum was associated with teachers reporting increased use of research-based instructional practices and decreased use of more traditional practices. Teachers' participation in professional development in discrete topics and issues had negligible correlation with teachers' use of research-based instructional practices. Teachers in the curriculum-based professional development had been connecting the mathematics that their students would study with how students learn it and how to teach it.

McMeeking, Orsi, and Cobb (2012) investigated the effect of a two-year professional development program on middle school students' state accountability mathematics test scores. Mathematics teachers participated in a sequence of content-oriented summer courses and pedagogy-oriented structured follow-up experiences during the subsequent academic year. Results of the research indicated that students' likelihood of achieving Proficient-level or better scores increased with teacher participation in the professional development program.

Professional collaboration. Professionalism of mathematics teachers can be enhanced when they collaborate with other mathematicians and teachers of mathematics to analyze instructional and curricular issues (Conference Board of the Mathematical Sciences, 2010). Teacher collaboration is positively related to student achievement, especially in schools with students from lower socioeconomic status (Wheelan & Kesselring, 2005). Teachers who collaborate regularly have a greater correlation with student mathematics achievement and a narrowing in traditional learning gaps across racial groups within socioeconomic groups than do teachers who work in isolation. Mathematics coaches or specialists who serve as mentors to mathematics teachers in a school or district can further enhance the effects of collaboration.

National, state, and local professional organizations provide opportunities for collaboration through participation in conferences and institutes and sharing of educational resources through publications such as journals and books. Another avenue for collaboration among teachers is the professional learning community. Professional learning communities provide structure for teachers to:

- discuss and prioritize the standards that students are to learn;
- develop common assessments to measure students' learning of the standards;
- use assessment results appropriately to inform instructional decisions;
- discuss and select research-based instructional strategies and plans; and
- plan for action when students are not demonstrating that they have attained the standards (Leinwand et al., 2014).

Instruction and student learning can be improved through collaborative co-planning of lessons. Teachers' collaboration in planning and implementing lessons has a positive relationship with improvement of instruction, stronger self-efficacy, greater job satisfaction, and improved student achievement (Johnson, Berg, & Donaldson, 2005; Lee & Smith, 1993). In some cultures such as Japanese, mathematics teachers collaboratively prepare detailed lesson plans (Stigler & Hiebert, 1999). In the United States, by contrast, teachers typically develop mathematics lesson plans quickly and individually (Ding and Carlson, 2013). Teachers' collaborative, detailed lesson planning has been shown to improve their instructional practices (Perry & Lewis, 2010; Stein, Russell, & Smith 2011); however, many teachers express concern that they do not have the time to devote to detailed lesson planning for every lesson that they teach (Ding & Carlson, 2013).

Teacher experience. In a meta-analysis, Greenwald, Hedges, & Laine (1996) found positive effects of teacher experience and teacher preparation on student achievement. Controlling for other variables, teaching experience has been found to make a difference, particularly in the early year or two of teaching (Clotfelter, Ladd, & Vigdor, 2007; Hanushek et al., 2005). Still other studies have found teacher experience to have little or no effect on student achievement (Nye et al., 2004; Tarr, Grouws, & Soria, 2013).

Teacher knowledge. Shulman (1986) distinguished types of teacher knowledge into three categories: (a) content knowledge, (b) pedagogical content knowledge, and (c) curricular knowledge. Baumert et al. (2010) investigated the effects of teachers' content knowledge in mathematics and pedagogical content knowledge on quality of instruction and student achievement in mathematics. In a year-long study of 10th-grade mathematics students and their teachers, results indicated that teachers' mathematical content knowledge was empirically distinguishable from their pedagogical content knowledge.

Content knowledge. Shulman (1986) defined content knowledge as understanding not only the facts and concepts of a subject area but the structures, that is the ways in which the concepts of the discipline are organized, as well. Teachers must have a deep understanding of the mathematics that they are expected to teach (Ball, Thames, &

Phelps 2008). They need to understand the problems they pose to students and to know that there are multiple approaches to solving many problems (Grossman, Schoenfeld, & Lee, 2005).

Tchoshanov (2010) examined the relationship of cognitive types of teacher content knowledge and student achievement and their correlation with teaching practice. Three types of teacher content knowledge and thinking processes for accomplishing a task successfully were studied: (a) knowledge of facts and procedures, (b) knowledge of concepts and connections, and (c) knowledge of models and generalizations. The first study focused on the association between type of teacher content knowledge and student achievement; the second study examined the correlation between type of teacher content knowledge and teaching practice, and the third study was a case study of middle level mathematics teachers' knowledge and understanding of fraction division. Tchoshanov found teacher knowledge of concepts and connections to be a significant predictor of students' mathematics achievement.

Metzler and Woessmann (2010) studied causal effects of teacher content knowledge in both mathematics and reading on the corresponding subject-area achievement of sixth-grade students in Peru. Results indicated a significant effect of teacher content knowledge on student achievement. Baumert et al. (2010) found that teachers' pedagogical content knowledge had greater effect on student achievement than their mathematical content knowledge; however, less content knowledge was correlated with less pedagogical content knowledge. No direct effects of content knowledge were found on quality of instruction; content knowledge had a direct effect only on instructional alignment with the curriculum and individual learning support.

Pedagogical content knowledge. Teachers' pedagogical content knowledge of mathematics has been found to be positively related to student growth in mathematics achievement (Hill, Rowan, & Ball, 2005). Shulman (1986) defined pedagogical content knowledge as content knowledge for teaching—the ways of representing the content that make it comprehensible to others. Content knowledge alone is insufficient—pedagogical content knowledge is essential for effective teaching of mathematics. Pedagogical content knowledge includes the ability to anticipate student errors or misconceptions, recognize and diagnose them when they occur, and address them in ways that result in student learning. Pedagogical content knowledge includes the ability to anticipate and respond to student patterns of understanding and misunderstanding in a content area and the ability to incorporate multiple representations of concepts that make the content accessible to a wider range of students (Grossman, Schoenfeld, & Lee, 2005).

Curricular knowledge. The third category of teacher knowledge that Shulman (1986) introduced was curricular knowledge—understanding of the curricular options available for instruction. Teachers should know not only the curricula available for their own instruction, but they should be familiar with the curricula that their students are studying in other areas and the curricula taught in their same subject area in the years preceding and following the content that they are teaching.

The three types of teacher knowledge suggested by Shulman were brought together by McMeeking et al. (2012), reporting that mathematics teachers' deeper knowledge of their content, curriculum, and how to use inquiry in instruction results in higher student achievement in mathematics. Teacher education is a proxy rather than direct measurement of teacher knowledge, but it is the measure available to represent teacher knowledge for this study. More direct measures are needed to more accurately determine the relationship between teachers' depth of mathematics content knowledge, pedagogical content knowledge in mathematics, knowledge of mathematics curricula, and student achievement in mathematics (National Mathematics Advisory Panel, 2008).

Teacher preparation. Even though easy-to-measure variables such as types and levels of teacher preparation are only proxy measurements for teacher professionalism, overall, they tend to be significant predictors of student achievement (Fuller, 1987). In a nationwide study of policies, cases, surveys, and National Assessment of Educational Progress results, Darling-Hammond (2000) found that teacher preparation and certification were the strongest predictors of student achievement in mathematics and reading, even when accounting for student characteristics such as socioeconomic status.

Saha (1983) found that the measure of teacher professionalism that had the most effect on student achievement was teacher preparation. Mathematics teachers' college degrees and coursework in mathematics are positively related to student achievement, especially at the secondary level. More specifically, students whose teachers have bachelor's degrees in mathematics have higher mathematics achievement than students whose teachers have bachelor's degrees in subjects other than mathematics, and students whose teachers have advanced degrees in mathematics have higher achievement in mathematics than those whose teachers have either no advanced degrees or advanced degrees in subjects other than mathematics (Goldhaber & Brewer, 1996; Rice, 2003; Wayne & Youngs, 2003).

Teacher self-efficacy. Teacher self-efficacy, a belief in one's ability to organize and execute instruction, is positively associated with quality of instruction and student motivation and achievement (Bandura, 1997; Henson, 2002; Mullis et al., 2009). Teachers with greater self-efficacy are more open to innovation and more likely to persist with struggling students and patiently work with students to correct misconceptions. Greater content knowledge, pedagogical content knowledge, and collaboration among teachers have all been reported to lead to greater self-efficacy and increased student achievement (Lee & Smith, 1993; McMeeking et al., 2012). Ongoing professional development is needed to foster continual improvement in teacher quality and self-efficacy, especially as teachers practice research-based instruction (Henson, 2002; Martin, 2010).

Summary

Variables that influence student achievement in mathematics are many and confounding. Further, some of the variables are deeply rooted and stable, so rapid or easy modification to them is in many cases unlikely. This review of literature revealed five major learning contexts for student achievement in mathematics: a students' family/home, culture, beliefs, school, and teacher/classroom.

Variables related to mathematics achievement in the context of a student's family and home include educational resources at home, parents' educational attainment, and parents' expectations for and involvement in their children's education. The magnitude of effect of home-related variables appears to vary by the socioeconomic status of both the school and country.

Students' beliefs regarding mathematics, particularly self-confidence in and value of the subject, have been shown to be related to mathematics achievement; however, self-confidence within some Asian countries in some studies has appeared as having a negative relationship with mathematics achievement.

The context of school has a strong effect on student learning internationally, and in poorer countries, the effect of school on student achievement is even more powerful than it is in wealthier countries. School-related variables influencing student achievement include school climate, school resources, administrator leadership, and school socioeconomic status. The effect of school climate has been operationalized by various indicators across studies; nevertheless, the effect has been consistently shown to have a significant effect on student achievement. School resources associated with student achievement include a wide range of indicators from human resources to material resources. To foster student achievement in mathematics, school administrators should provide for a positive school climate, sustained professional development for teachers aligned with their mathematics content and effective instructional practices, teacher collaboration, effective curricula and instructional materials, and appropriate tools and technology for teaching and learning mathematics. Problems at the school-level associated with having students from lower socioeconomic status are compounded by the likelihood of having less effective teachers.

In this study, variables relating to the context of the classroom are framed by the five essential elements of teaching and learning mathematics as described by NCTM: a commitment to access and equity, a powerful curriculum, appropriate tools and technology; meaningful and aligned assessment; and a culture of professionalism.

The effect of student access and equity to mathematics content is confounded by other variables including the quality of instructional materials and practices related to the curriculum and instructional time.

Curriculum includes the standards that students are intended to learn, instructional materials, and teachers' instructional practices. It takes sustained efforts of transitioning to research-based curricula to yield significantly higher student achievement compared to the previous use of other curricula. One of the most important qualities of standards found in international studies of mathematics achievement has been coherence—sequence and depth of topics that follow the logical structure of the discipline both within grades and across grades. Instructional materials aligned with research-based standards and designed with problem-solving activities appropriate for group collaboration provide greater support for research-based instructional practices than more traditional materials. Research-based instructional practices such as problem-solving that allows multiple entry points, representations, tools, and strategies and elicits explanation of student thinking foster student achievement.

Tools such as physical manipulatives and technology such as calculators and computer applications can be effective in helping students make sense of mathematical concepts, reason mathematically, and communicate their mathematical thinking.

Assessment should be integrated into instruction so that assessment supports student learning, not only measures it. Well-designed assessments allow students multiple ways and occasions to demonstrate their understandings and skills. Effective assessment practices include prompt corrective feedback to extend student learning.

Many studies have shown significant positive relationships between measures of teacher professionalism and student achievement. Measures of teacher professionalism include but are not limited to the extent of teachers' professional development, collaboration with colleagues, teaching experience, knowledge of content and pedagogy, preparation, and self-efficacy.

Effective professional development is ongoing, grounded in research-based standards and curricula, aligned with research-based instructional materials, and supports research-based instructional practices.

Teachers who collaborate have a greater correlation with student mathematics achievement and a narrowing in traditional learning gaps across racial groups within socioeconomic groups than do teachers who work in isolation. The effect of teacher experience has been found in some studies to have a positive relationship with student achievement, especially in the first year or two of teaching; however, other studies have found little or no effect of teacher experience on student achievement.

Shulman distinguished three types of teacher knowledge: content knowledge, pedagogical content knowledge, and curricular knowledge. Teachers' pedagogical content knowledge has been found to have greater effect on student achievement than their mathematical content knowledge; however, less content knowledge is correlated with less pedagogical content knowledge. Mathematics teachers' deeper knowledge of their content, curriculum, and how to use inquiry in instruction results in higher student achievement in mathematics.

Teacher preparation has been found to be a strong predictor of student achievement in mathematics; specifically, students whose teachers have a bachelor's or advanced degree in mathematics have higher achievement than those whose teachers have degrees in other subject areas. Finally, teacher self-efficacy is positively associated with students' learning experiences and achievement. Teacher self-efficacy is facilitated by greater content knowledge, pedagogical content knowledge, and collaboration among teachers.

An example of a convergence of many of the variables investigated in this dissertation study is found in Ramirez' (2004) investigation of the likely contributors to low achievement of Chilean eighth-grade students in mathematics in the 1999 TIMSS. Ramirez compared Chile to four countries and one large school system that had comparable economic conditions but superior mathematics performance. Results indicated that (a) compared to South Korea, Malaysia, the Slovak Republic, and Miami-Dade County Public Schools, Chilean eighth-graders had parents with fewer years of schooling and with fewer educational resources at home; (b) Chilean students were taught by teachers who felt less prepared to teach and who covered fewer advanced mathematics content in class than teachers in other countries; and (c) school assets in Chile were unequally distributed across social classes. Schools with students from homes with higher socioeconomic status had more instructional resources and better prepared teachers, and these teachers taught more advanced mathematics content. Schools with their own mathematics curriculum and whose teachers provided more advanced content had significantly higher student achievement in mathematics, even after controlling for the socioeconomic status and school setting (public/private). Ramirez found that regardless of school characteristics, students who expected to graduate from college thought that doing mathematics was not so difficult, and who thought that their academic performance did not depend on luck or innate talent attained significantly higher mathematics achievement.

Educational processes between countries of higher and lower socioeconomic status are not the same (Heyneman & Loxley, 1983; Saha, 1983). This study investigated systematic differences in variables that affect student achievement in mathematics among countries across a wide range of socioeconomic status. Many of the variables in this study are confounded with other variables in efforts to isolate effects on student achievement. Home-related variables are confounded with school-related variables because students attend schools where their parents have resources to select their home's location. Teaching-related variables are confounded with student-related variables because students within schools are often placed into classes or with teachers based on student characteristics such as achievement. Furthermore, teachers are not randomly assigned to classes (Nye et al., 2004).

Literature that addressed contexts and variables related to student achievement, especially in mathematics, was searched to draw out the most salient variables that are associated with student achievement in mathematics. The variables that were found and described in this review of the literature were matched with as many items in TIMSS 2011 background questionnaires as feasible to measure these variables and investigate the extent to which they predict mathematics achievement in Chinese Taipei, Ghana, and the United States.

CHAPTER III

METHODS

The purpose of this study is to investigate the extent to which contexts and variables of home, student beliefs, school, and classroom predict mathematics achievement across three countries that were selected to represent a range of cultures, socioeconomic development, and mathematics achievement. A review of both classic and recent literature indicated five fundamental contexts for learning mathematics: home/family, culture, student beliefs, school, and classroom/teacher. The TIMSS has collected data about these contexts for learning and assessed student achievement in mathematics every four years since 1995. The TIMSS 2011 collected this data from approximately 240,000 eighth-grade students in 42 countries. This chapter will describe the TIMSS 2011 that was selected for this study to investigate the relationships among these variables and the analyses that were used to conduct the investigation.

TIMSS is a project of the International Association for the Evaluation of Educational Achievement (IEA), an independent cooperative of national educational research institutions and research agencies with the purpose of providing countries with information to improve teaching and learning in mathematics and science. IEA's mission is to provide high quality data regarding student achievement and the social and educational contexts in which students achieve. Funding for TIMSS is provided by the National Center for Education Statistics (NCES) of the U.S. Department of Education and the participating countries, with support from Boston College and the United Kingdom’s National Foundation for Educational Research. TIMSS is directed by the TIMSS & PIRLS International Study Center at Boston College (Mullis et al., 2004).

Participants

Population and sample

The international target population for the TIMSS 2011 was all students in their fourth and eighth year of formal schooling. This dissertation study used data from only the eighth-grade population. Students in each participating country were sampled in two stages, first by randomly selecting a school from all schools in which eligible students were enrolled and then randomly selecting one or two classes from within the school. Intact classes of students were sampled rather than individuals from across the grade level or of a certain age because students’ educational experiences are typically organized in groups by classes (Mullis et al., 2009).

Sampling the target population. The TIMSS standard for sampling precision is that national student samples yield a standard error no greater than .035 standard deviation units from the country’s mean achievement. With a standard deviation of 100 on the TIMSS achievement scales, this standard error corresponds to a 95% confidence interval of ±7 score points for the achievement mean and ±10 score points for the difference between achievement means from successive cycles such as the TIMSS 2007 and TIMSS 2011. Sample estimates of any student-level percentage estimate such as student background variables should have a 95% confidence interval of ± 3.5 points

(Joncas & Foy, 2012). For most countries, the TIMSS precision requirements were met with a school sample of 150 schools and a student sample of 4,000 eighth-grade students.

Sampling schools. Statistics Canada systematically drew the school sample with probabilities proportional to size, resulting in schools with more students having a higher probability of being sampled than schools with fewer students. This difference in the selection probabilities of larger and smaller schools was offset at the second stage of sampling by selecting a fixed number of classes (usually one, sometimes two) with equal probability from the sampled schools so that classes in large schools with many eighth-grade classes had a lower probability of being sampled than classes in smaller schools that had few classes (Joncas & Foy, 2012).

Sampling classes. Depending on the average class size in the country, one class from each sampled school was typically sufficient to achieve the desired student sample size. For example, if the average class size in a country was 27 students, a single class from each of 150 schools would provide a sample of 4,050 students, assuming full participation by schools and students (Joncas & Foy, 2012). Within each sampled school, one or two intact classes were selected from all classes with eighth-grade students with equal probability of selection using systematic random sampling. The selection of classes with equal probability, combined with the probabilities proportional to size sampling method for schools, was intended to yield a self-weighting student sample. A minimum class size was specified for each country because small classes tend to increase the risk of unreliable survey estimates. Prior to sampling classes in a school, any class smaller than the specified minimum was combined with another class in the school for sampling purposes (Joncas & Foy, 2012).

Instrumentation

The TIMSS 2011 mathematics framework was similar to the TIMSS 2007 mathematics framework with minor revisions recommended from reviews conducted by the mathematics experts and countries participating in TIMSS 2011. The eighth-grade mathematics assessment framework for TIMSS 2011 was organized around two dimensions: a content dimension specifying the mathematics to be assessed (number, algebra, geometry, and data and chance) and a cognitive dimension specifying the thinking processes to be assessed (knowing, applying, and reasoning; Mullis et al., 2009).

Content Domains

The TIMSS 2011 eighth-grade mathematics assessment consisted of a large pool of content items; however, each student was provided only a sample of the items. The content domains for the eighth-grade mathematics assessment and target percentages of testing time devoted to each are shown in Table 1. Each content domain had several topic areas which were standards addressed in the mathematics curriculum in the majority of participating countries (Mullis et al., 2009).

Table 1

Target Percentages of Content Domains

Content Domain	Percentage of Assessment
Number	30
Algebra	30
Geometry	20
Data and chance	20

Cognitive Domains

The cognitive domains for the eighth-grade mathematics assessment and target percentages of testing time devoted to each are shown in Table 2. The first domain, *knowing,* addressed the facts, concepts, and procedures students need to know. The second domain, *applying,* focused on the ability of students to apply knowledge and conceptual understanding to solve problems or answer questions. The third domain, *reasoning*, addressed problem-solving beyond just routine problems including unfamiliar situations, complex contexts, and multistep problems.

Table 2

Target Percentages of Cognitive Domains

Cognitive Domain	Percentage of Assessment
Knowing	35
Applying	40
Reasoning	25

Background Questionnaires

The TIMSS 2011 contextual framework addressed home, cultural, school, and classroom environments and student beliefs that support effective contexts for learning, based on the literature on predictors of achievement in mathematics (Mullis et al., 2009). To gather data associated with the contextual variables that affect student learning, TIMSS administered background questionnaires to students, their teachers, and their school principals. TIMSS also administered curriculum questionnaires to specialists in each participating country to collect information about educational policies and the national contexts that shape the content and implementation of the mathematics curricula across countries. The TIMSS 2011 database includes contextual questionnaire responses provided by 239,960 eighth-grade mathematics students, 11,399 mathematics teachers, and 7,840 school principals from 42 countries.

Student questionnaires. Each student who took the TIMSS assessment was given a questionnaire to complete. The questionnaire asked students about their basic demographic information, home environment, school climate, and about their beliefs about their self-confidence in and the value of mathematics. The student questionnaire was designed to take 15-30 minutes to complete.

Teacher questionnaires. A teacher questionnaire was completed by the teachers of the students sampled to take part in the TIMSS 2011. The questionnaire was designed to gather information on teacher characteristics, the classroom contexts for teaching and learning mathematics, and the mathematics topics taught. The teacher questionnaire asked teachers specifically about their education, preparation, and experience; their opportunities for collaboration with colleagues and professional development, and their beliefs about their self-efficacy in teaching mathematics. The questionnaire also collected information on characteristics of the classroom environment: instructional time, materials, and activities for teaching mathematics and promoting student engagement; use of technology and tools; and assessment practices. This questionnaire required about 30 minutes to complete.

School questionnaires. The principal of each school participating in TIMSS was asked to respond to the school questionnaire. It asked about the school's climate and resources for learning, the practices of the administrator, the students' readiness for learning, involvement of parents, and the teaching staff. It was designed to take about 30 minutes to complete.

Curriculum questionnaires. The National Research Coordinator (NRC) in each country was responsible for completing the mathematics curriculum questionnaire which was designed to collect basic information about the organization of the mathematics curriculum in each country and the content intended to be covered up to the eighth grade. It also included questions on attrition and retention policies, local or national assessments, and standards for mathematics instruction (Mullis et al., 2009).

How the Items Were Derived

Although the majority of the TIMSS 2011 assessment items and questionnaires were carried over from TIMSS 2007 to allow measuring trends, the instruments are updated for each new TIMSS cycle to maintain relevance of the assessment to current learning goals and policy issues. In addition, new questionnaire items and scales are developed for each assessment because countries request particular information about particular issues (Mullis, Drucker, Preuschoff, Arora, & Stanco, 2012).

The TIMSS & PIRLS International Study Center uses a collaborative process to develop the new items needed for the mathematics achievement tests and questionnaires for each cycle. The process includes:

- updating the frameworks,
- developing items and their scoring guides in alignment with the frameworks,
- conducting a full-scale field test,

- selecting the assessment items based on the frameworks and field test results, and
- conducting training for reliably scoring constructed-response items (Mullis, Drucker, Preuschoff, et al., 2012).

Development of content items. NRCs and content experts from the participating countries collaborated to develop a bank of TIMSS test items and the scoring guides for constructed-response items. They also reviewed the items prior to and following the field test and selected the items for the assessment (Mullis, Drucker, Preuschoff, et al., 2012). Results from the field test were used to evaluate item difficulty, item discrimination between high- and low-performing students, the effectiveness of distractors in selected-response items, scoring suitability and reliability for constructed-response items, and evidence of bias toward or against individual countries or gender (Kastberg, Roey, Ferraro, Lemanski, & Erberber, 2013).

TIMSS 2011 used a matrix-sampling method in which the entire bank of mathematics items was packaged into a set of 14 student assessment booklets with approximately 12-18 items in each booklet. Within each booklet, the distribution of items across content and cognitive domains matched as closely as possible the distribution across the item pool overall. Each item appeared in two booklets so that student responses from the various booklets could be linked. Each student was given one booklet; the assessment time for each eighth-grade student booklet was designed to take 90 minutes to complete. An additional 30 minutes to complete the student questionnaire, after students completed the assessment, was also planned (Mullis et al., 2009).

Development of questionnaire items. Development of the background questionnaire items for TIMSS 2011 began with updating the contextual frameworks to reflect recent research findings about effective educational policies and practices. The NRCs then met to review and revise questionnaire items to ensure alignment with the goals of the contextual frameworks. The TIMSS questionnaire committee reviewed the revised drafts of the field test questionnaires for alignment with the contextual frameworks, analytic potential of the items and reporting scales, and clarity of the specific questions. The TIMSS & PIRLS International Study Center implemented the committee's recommendations, and the draft field test questionnaires were reviewed again by the NRCs. The NRCs made suggestions for final revisions which were then implemented by the TIMSS & PIRLS International Study Center. The field test questionnaires were finally provided to the NRCs for translation, production, and data collection (Mullis, Drucker, Preuschoff, et al., 2012).

Field test. A full-scale field test was conducted with a sample size of approximately 30 schools and 200 student responses in each participating country with the goal of yielding sufficient data to evaluate the validity and reliability of the various scales. The samples for the field test and the assessment were drawn simultaneously, using the same random sampling procedures. This ensured that field test samples closely approximated assessment samples and that a school was selected for either the field test or the assessment, but not both (Mullis, Drucker, Preuschoff, et al., 2012).

The TIMSS & PIRLS International Study Center reviewed and analyzed the field test data. Content items were eliminated from the item bank if they had poor measurement properties such as being too difficult or easy or having low discrimination.

Afterward, TIMSS & PIRLS International Study Center staff collaborated with the NRCs and the task force to assemble a set of recommended assessment booklets for review by the content item committee for content accuracy, clarity, and adherence to the frameworks (Mullis, Drucker, Preuschoff, et al., 2012).

Similarly, the TIMSS & PIRLS International Study Center prepared a set of questionnaires along with the field test data for review by the questionnaire committee. This expert committee reviewed each questionnaire item for clarity, examined the data to ensure that the options provide useful information, and made suggestions for refinements in preparation for data collection. Finally, NRCs met to review and approve all the assessment instruments. The TIMSS & PIRLS International Study Center made the final revisions and sent the newly developed assessment booklets and updated questionnaires to the countries for translation and adaptation (Mullis, Drucker, Preuschoff, et al., 2012).

How the Instrument is Scored

Two formats were used in each booklet of assessment items in the TIMSS—selected-response and constructed-response. At least half of the total points in each booklet were from selected-response items, worth one score point each. Most constructed-response items were worth one or two score points, depending on the nature of the task and the skills it required. Constructed-response items allowed for partial as well as full credit. Each booklet of eighth-grade items was created to provide about 18 score points.

Achievement Scales

The major purposes of the TIMSS mathematics assessment are to provide countries with information to (a) improve teaching and learning in mathematics and (b) measure trends in mathematics achievement over time. To this end, student responses are placed on common scales to provide an overall picture of the assessment results for each country and a common metric on which countries can compare their students' progress in mathematics from assessment to assessment. The TIMSS mathematics achievement scales were established in 1995 to have a scale average of 500 and a standard deviation of 100 (Mullis et al., 2009).

TIMSS uses item response theory (IRT) to describe student achievement and trends. Plausible values methodology is used to generate multiple imputed scores for each student (Rubin, 1987). Plausible values are not estimates of individual student scores, but rather are imputed scores for students with similar response patterns and background characteristics in the sampled population. TIMSS uses conditioning, combining student responses to the content items with information about students' contexts for learning, to improve the reliability of the student scores. The plausible values approach with conditioning uses all available data to estimate directly the characteristics of student populations and groups. TIMSS extracts five plausible values from each student's likely achievement distribution (Foy, Brossman, & Galia, 2012).

Context Scales

In addition to student achievement being scaled, TIMSS questionnaires were designed so that contexts for student learning could be scaled as well. Each questionnaire item addresses only a very small aspect of the construct it was intended to measure, but the questionnaires were designed so that multiple items can be grouped to provide overall indicators of their associated constructs (Preuschoff, 2011).

Most questions in the TIMSS questionnaires are closed-response, asking the participant to select a response from a range of two to five options that best describe the student's school, home, or classroom, or that indicates level of agreement with a statement. Some questions, however, are open-response, for example, asking for the number of computers that can be used by students in a school or the total amount of instruction time per day in a school. Each questionnaire was designed so that sets of individual items could be combined to form composite variables to measure constructs in effective home, school, and classroom contexts for learning (Mullis, Martin, Kennedy, Trong, & Sainsbury, 2009; Mullis, Martin, Ruddock, O'Sullivan, & Preuschoff, 2009).

Most questionnaire items in TIMSS 2011 were designed so that the response data from students, teachers, and principals could be combined into scales using the one-parameter Item Response Theory (Rasch) partial credit model to measure a single latent variable (Martin, Mullis, Foy, & Arora, 2012; Mullis, Drucker, et al., 2012). For example, Preuschoff (2011) used TIMSS 2007 to construct variables and scales for effective classroom environments for learning mathematics and students' motivation to learn mathematics. Combining a set of items into a composite variable provides a more reliable measure of a construct compared to a single item to represent a construct (DeVellis, 2003; Messick, 1989). This study used the methods that Preuschoff found successful in constructing these variables and scales to derive additional variables and scales to represent contexts for learning for which no preexisting scales were found.

After reviewing classic and recent literature for variables predicting student mathematics achievement, the author examined the TIMSS 2011 student, teacher, and school questionnaires for eighth-grade mathematics and categorized each item that could be associated with the contexts for learning that were identified in the review of literature. In the student questionnaire, approximately 64 questions were identified that related to home, student, school, and classroom contexts for learning mathematics; in the teacher questionnaire, there were approximately 156 questions related to home, student, school, and classroom contexts for learning mathematics; and in the school questionnaire there were approximately 80 questions related to home, student, school, and classroom contexts for learning mathematics.

Several of the constructs identified in the review of literature had variables which had already been empirically derived and scales already constructed from questionnaire items that this author had identified to represent those constructs. The constructs for which variables had previously been derived and scales constructed are shown in Table 3. For the remaining constructs for which no preexisting composite variables were found, the author derived variables from the identified questionnaire items that correspond to the constructs found in the review of literature. The variables derived by the author for this dissertation study are shown in Table 4. For each contextual variable included in this study, the author either (a) selected a variable previously derived from TIMSS 2011 questionnaire items or (b) derived a variable from TIMSS 2011 questionnaire items.

Variable derivation. The first step in a creating a scale to measure a latent construct was to derive a variable from a set of items that indicate that construct. The Rasch model assumes unidimensionality of the data, so principal components analyses

(PCA) were used in SPSS (23.0) to reduce the dimensionality of each set of identified items to one component (Bond & Fox, 2007). In each analysis, component loadings and shared variance were used to determine which items to retain or remove in deriving the variable. Component loadings of .50 or above were considered to provide evidence that the item related to the construct under investigation. Items with component loadings below .30 were considered to be unrelated to the construct under investigation and removed from each scale in this analysis. In addition, items that shared less than 9% of their variance with the component were considered to be unrelated to the component and removed (Comrey & Lee, 1992). One exception was an item in the composite variable Administrator Leadership that had a loading of .27; however, it accounted for 11.68% of the variance in the component, and that item was retained in the variable. Using this method, the author derived composite variables from each set of items identified in the TIMSS contextual questionnaires to measure each construct under investigation for which a previously-derived variable had not been found.

Table 3

Previously Existing Composite Variables and Scales

Domain	Related Variables	Questionnaire	Items
Parent education		Student	What is the highest level of education completed by your mother? What is the highest level of education completed by your father?
Self-efficacy in Mathematics		Student	I usually do well in mathematics I learn things quickly in mathematics I am good at working out difficult mathematics problems
School climate	School emphasis on academic success - teachers	Teacher	Teachers' understanding of the school's curricular goals Teachers' degree of success in implementing the school's curriculum Teachers' expectations for student achievement Parental support for student achievement Students' desire to do well in school
	School emphasis on academic success - principals	School	Teachers' understanding of the school's curricular goals Teachers' degree of success in implementing the school's curriculum Teachers' expectations for student achievement Parental support for student achievement Students' desire to do well in school

Table 3 (Continued)

School climate	School discipline and safety	School	To what degree is each of the following a problem among students in your school? Arriving late at school Absenteeism (i.e., unjustified absences) Classroom disturbance Cheating Profanity Vandalism Theft Intimidation or verbal abuse among students (including texting, emailing, etc.) Physical injury to other students Intimidation or verbal abuse of teachers or staff Physical injury to teachers or staff
School resources	Computer availability for instruction		Students per computer
School SES		School	Approximately what percentage of students in your school have the following backgrounds? Come from economically disadvantaged homes Come from economically affluent homes
Instruction	Instruction to engage students	Teacher	How often do you do the following in teaching this class? Summarize what students should have learned from the lesson Use questioning to elicit reasons and explanations Encourage all students to improve their performance Praise students for good effort

Table 3 (Continued)

Collaboration	Teacher	How often do you have the following types of interactions with other teachers? Discuss how to teach a particular topic Collaborate in planning and preparing instructional materials Share what I have learned about my teaching experiences Visit another classroom to learn more about teaching Work together to try out new ideas
Teacher experience	Teacher	By the end of this school year, how many years will you have been teaching?
Teacher knowledge	Teacher	What is the highest level of formal education you have completed?
Teacher self-efficacy	Teacher	In teaching mathematics, how confident do you feel to do the following? Answer students’ questions about mathematics Show students a variety of problem solving strategies Provide challenging tasks for capable students Adapt my teaching to engage students’ interest Help students appreciate the value of learning mathematics

Table 4

Author-Derived Composite Variables and Scales

Domain	Related Variables	Questionnaire	Items	Percent of Variance	Factor Loadings
Home possessions for learning	Possessions	Student	About how many books are there in your home?	47	-.641
			Computer		.809
			Study desk/table for your use		.641
			Internet connection		.809
			Books		.476
Parent expectations and involvement		Student	My parents ask me what I am learning in school	60	.786
			I talk about my schoolwork with my parents		.754
			My parents make sure that I set aside time for my homework		.797
			My parents check if I do my homework		.758
Value mathematics		Student	How much do you agree with these statements about your mathematics lessons?	57	
			I enjoy learning mathematics		.853
			I learn many interesting things in mathematics		.809
			I like mathematics		.846
			It is important to do well in mathematics		.597
			I am interested in what my teacher says		.754
			I think learning mathematics will help me in my daily life		.661
			I would like a job that involves using mathematics		.705

Table 4 (Continued)

Resources for general instruction		School	How much is your school's capacity to provide instruction affected by a shortage or inadequacy of the following?	58	
			Instructional materials (e.g., textbooks)		.768
			Supplies (e.g., papers, pencils)		.731
			School buildings and grounds		.815
			Heating/cooling and lighting systems		.725
			Instructional space (e.g., classrooms)		.823
			Technologically competent staff		.684
Resources for mathematics instruction		School	Teachers with a specialization in mathematics	63	.434
			Computers for mathematics instruction		.851
			Computer software for mathematics instruction		.894
			Library materials relevant to mathematics instruction		.852
			Audio-visual resources for mathematics instruction		.892
			Calculators for mathematics instruction		.757
School SES	Home resources limiting teaching	Teacher	To what extent do the following limit how you teach?	50	
			Students lacking prerequisite knowledge or skills		.745
			Students suffering from lack of basic nutrition		.614
			Students suffering from not enough sleep		.733
			Disruptive students		.728
			Uninterested students		.722
Administrator leadership		School	During the past year, approximately how much time have you spent on the following school leadership activities as a school principal?	47	
			Keeping an orderly atmosphere in the school		.826
			Ensuring that there are clear rules for student behavior		.851
			Addressing disruptive student behavior		.711
			Creating a climate of trust among teachers		.611

			Participating in professional development activities specifically for school principals		.272

Table 4 (Continued)

Access and equity	Mathematics instructional hours per year	Teacher	Instructional time mathematics hours per week	n/a	n/a
		School	Total instructional days per week		
		School	Total instructional days per year		
Access and equity	Mathematics topics	Teacher	Representing, comparing, ordering, and computing with integers	47	.649
			Problem solving involving percents and proportions		.646
			Numeric, algebraic, and geometric patterns or sequences		.590
			Simplifying and evaluating algebraic expressions		.771
			Simple linear equations and inequalities		.762
			Simultaneous Equations		.768
			Representation of functions as ordered pairs, tables, graphs, words, or equations		.692
			Points on the Cartesian Plane		.594
Instructional materials	Textbooks and worksheets	Teacher	When you teach mathematics to this class, how do you use the following resources?	51	
			Textbooks		.718
			Workbooks or worksheets		.718
Instructional materials	Technology and tools	Teacher	When you teach mathematics to this class, how do you use the following resources?	52	
			Concrete objects that help students understand quantities or procedures		.719
			Computer software for mathematics instruction (reverse coded)		.719
	Research-based practices	Teacher	In teaching mathematics to this class, how often do you usually ask students to do the following?	45	
			Work problems (individually or with peers) with my guidance		.471
			Explain their answers		.622
			Relate what they are learning in mathematics to their daily lives		.711

			Decide on their own procedures for solving complex problems		.787

Table 4 (Continued)

			Work on problems for which there is no immediately obvious method of solution		.732
Tools and technology	Calculator use	Teacher	How often do students in this class use calculators in their mathematics lessons for the following activities?	76	
			Check answers		.890
			Do routine computations		.881
			Solve complex problems		.877
			Explore number concepts		.847
	Computer use	Teacher	How often do you have the students do the following computer activities during mathematics lessons?	76	
			Explore mathematics principles and concepts		.889
			Practice skills and procedures		.891
			Look up ideas and information		.887
			Process and analyze data		.829
Assessment	Assessment question types	Teacher	How often do you include the following types of questions in your mathematics tests or examinations?	50	
			Questions involving application of mathematical procedures		.636
			Questions involving searching for patterns and relationships		.748
			Questions requiring explanations or justifications		.735
	Assessment emphasis	Teacher	How much emphasis do you place on the following sources to monitor students' progress in mathematics?	42	
			Evaluation of students' ongoing work		.579
			Classroom tests (for example, teacher-made or textbook tests)		.687
			National or regional achievement tests		.688

Table 4 (Continued)

Professional development	Teacher	In the past two years, have you participated in professional development in any of the following?	44	
		Mathematics content		.707
		Mathematics pedagogy/instruction		.668
		Mathematics curriculum		.726
		Integrating information technology into mathematics		.450
		Improving students' critical thinking or problem solving skills		.720
		Mathematics assessment		.704
		Addressing individual students' needs		.638
Teacher preparation	Teacher	Computing, estimating, or approximating with whole numbers	63	.820
		Concepts of fractions and computing with fractions		.902
		Concepts of decimals and computing with decimals		.896
		Representing, comparing ordering, and computing with integers		.886
		Problem solving involving percents and proportions		.851
		Simplifying and evaluating algebraic expressions		.638
		Simple linear equations and inequalities		.779
		Points on the Cartesian plane		.628
		Reading and displaying data using tables, pictographs, bar graphs, pie charts, and line graphs		.688

Partial credit model. After previously-derived variables were selected and new composite variables were derived to represent each construct identified in the review of literature, scales were constructed as metrics for the new composite variables. The pre-existing composite variables had been scaled using the one-parameter IRT (Rasch) model and its extension for polytomous items, the Partial Credit Model (Bond & Fox, 2007). This model has also been used successfully for scaling background questionnaire data in the International Association for the Evaluation of Educational Achievement's Civic Education Study (Schulz & Sibberns, 2004) and the Programme for International Student Assessment (Organization for Economic Cooperation and Development, 2014). The composite variables that were derived for this study were scaled with the same one-parameter IRT (Rasch) Partial Credit Model. ConQuest Generalized Item Response Modeling Software (Wu, Adams, Wilson, & Haldane, 2007) was used to estimate the Rasch item parameters and derive individual student scores for each latent variable.

Model fit. To fit the usual Rasch model, a set of data must be invariant and unidimensional (Bond & Fox, 2007). Invariance is stability of item and person parameters of a variable across repeated calibrations, and unidimensionality is the measurement of one single construct. The derivation of unidimensional composite variables through principal components analyses was described in the previous section. Rating-scale and partial-credit analyses yielded fit statistics to measure the invariance of each derived variable. The infit (weighted) mean-square statistic is the ratio of a chi-squared statistic to its degrees of freedom so that its scale has an expected value of one and ranges from zero to positive infinity. Infit statistics greater than 1.3 are considered to indicate a response pattern that was too haphazard with too much variation. Infit statistics less than .75 are considered to have a response pattern that was too determined with too little variation (Bond & Fox, 2007). Infit statistics for each item comprising each author-derived variable are provided in Appendix B. The infit statistic for every item in each scale fit within the .75-1.3 range except for one item in the variable Resources for Mathematics Instruction, MNSQ = 1.87). Items with weighted MNSQ between 1.5 and 2.0 are unproductive for construction of measurement but do not degrade the model (Linacre, 2002). Table 5 provides descriptive statistics for the 17 variables that were derived for this dissertation study.

Table 5

Summary Statistics of Composite Variables Derived by Author

Composite Variable	*N*	Possible Raw Score	Mean	*SD*	*SEM*	Cronbach's Alpha
Home possessions for learning	34,072	8	4.78	2.10	1.35	.59
Parent expectations involvement	33,949	12	8.11	3.40	1.72	.74
Value mathematics	33,986	21	14.60	4.95	2.15	.81
School resources for general instruction	32,416	18	6.16	4.67	1.83	.85
School resources for mathematics instruction	32,401	18	6.04	4.79	1.72	.87
Home resources limiting teaching	30,912	10	4.97	1.60	1.13	.68
Administrator leadership	33,851	10	8.06	1.79	1.12	.61
Mathematics topics taught	25,987	16	10.03	3.57	1.53	.82
Textbooks and worksheets for Instruction	30,887	4	2.71	.82	.81	.02
Tools and technology for instruction	30,900	4	2.62	.80	.78	.06
Research-based instruction	30,975	15	9.97	2.80	1.60	.67
Calculator use	17,098	12	5.96	3.49	1.23	.88
Computer use	10,064	12	3.29	3.02	1.00	.89
Assessment emphasis	30,433	6	4.22	1.06	1.13	.30
Assessment question types	30,681	6	4.38	1.10	.80	.47
Professional development	31,165	7	4.02	2.25	1.06	.78
Prepared to teach mathematics	26,134	18	15.94	3.13	.92	.91

Evaluation of Wright maps. Conquest software produces a map for each derived variable based on a graphical representation developed by Wright (1977) which orders questionnaire respondents and items on the same map from low to high so that item levels may be visually compared with the distribution of respondent scale scores. Wright maps relate item responses to locations on a scale, with item thresholds representing high levels of the variable shown higher on the map and item thresholds representing low levels of the variable shown lower on the map. Item thresholds that are located on the parts of the scale also covered by the scale score distribution indicate that item difficulties are approximately equivalent to respondents' abilities. The item map for each derived variable was examined for appropriate relationships of response thresholds and scale scores (Bond & Fox, 2007). Wright maps for each variable derived by the author are shown in Appendix B. The two variables derived to measure teachers' use of classroom assessment, assessment emphasis and assessment question types, showed mismatches of response thresholds and scale scores. The response thresholds for the two variables representing instructional materials, textbooks and worksheets for instruction and tools and technology for instruction, were also off the scale.

Scale transformation. After the data for each composite variable were determined whether they fit the Rasch model, individual student scores were obtained using maximum likelihood estimation in ConQuest. Conquest produces the most likely score for a student given the student's pattern of responses and the item parameters (Wu, Adams, Wilson, & Haldane, 2007). Scores are scaled in logit units with a mean of approximately zero and a standard deviation close to 1. Even though the logit metric theoretically ranges from minus infinity to plus infinity, it is typically represented from -4 to 4 (Ludlow & Haley, 1995). Logits may be difficult to interpret because they can take both negative and decimal values, so Schulz and Sibberns (2004) transformed logit units to a scale with a mean of 10 and a standard deviation of two. The transformation yields a scale still with decimals, but no negative values. The same metric was selected for the scales to be used in this dissertation study; the person parameters were transformed from the logit metric to a metric with a mean of 10 and a standard deviation of two.

Validity

The validity of an assessment is the degree to which evidence supports the intended interpretation of assessment scores for the proposed use of the assessment; so, in evaluating validity, it is the intended interpretations of scores for proposed uses that are evaluated, not the test itself (American Educational Research Association, American Psychological Association, & National Council on Measurement in Education, 2014). The intended uses of TIMSS are to provide countries with information to (a) improve teaching and learning in mathematics and (b) measure trends in mathematics achievement over time. The information in the preceding sections of this chapter such as the sampling of schools, classes, and students; development of the both the content and questionnaire items; and field testing; and scoring procedures include some of the evidence that supports the interpretations of results from TIMSS 2011 for their uses described above.

In addition to procedures described in previous sections of this chapter, TIMSS 2007 background questionnaires were updated for TIMSS 2011 to improve the questionnaires conceptually and empirically. Background questionnaire development began with updating the contextual frameworks to reflect recently published research literature about effective educational policies and practices. The questionnaires were then updated in alignment with the frameworks, so that they measured salient aspects of effective learning environments. The contextual questionnaires were developed with an emphasis on producing reliable scales that would provide valid measurement of effective home, school, and classroom environments for learning. The questionnaire development process included adding questionnaire items to strengthen existing measures, such as the self-confidence in learning mathematics scale and the index of school discipline and attendance problems (Mullis, Drucker, Preuschoff, et al., 2012).

Reliability

Foy, Martin, Mullis, and Stanco (2012) reported reliability coefficients for the TIMSS 2011 in eighth grade mathematics achievement scores in each participating country. Yemen, with a reliability coefficient of .57, was the only participating country that had a reliability coefficient less than .70. The median reliability coefficient was .82. Reliability coefficients were also computed for the questionnaire scales that were created for this dissertation study. The Cronbach’s Alpha reliability coefficients for these scales are provided in Table 5.

Research Design

Research Methodology

In TIMSS 2011, students were nested within schools, a hierarchical structure. Predictors of mathematics achievement at the student level included (a) family/home-related variables such as home possessions for learning, parent educational attainment, and parent expectations for and involvement in their children’s education; and (b) student beliefs, specifically, their self-confidence in mathematics and value of mathematics. Predictors of mathematics achievement at the school level included (a) school-related variables in domains such as school climate, school resources, administrator leadership, and school socioeconomic status; and (b) teaching/classroom-related variables in domains such as access and equity, curriculum, tools and technology, assessment, and professionalism of the teacher.

Multilevel models are useful for analyzing hierarchically-structured data. The primary purpose of multilevel modeling is to describe the specific relationships between the lower-level (in this case, student) and higher-level (in this case, school) predictors and the dependent variable (Kreft & De Leeuw, 1998). In the TIMSS 2011, students were nested in classes, and one class was sampled in most cases for each selected school. If school-level variables are disaggregated to the student level, then the assumption of independence of observations would be violated and standard errors would be smaller than they should. Conversely, if the student-level variables are aggregated to the school level, then the within-group information would be lost and interpretation restricted to the school level (Hox, 2002; Tabachnick & Fidell, 2007). To address the proposed research questions, a two-level hierarchical linear model was utilized. The Level-1 models represent the relationships among the student-level variables, and the Level-2 models represent the school-level variables (Raudenbush, Bryk, Cheong, Congdon, & du Toit, 2011).

Independent and Dependent Variables

The dependent variables of the study are the five plausible values in mathematics estimated for each eighth-grade TIMSS participant. The independent variables are listed in Table 6 in four contexts of learning: the participant’s family/home, beliefs, school, and classroom/teacher. All independent variables were derived from TIMSS 2011 questionnaire items.

Table 6

Independent Variables

Context for Learning	Composite Variable	Variable derived by
Home	Home possessions for learning	Author
	Parent educational attainment	TIMSS
	Parent expectations and involvement	Author
Student beliefs	Self-efficacy in mathematics	TIMSS
	Value of mathematics	Author
School	School emphasis on academic success (teachers)	TIMSS
	School emphasis on academic success (principals)	TIMSS
	School discipline and safety	TIMSS
	School computers available for instruction	TIMSS
	School resources for general instruction	Author
	School resources for mathematics instruction	Author
	Administrator leadership	Author
	School students economically disadvantaged	TIMSS
	Home resources limiting teaching	Author
Teacher	Mathematics instructional hours per year	Author
	Mathematics topics taught	Author
	Instructional materials—textbooks worksheets	Author
	Instructional materials—technology and tools	Author
	Instruction to engage students	TIMSS
	Research-based instructional practices	Author
	Tools and technology—calculator use	Author
	Tools and technology —computer use	Author
	Assessment question types	Author
	Classroom emphasis on assessment	Author
	Professional development	Author
	Teacher collaboration	TIMSS
	Teacher experience	TIMSS
	Teacher knowledge	TIMSS
	Teacher preparation	Author
	Teacher self-efficacy	TIMSS

Advantages and Disadvantages of Design

One advantage of using multilevel models for hierarchically-structured data over conventional regression is that predictors can be analyzed both within and between groups. Another advantage is that multilevel models account for the condition that nested observations are not independent, because individuals who belong to the same group tend to have and be influenced by similar characteristics, and thus error terms tend to be correlated resulting in smaller standard errors and a greater chance of committing Type I errors. Multilevel models can estimate appropriate unbiased errors by accounting for both within- and between-group variability at two or more levels simultaneously. In addition, multilevel models can estimate cross-level effects that conventional regression models cannot (Luke, 2004).

The inclusion of many variables in the research design.—five at Level 1 and 22 at Level 2—introduces potential complications. First, the more independent variables included in a regression model, the more likely it is that some of them will be correlated with and influence one another. Individual variables may then differ in their relative importance and even direction in their relationship with the dependent variable, depending on the other independent variables with which they are combined in a given model. Therefore, a given variable used in multiple models composed of different combinations from a pool of independent variables may differ in its relationship to the dependent variable depending on the other independent variables with which it is combined. This complicates the interpretation of a variable's overall relative importance in the research design (Nathans, Oswald, & Nimon, 2012; Reichwein Zientek & Thompson, 2006).

Second, the number of variables in this study makes unfeasible the modeling and analyzing of every combination of independent variables to find the most efficient model possible. The design for this study, which is to enter Level-1 variables stepwise into the unconditional model and Level-2 variables stepwise into the combined Level-1 model and then combine the variables with statistically significant relationships with mathematics achievement, was selected to balance optimal modeling with feasibility. Because of the potential consequences of having many variables in a regression analyses, it is possible, perhaps even likely, that the final model chosen for each country is not the most efficient combination of variables that exists among the variables in the study; rather the final model chosen will be the most efficient model of the ones that were included in the research design (Reichwein Zientek & Thompson, 2006). Even though the research design did not include creation of every possible combination of independent variables in this study, the theory-driven stepwise design is an acceptable compromise (Nathans et al., 2012).

Threats to Internal and External Validity

Because many contextual variables in the TIMSS cannot be measured directly, the questionnaire items represent proxy measurements for many constructs. For example, students' home possessions for learning are used as a measurement of students' socioeconomic status, school rates of student behavior problems are used as a measurement of school climate, and teacher educational attainment is used as a measurement of teacher knowledge. The use of these proxy variables in place of directly collected measures may contribute to measurement error.

Many of the measures in this dissertation study were self-reported by students, teachers, and school principals and may be another source of measurement error. Measures which may be especially susceptible to self-reporting bias include (a) student reports of their parents' expectations and involvement, the extent of their performance in mathematics, or the extent to which they value mathematics; (b) principal reports of their use of leadership practices; and (c) teacher reports of their use of research-based instructional practices, tools and technology, and assessment.

Hierarchical Linear Modeling

HLM is a method for statistical analysis of nested relationships such as the TIMSS in which variables associated with student homes and beliefs and their schools and classes can be examined simultaneously and in relationship with each other. TIMSS 2011 measured mathematics achievement with student participants from primarily one intact class with one teacher per school, resulting in a two-level nesting design. Variables related to students and their homes were analyzed with HLM at Level 1, and variables related to students' schools and classes were analyzed with HLM at Level 2. HLM allows investigation of these nested relationships by appropriately parsing the variance at each level.

Special Considerations

Three characteristics of the TIMSS design require special handling for analyses of its data. First, TIMSS uses five plausible values rather than a single score for the measure of mathematics achievement. Second, the complex sampling design requires sampling weights to elicit unbiased estimates of population parameters. Third, standard errors must be calculated with special procedures (Kastberg et al., 2013).

Plausible values. The TIMSS assessment design was based on Balanced Incomplete Block (BIB) spiraling of assessment items to increase mathematics content coverage without a corresponding increase in the assessment time demanded of students.

The procedure was that each student completed only a subset of the total pool of assessment items. The trade-off for increased content coverage through BIB spiraling was increased measurement error in the scores available for each student. The increased error was then accommodated through the estimation of five plausible values for each student rather than a single point estimate.

Plausible values are random draws from the estimated distribution of a student's achievement. The appropriate method for handling plausible values as outcome variables in regression analyses is that the analyses need to be conducted once with each plausible value and the results averaged. It is not legitimate to average the plausible values before analysis and then regress this mean on predictor variables (Kastberg et al., 2013). HLM 7 software used in this study accommodates the use of plausible values.

Sampling weights. The student sampling weight in TIMSS is a combination of weighting components reflecting selection probabilities and sampling outcomes at the school, class, and student levels. At each level, the weighting component is the inverse of the probability of selection at that level and includes an adjustment for nonparticipation. The school weight for a sampled school is the inverse of the probability of that school being sampled according to probability proportional to school size. The class-within-school weight for a sampled class is the inverse of the probability of the class being selected from all of the classes in its school. The student weight is the inverse of the probability of a student in a sampled class being selected. Generally, intact classes were sampled so that all students in the class were included with probability of one. The overall student sampling weight is the product of the final weighting components for school, class (within school), and student (within class).

All student data reported in the TIMSS international reports were weighted by the overall student sampling weight, known as TOTWGT in the TIMSS international databases (Joncas & Foy, 2012). TOTWGT is the recommended weight for student-level between-country analyses, SCHWGT is the recommended weight for school-level analyses, and MATWGT is the recommended weight for analyses linking mathematics teacher-level data to student data (Foy, Arora, & Stanco, 2013). These three weights were used at the recommended levels in the HLM analyses.

Standard errors. The BIB spiraling used in TIMSS testing procedures and resulting plausible values do not produce observed standard errors, so standard errors must be estimated. Parameter estimates are produced using the plausible values and the method previously described for analysis using the plausible values. First, each parameter is estimated for each of the five plausible values, and the five estimates are averaged. Then the standard error for the average estimate is calculated using the average of the sampling error from the five estimates and the variance between the five estimates. The HLM 7 software accommodates the special procedures required to estimate the measurement error (Raudenbush et al., 2011).

Model Equations

Unconditional models. HLM modeling typically begins with an unconditional model containing only the grouping variable—in this study, schools—and the dependent variable—in this study, the five plausible values of mathematics achievement. The unconditional model partitions the variance of student mathematics achievement into between-school and within-school components. In this study, the unconditional model for student mathematics scores addressed the question, “Is there a school-level effect on the student-level mathematics scores?” If there is a school-level effect, then ordinary regression methods are not appropriate because they will not account for that effect, and a multi-level model is needed to explain variance at both levels.

Equation 1 shows the student-level component of the unconditional model, and Equation 2 shows the school-level component.

Student level:

$$\mathrm{MATACH}_{ij} = \beta_{0j} + r_{ij} \qquad \text{(Eq. 1)}$$

School level:

$$\beta_{0j} = \gamma_{00} + u_{0j} \qquad \text{(Eq. 2)}$$

Mixed model:

$$\mathrm{MATACH}_{ij} = \gamma_{00} + u_{0j} + r_{ij} \qquad \text{(Eq. 3)}$$

In all the models of this study, MATACH_{ij} represents the five plausible values for mathematics achievement for student *i* nested in school *j;* β_{0j} is the mean mathematics achievement for school *j*; γ_{00} is the school-level intercept representing the mean mathematics achievement across all schools; u_{0j} is the random error associated with student *i* in school *j* representing the variation in the overall mean school achievement for school *j*; and r_{ij} is the residual error, the variance associated with school *j* unaccounted for by the predictors in the model. The random component u_{0j} is the feature of HLM that distinguishes it from single-level regression because it allows the intercepts of schools to vary. Single-level regression calculates only one intercept and assumes it to be equal across schools. HLM relaxes this assumption, estimating the intercepts freely and the relationships between variables more accurately (Anderson, 2012).

Models for home-related variables. The review of literature regarding variables of a student's home or family that predict mathematics achievement elicited three primary variables: home possessions for learning, parent educational attainment, and parent expectations and involvement in their education. TIMSS 2011 background questionnaires of students contained items that addressed these variables related to students' homes. Composite variables were derived from these items to measure these predictors related to students' homes.

The three student home-related variables of home possessions for learning, parent educational attainment, and parent expectations and involvement in their children's education were entered separately into each country's unconditional model to examine the extent to which these home-related variables accounted for variance in student mathematics achievement. Then, all of the statistically significant home-related variables were entered together into the unconditional model to construct a combined home-related variables model. Equation 4 shows Level 1 of the mathematical model for the relationship between home-related variables and eighth-grade mathematics achievement in each country. The school-level equations are shown in Equations 5-8, and the mixed model for home-related variables is shown in Equation 9.

Student level:

$$\text{MATACH}_{ij} = \beta_{0j} + \beta_{1j}*(\text{HOMVAR1}_{ij}) + \beta_{2j}*(\text{HOMVAR2}_{ij}) + \beta_{3j}*(\text{HOMVAR3}_{ij}) + r_{ij} \qquad \text{(Eq. 4)}$$

School level:

$$\beta_{0j} = \gamma_{00} + u_{0j} \qquad \text{(Eq. 5)}$$

$$\beta_{1j} = \gamma_{10} + u_{1j} \qquad \text{(Eq. 6)}$$

$$\beta_{2j} = \gamma_{20} + u_{2j} \qquad \text{(Eq. 7)}$$

$$\beta_{3j} = \gamma_{30} + u_{3j} \qquad \text{(Eq. 8)}$$

Mixed Model:

$$MATACH_{ij} = \gamma_{00} + \gamma_{10}* HOMVAR1_{ij} + \gamma_{20}* HOMVAR2_{j} + \gamma_{30}* HOMVAR3_{iij} + u_{0j}$$

$$+ u_{1j}* HOMVAR1_{ij} + u_{2j}* HOMVAR2_{ij} + u_{3j}* HOMVAR3_{iij} + r_{ij} \quad \text{(Eq. 9)}$$

Models for student-beliefs variables. The review of literature regarding variables of student beliefs that predict mathematics achievement elicited two primary predictors: self-confidence in mathematics and value of mathematics. TIMSS 2011 background questionnaires of students contained items that addressed these variables related to student beliefs. Composite variables were derived from these items to measure these predictors related to student beliefs.

The two student-beliefs variables of self-confidence in mathematics and value mathematics were entered separately into each country's unconditional model to examine the extent to which these student-belief variables accounted for variance in student mathematics achievement. Then, if both of the student-belief variables were statistically significant, they were entered together into the unconditional model to construct a combined student-beliefs variables model. Equation 10 shows Level 1 of the mathematical model for the relationship between student-belief variables and eighth-grade mathematics achievement in each country. The school-level equations are shown in Equations 11-13, and the mixed model for student-belief variables is shown in Equation 14.

Student Level:

$$MATACH_{ij} = \beta_{0j} + \beta_{1j}*(STUVAR1_{ij}) + \beta_{2j}*(STUVAR2_{ij}) + r_{ij} \qquad \text{(Eq. 10)}$$

School level:

$$\beta_{0j} = \gamma_{00} + u_{0j} \qquad \text{(Eq. 11)}$$

$$\beta_{1j} = \gamma_{10} + u_{1j} \qquad \text{(Eq. 12)}$$

$$\beta_{2j} = \gamma_{20} + u4 \qquad \text{(Eq. 13)}$$

Mixed Model:

$$MATACH_{ij} = \gamma_{00} + \gamma_{10}*STUVAR1_{ij} + \gamma_{20}*STUVAR2_{ij} + u_{0j} + u_{1j}*STUVAR1_{ij} + u_{2j}*STUVAR2_{ij} + r_{ij} \qquad \text{(Eq. 14)}$$

Models for school-related variables. The review of literature regarding variables of a student's school that predict mathematics achievement elicited four primary domains: school climate, school resources, administrator leadership, and school socioeconomic status. TIMSS 2011 background questionnaires contained items that addressed these variables related to students' schools. Composite variables were derived from these items to measure these variables related to students' schools.

The nine school-related variables representing domains of school climate, school resources, administrator leadership, and school socioeconomic status were entered separately into each country's full Level-1 model composed of all the statistically significant Level -1 predictors to examine the extent to which these school-related variables accounted for variance in student mathematics achievement. For the school-level domains that had two or more variables, all of the statistically significant school-related variables were entered into the full Level -1 model together to construct a combined model for that domain. Finally, all of the statistically significant school-related variables were entered into the full Level -1 model to construct a combined school-related variables model. Equation 15 shows Level 1 of the mathematical model for the relationship between school-related variables and eighth-grade mathematics achievement in each country. The Level 2 equations are shown in Equations 16-21, and the mixed model for school-related variables is shown in Equation 22.

Student level:

$$\text{MATACH}_{ij} = \beta_{0j} + \beta_{1j}*(\text{HOMVAR1}_{ij}) + \beta_{2j}*(\text{HOMVAR2}_{ij}) + \beta_{3j}*(\text{HOMVAR3}_{ij}) + \beta_{4j}*(\text{STUVAR1}_{ij}) + \beta_{5j}*(\text{STUVAR2}_{ij}) + r_{ij} \qquad \text{(Eq. 15)}$$

School level:

$$\beta_{0j} = \gamma_{00} + \gamma_{01}*(\text{SCHVAR1}_{j}) + \gamma_{02}*(\text{SCHVAR2}_{j}) + \gamma_{03}*(\text{SCHVAR1}_{j}) + u_{0j} \qquad \text{(Eq. 16)}$$

$$\beta_{1j} = \gamma_{10} + u_{1j} \qquad \text{(Eq. 17)}$$

$$\beta_{2j} = \gamma_{20} + u_{2j} \qquad \text{(Eq. 18)}$$

$$\beta_{3j} = \gamma_{30} + u_{3j} \qquad \text{(Eq. 19)}$$

$$\beta_{4j} = \gamma_{40} + u_{4j} \qquad \text{(Eq. 20)}$$

$$\beta_{5j} = \gamma_{50} + u_{5j} \qquad \text{(Eq. 21)}$$

Mixed Model:

$$\text{MATACH}_{ij} = \gamma_{00} + \gamma_{01}*\text{SCHVAR1}_{j} + \gamma_{02}*\text{ SCHVAR2}_{j} + \gamma_{03}*\text{ SCHVAR3}_{j} + \gamma_{10}*\text{ HOMVAR1}_{ij} + \gamma_{20}*\text{ HOMVAR2}_{ij} + \gamma_{30}*\text{ HOMVAR3}_{ij} + \gamma_{40}*\text{ STUVAR1}_{ij} + \gamma_{50}*\text{ STUVAR2}_{ij} + u_{0j}+ u_{1j}*\text{ HOMVAR1}_{ij} + u_{2j}*\text{ HOMVAR1}_{ij} + u_{3j}*\text{ HOMVAR3}_{ij} + u_{4j}*\text{ STUVAR1}_{ij} + u_{5j}*\text{ STUVAR2}_{ij} + r_{ij} \qquad \text{(Eq. 22)}$$

Models for teacher-related variables. The review of literature regarding variables of a student's teacher or classroom that predict mathematics achievement elicited five primary domains: access and equity, instruction, tools and technology, assessment, and teacher professionalism. TIMSS 2011 background questionnaires of teachers contained items that addressed these variables related to students' teachers. Composite variables were derived from these items to measure these variables related to students' teachers.

The 12 teacher-related variables representing teacher-level domains of access and equity, instruction, assessment, and teacher professionalism were entered separately into each country's full Level-1 model composed of all the statistically significant Level-1 predictors to examine the extent to which these teacher-related variables accounted for variance in students' mathematics achievement. The variables representing tools and technology were not included in the HLM because in all three countries included in this study, the missing data for items composing these variables diminished the sample size for such each country to too great an extent to include them in the full model. Tools and technology were studied separately in an exploratory analysis to preserve the sample size for the full HLM model.

After the variables in each teacher-related domain were added separately to the full Level-1 model, then all of the statistically significant variables in that domain were entered into the full Level-1 model together to construct a combined model for that domain. Finally, all the teacher-related variables that were statistically significant were entered together into the Level-1 full model to construct a combined teacher-related variables model. Equation 23 shows Level 1 of the mathematical model for the relationship between teacher-related variables and eighth-grade mathematics achievement in each country. The school-level equations are shown in Equations 24-29, and the mixed model for teacher-related variables is shown in Equation 30.

Student level:

$$\mathrm{MATACH}_{ij} = \beta_{0j} + \beta_{1j}*(\mathrm{HOMVAR1}_{ij}) + \beta_{2j}*(\mathrm{HOMVAR2}_{ij}) + \beta_{3j}*(\mathrm{HOMVAR3}_{ij}) + \beta_{4j}*(\mathrm{STUVAR1}_{ij}) + \beta_{5j}*(\mathrm{STUVAR2}_{ij}) + r_{ij} \qquad \text{(Eq. 23)}$$

School level:

$$\beta_{0j} = \gamma_{00} + \gamma_{01}*(\mathrm{TCHVAR1}_{j}) + \gamma_{02}*(\mathrm{TCHVAR2}_{j}) + \gamma_{03}*(\mathrm{TCHVAR1}_{j}) + u_{0j} \qquad \text{(Eq. 24)}$$

$$\beta_{1j} = \gamma_{10} + u_{1j} \qquad \text{(Eq. 25)}$$

$$\beta_{2j} = \gamma_{20} + u_{2j} \qquad \text{(Eq. 26)}$$

$$\beta_{3j} = \gamma_{30} + u_{3j} \qquad \text{(Eq. 27)}$$

$$\beta_{4j} = \gamma_{40} + u_{4j} \qquad \text{(Eq. 28)}$$

$$\beta_{5j} = \gamma_{50} + u_{5j} \qquad \text{(Eq. 29)}$$

Mixed Model:

$$\mathrm{MATACH}_{ij} = \gamma_{00} + \gamma_{01}*\mathrm{TCHVAR1}_{j} + \gamma_{02}*\mathrm{TCHVAR2}_{j} + \gamma_{03}*\mathrm{TCHVAR3}_{j} + \gamma_{10}*\mathrm{HOMVAR1}_{ij} + \gamma_{20}*\mathrm{HOMVAR2}_{ij} + \gamma_{30}*\mathrm{HOMVAR3}_{ij} + \gamma_{40}*\mathrm{STUVAR1}_{ij} + \gamma_{50}*\mathrm{STUVAR2}_{ij} + u_{0j} + u_{1j}*\mathrm{HOMVAR1}_{ij} + u_{2j}*\mathrm{HOMVAR1}_{ij} + u_{3j}*\mathrm{HOMVAR3}_{ij} + u_{4j}*\mathrm{STUVAR1}_{ij} + u_{5j}*\mathrm{STUVAR2}_{ij} + r_{ij} \qquad \text{(Eq. 30)}$$

Full model. All the statistically significant Level-2 variables representing school- and teacher-related variables were entered together into each country's full Level-1 model composed of all the statistically significant Level-1 predictors to examine the extent to which all the statically significant variables together accounted for variance in student mathematics achievement. Equation 31 shows Level 1 of the mathematical model for the relationship between the combined Level-2 variables and eighth-grade mathematics achievement in each country. The Level-2 equations are shown in Equations 32-37, and the mixed model for Level-2 variables is shown in Equation 38.

Student level:

$$\text{MATACH}_{ij} = \beta_{0j} + \beta_{1j}*(\text{HOMVAR1}_{ij}) + \beta_{2j}*(\text{HOMVAR2}_{ij}) + \beta_{3j}*(\text{HOMVAR3}_{ij})$$

$$+ \beta_{4j}*(\text{STUVAR1}_{ij}) + \beta_{5j}*(\text{STUVAR2}_{ij}) + r_{ij} \qquad \text{(Eq. 31)}$$

School level:

$$\beta_{0j} = \gamma_{00} + \gamma_{01}*(\text{SCHVAR1}_{j}) + \gamma_{02}*(\text{SCHVAR2}_{j}) + \gamma_{03}*(\text{SCHVAR1}_{j}) + \gamma_{04}*(\text{TCHVAR1}_{j})$$

$$+ \gamma_{05}*(\text{TCHVAR2}_{j}) + \gamma_{06}*(\text{TCHVAR1}_{j}) + u_{0j} \qquad \text{(Eq. 32)}$$

$$\beta_{1j} = \gamma_{10} + u_{1j} \qquad \text{(Eq. 33)}$$

$$\beta_{2j} = \gamma_{20} + u_{2j} \qquad \text{(Eq. 34)}$$

$$\beta_{3j} = \gamma_{30} + u_{3j} \qquad \text{(Eq. 35)}$$

$$\beta_{4j} = \gamma_{40} + u_{4j} \qquad \text{(Eq. 36)}$$

$$\beta_{5j} = \gamma_{50} + u_{5j} \qquad \text{(Eq. 37)}$$

Mixed Model:

$$\text{MATACH}_{ij} = \gamma_{00} + \gamma_{01}*\text{SCHVAR1}_{j} + \gamma_{02}*\text{SCHVAR2}_{j} + \gamma_{03}*\text{SCHVAR3}_{j} +$$

$$\gamma_{04}*\text{TCHVAR1}_{j} + \gamma_{05}*\text{TCHVAR2}_{j} + \gamma_{06}*\text{TCHVAR3}_{j} + \gamma_{10}*\text{HOMVAR1}_{ij} +$$

$$\gamma_{20}*\text{HOMVAR2}_{ij} + \gamma_{30}*\text{HOMVAR3}_{ij} + \gamma_{40}*\text{STUVAR1}_{ij} + \gamma_{50}*\text{STUVAR2}_{ij}$$

$$+ u_{0j}+ u_{1j}*\text{HOMVAR1}_{ij} + u_{2j}*\text{HOMVAR1}_{ij} + u_{3j}*\text{HOMVAR3}_{ij} + u_{4j}*\text{STUVAR1}_{ij} +$$

$$u_{5j}*\text{STUVAR2}_{ij} + r_{ij} \qquad \text{(Eq. 38)}$$

Summary

The purpose of this study was to investigate four questions across three countries representing a wide range of cultures and levels of mathematics achievement:

1. To what extent do home-related variables (home possessions for learning, parent educational attainment, and parent expectations for and involvement in their children's education) predict eighth-grade mathematics achievement in each country?
2. To what extent do student beliefs (self-confidence in learning mathematics, value of mathematics) predict eighth-grade mathematics achievement in each country?
3. To what extent do school-related variables (school climate, school resources, administrator leadership, and school socioeconomic status) predict eighth-grade mathematics achievement in each country?
4. To what extent do teaching-related variables (access and equity, curriculum, tools and technology, assessment, and teacher professionalism) predict eighth-grade mathematics achievement in each country?

To address the proposed research questions, a two-level hierarchical linear model was used. Level 1 represents the relationships among the student-level variables, and Level 2 represents the school-level variables. The results of this study extend the present understanding of the contexts and variables that may predict mathematics achievement in countries across a range of cultures, socioeconomic development, and academic achievement.

CHAPTER IV

RESULTS

This chapter describes how 26 variables associated with students' homes, beliefs, schools, and teachers related to mathematics achievement in three countries that participated in TIMSS 2011—Chinese Taipei, Ghana, and the United States. Multilevel modeling was used to investigate the relationships between these variables and mathematics achievement in each of the three countries.

Missing Data

Before the creation of any multilevel models, all the predictor variables were examined for missing data. Each of the predictor variables in both levels 1 and 2 had some missing response data from students, teachers, or schools in at least one of the three countries. Calculator use and computer use at the school level, in particular, had a large number of non-responses in all three countries. Table 7 shows the amount of missing data compared to valid data for class calculator use and class computer use in each country. Missing data and valid data for the predictor research-based practices, which had more typical response rates, was included in the table for comparison purposes. If the variables calculator use and computer use were included in the full model, the sample sizes for each country would be reduced by more than half. Therefore, those two variables were examined in separate exploratory models rather than being included in the full model of this study.

Table 7

Missing School-Level Data for Class Calculator Use and Class Computer Use Compared with Research-Based Practices

Country		Class calculator use	Class computer use	Research-based practices
Chinese Taipei	Valid	2,226	1,194	5,042
	Missing	2,816	3,848	0
Ghana	Valid	1,168	826	7,661
	Missing	6,679	7,021	186
U.S.	Valid	6,707	3,335	7,649
	Missing	3,134	6,506	2,192

Table 8 shows the sample size differences between the unconditional models and full models due to non-responses for items used in predictor variables in each country examined in this study. Listwise deletion of cases was selected as the method of handling missing data when creating the HLM files.

Table 8

Sample Sizes for Each Country in Unconditional and Full Models

Country	Students			Schools		
	Unconditional	Full	%	Unconditional	Full	%
Chinese Taipei	5,042	4,090	81.12	150	135	90.00
Ghana	7,847	4,016	51.18	161	97	60.25
U.S.	9,841	4,140	40.07	470	266	56.60

Multilevel Variance

For each country in this study, the HLM began with an unconditional model to determine the variance of student mathematics achievement attributable to differences both between schools and within schools. A greater between-school variance indicates a greater need for a multi-level model to explain variance at both levels.

Table 9 provides the results for the three unconditional models that were created for this study—one model for each of the countries. The chi-square result (χ^2) was statistically significant ($p < .001$) for each of the countries, indicating there is sufficient variance in mathematics achievement between schools to justify using HLM.

The intraclass correlation coefficient (ICC) is another measure that can be calculated from an unconditional model to determine whether a multilevel model is needed to explain variability in student mathematics achievement is. The ICC is the ratio of the between-school variance ($\hat{\tau}_{00}$) to the total variance—between-school and within-school variance ($\hat{\sigma}^2$)—as shown in Equation 39.

$$\text{ICC} = \frac{\hat{\tau}_{00}}{(\hat{\tau}_{00} + \hat{\sigma}^2)} \qquad \text{(Eq. 39)}$$

The ICC is a measure of the dependence of observations on the influence of groups (Hox, 2002). For example, an ICC of .55 in U.S. mathematics achievement scores as shown in Table 9 indicates that the influence of schools accounts for 55% of the variability in mathematics achievement among students, and 45% of the variability is at the student level within schools. An HLM is beneficial because it accounts for the variability at both levels, and ordinary regression models do not.

Table 9

Variance Components and Percentage of Total Variance in Unconditional Models

Country	Between-school variance	Within-school variance	χ^2	*p*	Variation between schools	Variation within schools
Chinese Taipei	2,317.05	8,233.28	1,315.55	<.001	22%	78%
Ghana	3,268.37	4,327.91	3,043.88	<.001	43%	57%
U.S.	2,928.12	2,372.31	6,013.34	<.001	55%	45%

Results for Chinese Taipei

Descriptive Statistics

Descriptive statistics for the dependent variable of mathematics achievement and student-level independent variables for Chinese Taipei are shown in Table 10. Mathematics achievement is the outcome variable; Chinese Taipei had the third highest mean scale score of mathematics achievement (*M* = 615.17, *SD* = 101.34) of the 42 countries that participated in the TIMSS 2011 eighth-grade mathematics assessment. Home possessions for learning, parent education, and parent expectations and involvement are the three home-related predictors; and self-confidence in mathematics and value mathematics are the two student-belief predictors. Scale scores of three of the five Level-1 predictors were transformed to have a mean of 10 and standard deviation of two across the countries in this study. An exception is the variable value mathematics for which scores have a mean of 10 and a standard deviation of 65. Scores for parent education were not transformed because they were already relatively easy to interpret. For example, in Chinese Taipei, students' parents typically had upper secondary educational attainment (*M* = 2.45, *SD* = 1.05). Perhaps the most surprising of Chinese

Taipei's descriptive statistics was the relatively low value students indicated for mathematics as an area of study (*M* = -36.87, *SD* = 59.47).

Table 10

Level 1 Descriptive Statistics for Chinese Taipei (N = 4,090)

Domain	Variable	*M*	*SD*	Min	Max
	Mathematics achievement	615.17	101.34	166.42	918.1
Home resources	Home possessions for learning	10.81	1.64	5.08	13.42
	Parent education	3.56	1.05	1	5
	Parent expectations and involvement	8.86	2.01	4.99	13.19
Student beliefs	Self-confidence in mathematics	8.62	2.38	3.18	15.82
	Value mathematics	-36.87	59.47	-196.87	134.18

Descriptive statistics for the school-level independent variables for Chinese Taipei are shown in Table 11. Like the Level-1 predictors, most scale scores for Level-2 predictors were transformed to have a mean of 10 and standard deviation of two to facilitate interpretation. Exceptions to this were computer availability for instruction, students economically disadvantaged, mathematics instructional hours per year, teacher experience, and teacher education. The scale for computer availability for instruction corresponds to fewer computers per students as the value increases from one to four, and results for computer availability for instruction (*M* = 2.7, *SD* = .59) in Chinese Taipei indicate that computer availability typically approached one computer for six or more or more students, the lowest availability of the three countries studied for this dissertation. School administrators reported that their students typically were neither more affluent nor more economically disadvantaged (*M* = 2.97, *SD* = .57). Eighth-grade students averaged about 168 hours of yearly mathematics instruction, the greatest of the three countries. Eighth-grade teachers of mathematics in Chinese Taipei had taught for approximately 14 years (*M* = 13.87, *SD* = 8.22) on average, twice the teaching experience of mathematics teachers in Ghana, and about the same experience of mathematics teachers in the U.S. For the predictor teacher education (*M* = 1.96, *SD* = 1.09), teachers in Chinese Taipei typically had majored in mathematics education, but not mathematics.

Table 11

Level 2 Descriptive Statistics for Chinese Taipei (N = 135)

Domain	Variable	*M*	*SD*	Min	Max
School climate	School emphasis on academic achievement-teachers	10.93	1.81	4.99	16.21
	School emphasis on academic achievement-principals	11.41	1.51	4.91	15.57
	School discipline and safety	11.46	1.7	7.95	13.94
School resources	Computer availability for instruction	2.7	0.59	1	3
	Resources for general instruction	10.39	2.11	3.74	13.63
	Resources for mathematics instruction	10.11	1.89	6.44	15.93
Administrator leadership	Administrator leadership	9.5	1.89	4.94	12.91
School socioeconomic status	Students economically disadvantaged	1.97	0.57	1	3
	Home resources limiting teaching	10.48	1.79	5.63	14.33
Access and equity	Mathematics hours per year	167.86	30.79	110	283.64
	Mathematics topics taught	12.78	1.29	9.15	14.18
Curriculum	Textbooks or workbooks for instruction	11.69	1.69	6.08	13.34
	Tools or technology for instruction	9.4	1.61	5.07	12.99
	Instruction to engage students	8.39	2.55	2.32	11.94
	Research-based instruction	8.71	1.81	5.67	14.73
Assessment	Classroom assessment question types	9.72	2.06	4.07	12.99
	Classroom emphasis on assessment	9.11	2.14	2.77	12.47
Teacher professionalism	Professional development	9.81	1.74	6.2	12.9
	Professional collaboration	8.79	2.06	4.85	14.45
	Teacher experience	13.87	8.22	0	46
	Teacher education	1.96	1.09	1	4
	Teacher preparation	8.28	1.56	3.24	11.99

Table 11 (Continued)

Teacher self-efficacy	9.43	2.02	5.07	11.99

Assumptions

Residuals of both Level-1 and -2 intercepts and predictors of the Chinese Taipei final model were examined to check the multilevel regression assumptions of normality and homoscedasticity. First, scatter plots of mathematics achievement by standardized Level-1 and -2 residuals were examined to check for the assumption of homoscedasticity. Homoscedasticity is indicated if the plotted points have no strong structure and are evenly divided above and below their mean value of zero (Hox, 2002). Visual examination of the scatter plots in Figures 1-7 found no major violations of the assumption of homoscedasticity.

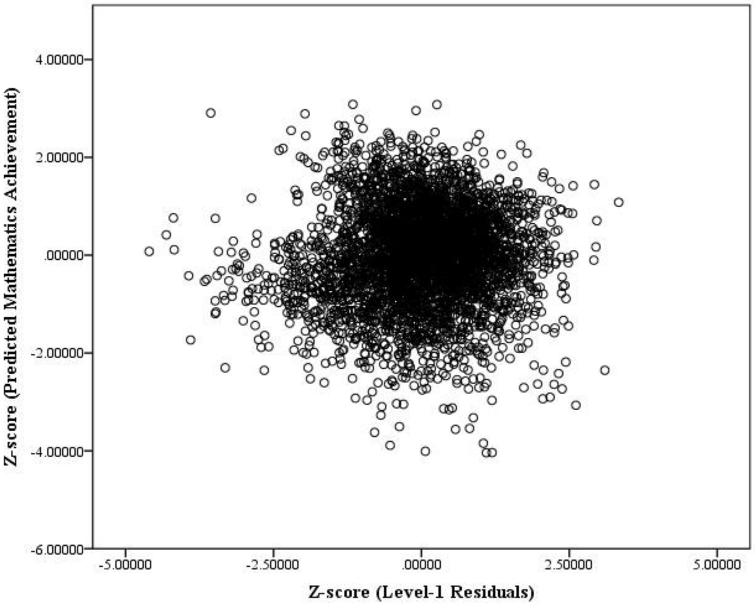

Figure 1. Predicted Chinese Taipei mathematics achievement standardized by Level-1 residuals.

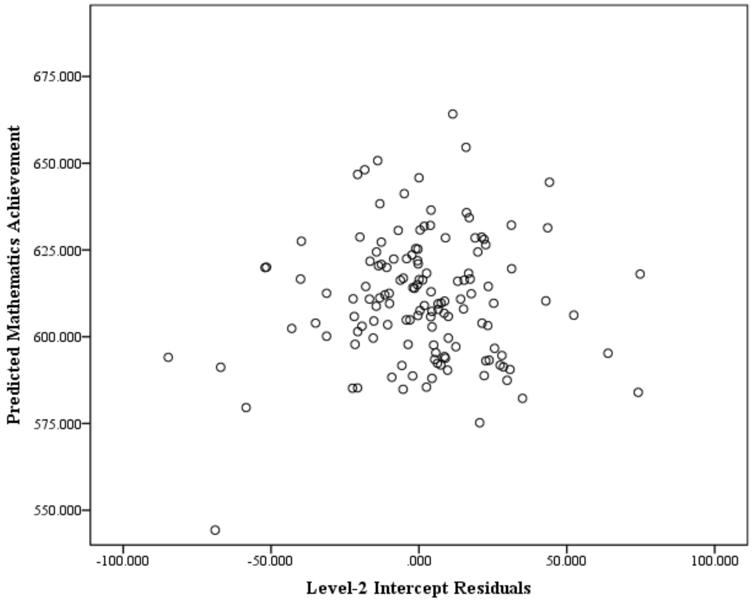

Figure 2. Predicted Chinese Taipei mathematics achievement by Level-2 intercept residuals.

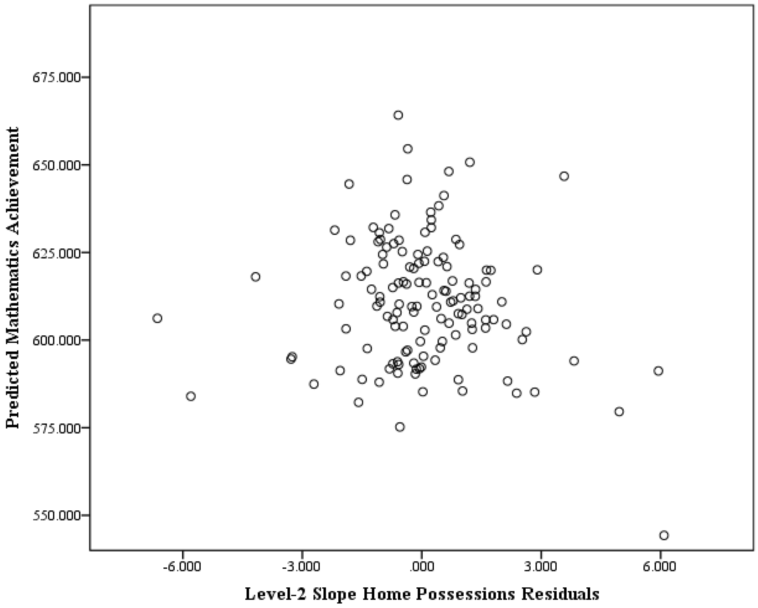

Figure 3. Predicted Chinese Taipei mathematics achievement by Level-2 slope home possessions residuals.

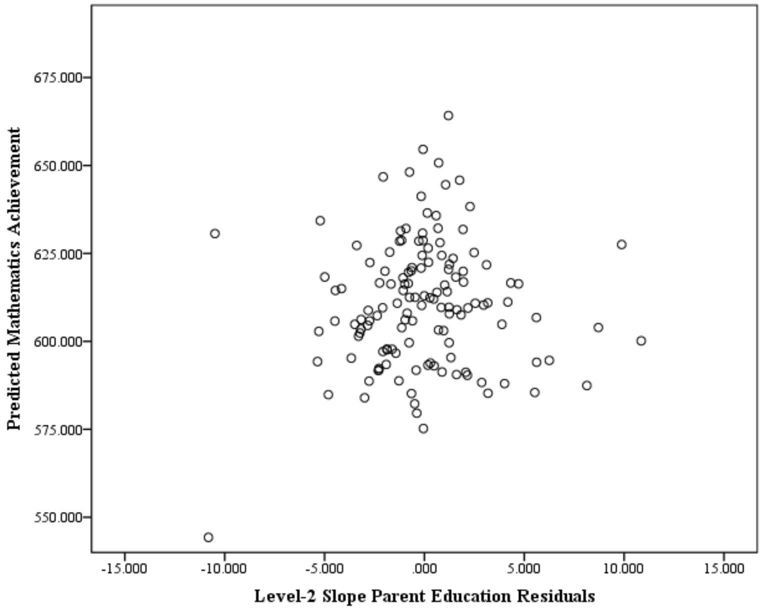

Figure 4. Predicted Chinese Taipei mathematics achievement by Level-2 parent education residuals.

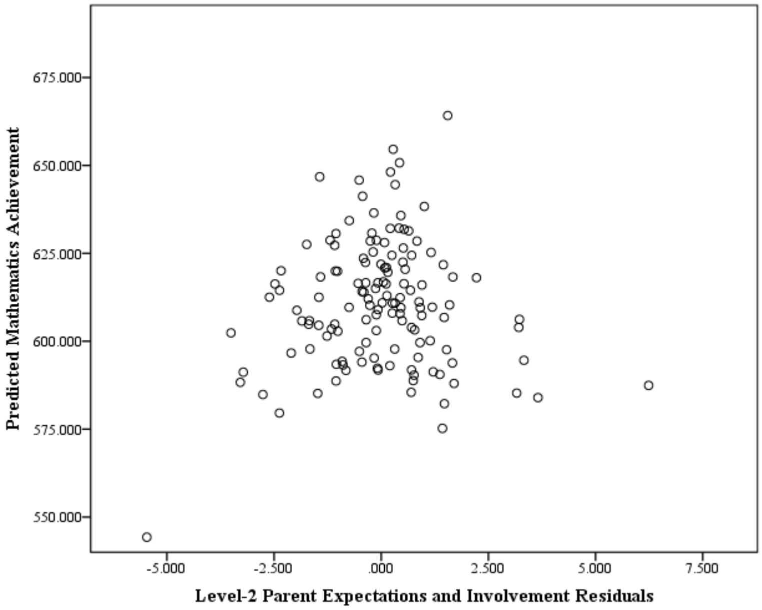

Figure 5. Predicted Chinese Taipei mathematics achievement by Level-2 slope parent expectations and involvement residuals.

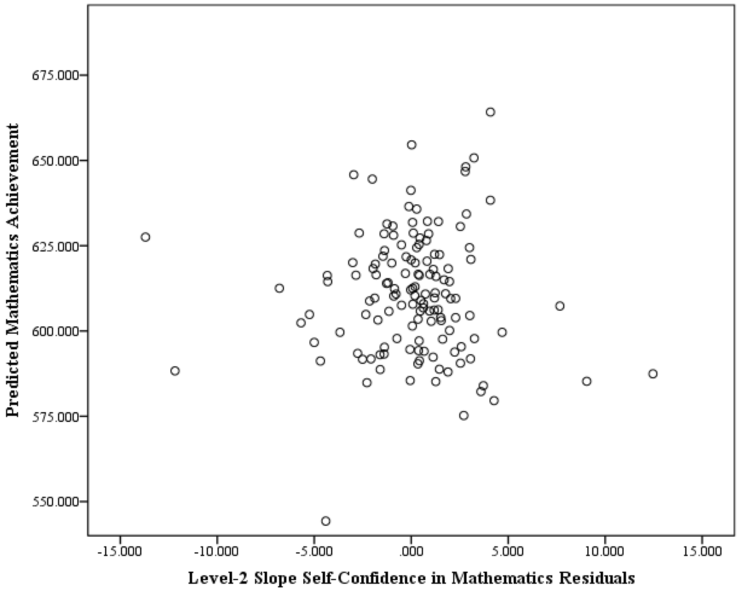

Figure 6. Predicted Chinese Taipei mathematics achievement by Level-2 slope self-confidence in mathematics residuals.

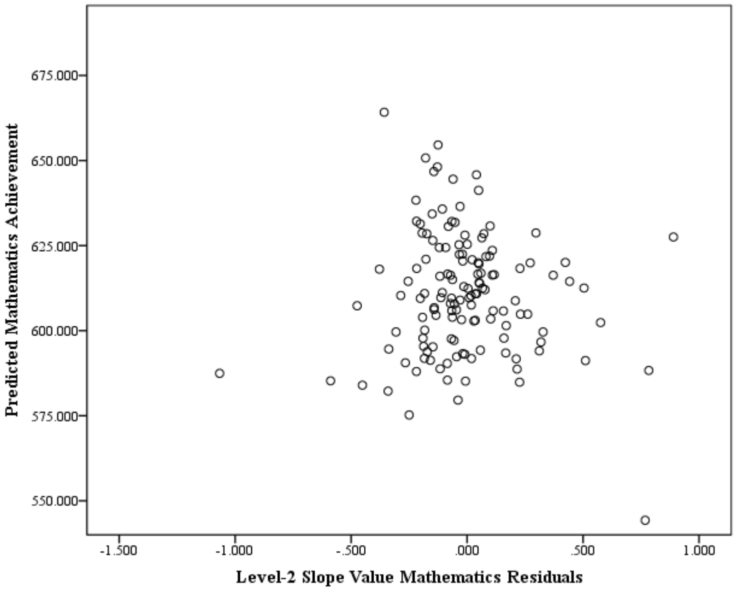

Figure 7. Predicted Chinese Taipei mathematics achievement by Level-2 slope value mathematics residuals.

The assumption of normality was checked by examining plots of predicted normal values by both Level-1 and Level-2 standardized residuals, shown in Figures 8-15.

Residuals with a normal distribution are indicated by a straight diagonal line (Hox, 2002). No major violations of the normality were found despite indication of slight negative skew in the Level-1 residuals shown in Figure 8 and slight heavy-tailed distribution in the Level-2 residuals for intercept in Figure 9, home possessions in Figure 10, parent education in Figure 11, self-confidence in mathematics in Figure 13, and value mathematics in Figure 14.

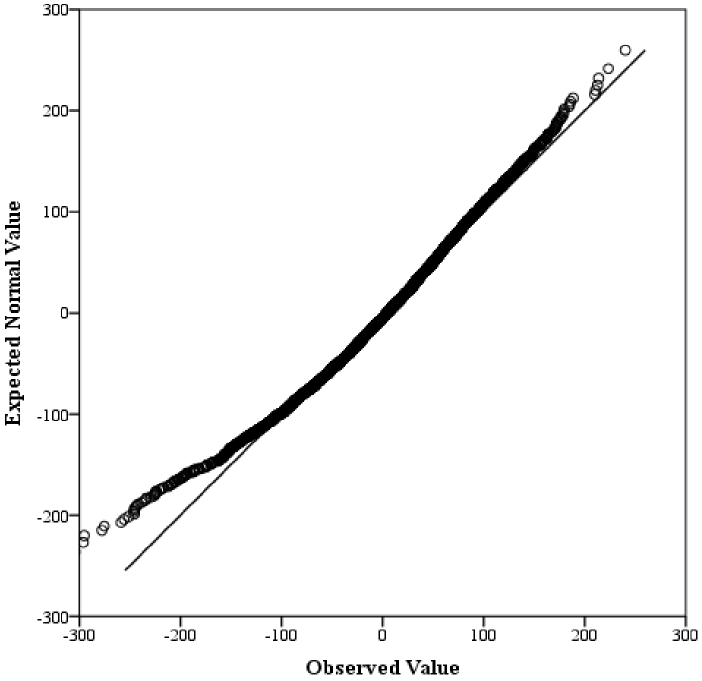

Figure 8. Normal Q-Q plot of Chinese Taipei Level-1 residuals.

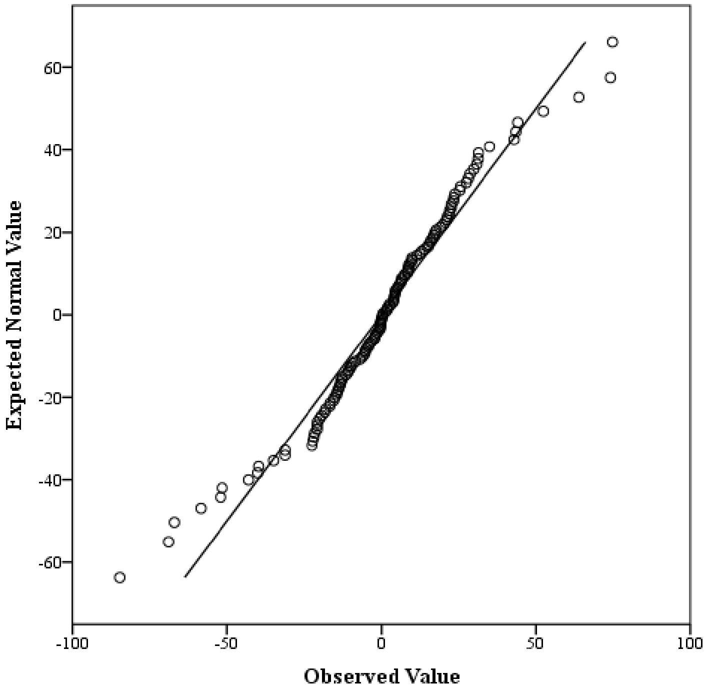

Figure 9. Normal Q-Q plot of Chinese Taipei Level-2 intercept residuals.

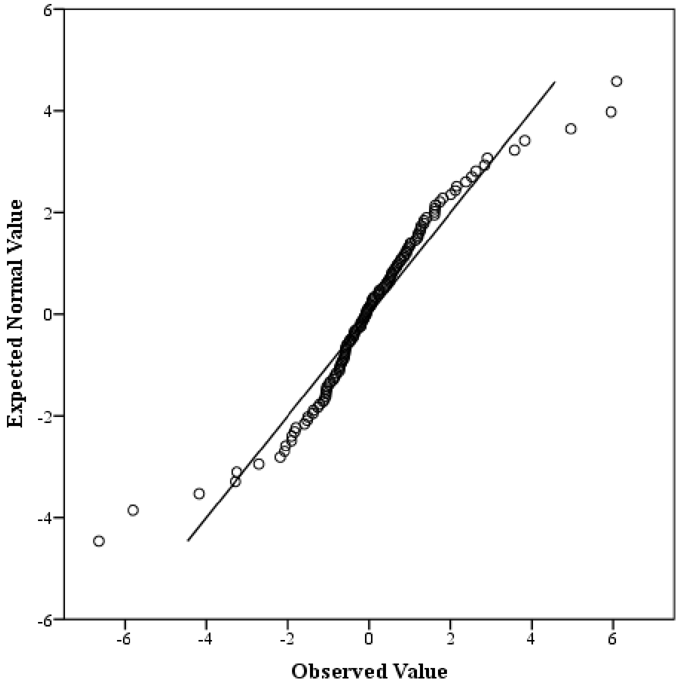

Figure 10. Normal Q-Q plot of Chinese Taipei Level-2 home possessions residuals.

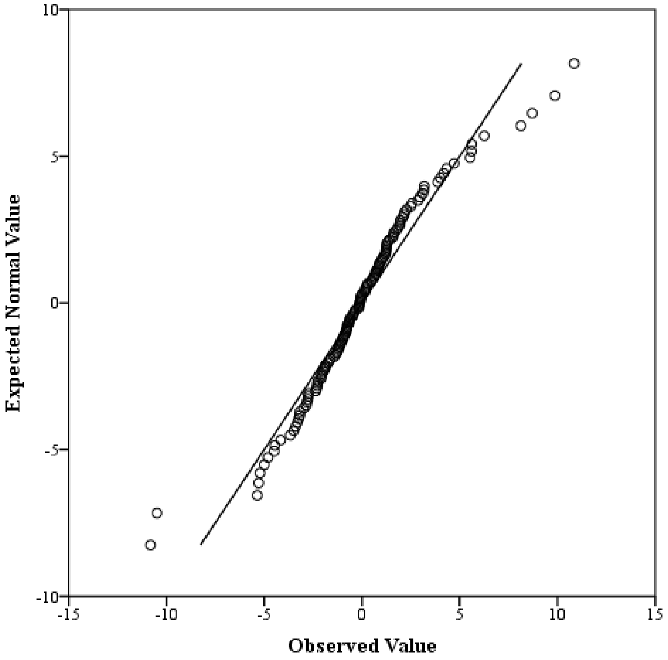

Figure 11. Normal Q-Q plot of Chinese Taipei Level-2 parent education residuals.

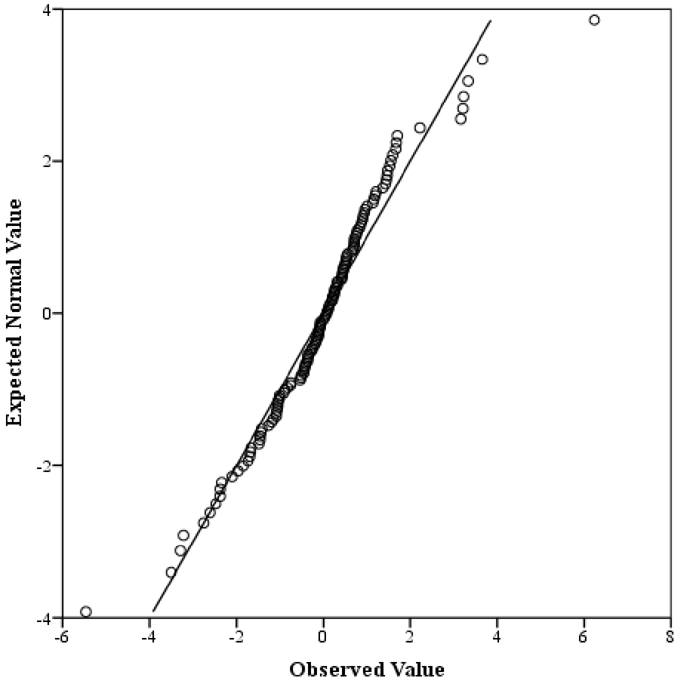

Figure 12. Normal Q-Q plot of U.S. Level-2 parent expectations and involvement residuals.

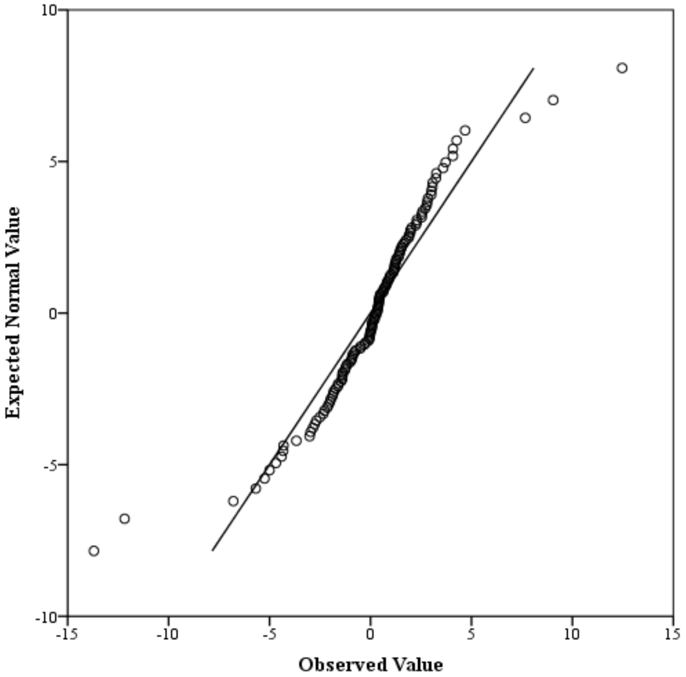

Figure 13. Normal Q-Q plot of Chinese Taipei Level-2 self-confidence in mathematics residuals.

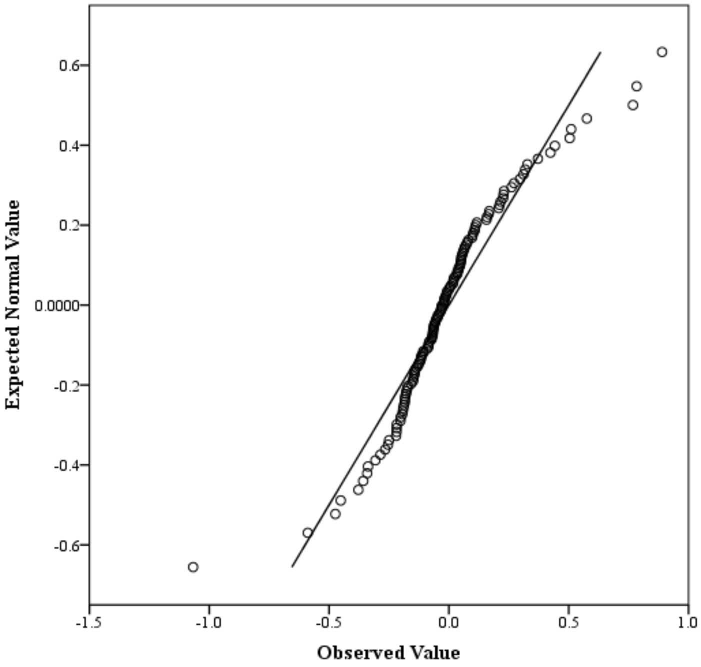

Figure 14. Normal Q-Q plot of Chinese Taipei Level-2 value mathematics residuals.

Unconditional Model

Multilevel modeling began with an unconditional model, Model 1, containing only the dependent variable which was the five plausible values of student mathematics achievement, and the grouping variable of schools. HLM 7 software accommodates the plausible values by running the requested analysis for each plausible value and then averaging the results. For the Chinese Taipei unconditional model, the estimated fixed effect value for the intercept was 609.81 ($SE = 4.46$, $p < .001$), which represents the predicted mathematics achievement score without accounting for other variables. The average level of mathematics achievement was significantly different across schools in Chinese Taipei ($\hat{\tau}_{00} = 2{,}317.05$, $SE = 325.84$, $p < .001$); however, the amount of unexplained variance within schools was much greater than that between schools ($\hat{\sigma}^2 = 8{,}233.28$, $SE = 243.15$). The ICC of .22 indicates that approximately 22% of the total variance in mathematics scores occurred between schools, and the remaining 78% was within schools.

Home-Related Variables

Research Question 1 for each country in this study is the extent to which home-related variables (home possessions for learning, parent educational attainment, and parent expectations for and involvement in their children's education) predict eighth-grade mathematics achievement. To address this question, the three variables related to the student's home were entered separately as Models 2-4 into the unconditional model as singular predictors of eighth-grade mathematics achievement in Chinese Taipei. Then, all three home-related variables, having been found to contribute statistically significantly to mathematics achievement, were entered into a combined model of home-related variables, Model 5, to predict mathematics achievement as a group.

Deviances. The first analysis of Models 2-4 was an evaluation of goodness-of-fit of each model in comparison to the unconditional model by comparing the deviance of each model. Deviances are compared as relative statistics, and lower deviances indicate better fitting models. The deviance of Model 1 was used as a baseline from which to compare the subsequent models. Results of the significance tests for change in deviance, shown in Table 12, indicate that each of Models 2-4 had a statistically significant lower deviance than Model 1, and therefore all three were better fitting models than the unconditional model.

Table 12

Deviances for Chinese Taipei Home Variables Models

Model	Predictor	Deviance	χ^2	p
1	Unconditional	48,696.42		
2	Home possessions for learning	48,350.15	346.27	<.001
3	Parent education	48,445.47	250.95	<.001
4	Parent expectations and involvement	48,595.63	100.79	<.001

Pseudo R^2. To further evaluate model fit, a pseudo R^2 was examined to compare Models 2-4 with Model 1. Equation 40 was used to estimate the proportional reduction in unexplained variance in the random parameters accounted for by each of the home-related variables compared to the unconditional model (Anderson, 2012).

$$\text{Pseudo } R^2 = \frac{(\hat{\sigma}^2_{\text{unconditonal}} - \hat{\sigma}^2_{\text{conditional}})}{\hat{\sigma}^2_{\text{unconditonal}}} \qquad \text{(Eq. 40)}$$

Results of pseudo R^2 calculations, shown in Table 13, indicate that the predictors home possessions for learning and parent education reduced the between-school variance between 30% and 34% each. Model 4, with parent expectations and involvement as the singular predictor, reduced the between-school variance compared to Model 1 by 9%. The relatively high between-school variances for both home possessions for learning and parent education indicate that schools in Chinese Taipei vary in the populations of students they serve by categories that include socioeconomic status and parent education.

Table 13

Comparison of Pseudo R^2 between Chinese Taipei Models 2-4 and Model 1

Model	Predictor	Between-School Variance	Within-School Variance
2	Home possessions for learning	.34	.08
3	Parent education	.30	.06
4	Parent expectations and involvement	.09	.03

Fixed and random effects. Fixed effects coefficient estimates for all three home-related variables—home possessions for learning (γ = 17.16, *SE* = 1.12, $p < .001$), parent education (γ = 23.95, *SE* = 1.72, $p < .001$), and parent expectations and involvement (γ = 6.74, *SE* = 0.86, $p < .001$)—had statistically significant relationships with eighth-grade mathematics achievement in Chinese Taipei. In addition, random effects coefficient estimates for all three home-related variables were statistically significant, indicating that each of the three predictors varied across schools. Estimations of coefficients for fixed effects terms are shown in Table 14, and estimations of random effects are shown in Table 15.

Table 14

Estimation of Fixed Effects for Chinese Taipei Models 2-4

Model	Parameter	Coefficient	*SE*	*p*
2	Intercept	611.70	3.77	<.001
	Home possessions for learning	17.16	1.12	<.001
3	Intercept	611.81	3.86	<.001
	Parent education	23.95	1.72	<.001
4	Intercept	610.72	4.28	<.001
	Parent expectations and involvement	6.74	0.86	<.001

Table 15

Estimation of Random Effects for Chinese Taipei Models 2-4

Model	Parameter	Variance Components	*SE*	*p*
2	Between-schools	1,539.21	230.47	<.001
	Home possessions for learning	16.06	16.09	.03
	Within-schools	7,596.51	227.72	
3	Between-schools	1,613.50	237.26	<.001
	Parent education	75.05	46.85	.01
	Within-schools	7,730.95	230.08	
4	Between-schools	2,115.94	301.70	<.001
	Parent expectations and involvement	23.26	12.10	.003
	Within-schools	7,988.05	240.93	

Combined model. After each of home-related variables was found to reduce variance compared to Model 1, a pseudo R^2 was examined to compare Model 5 with Models 2-4. Equation 41 was used to estimate the proportional reduction in unexplained variance in the random parameters accounted for by the combined home-related variables model compared to the models with singular predictors. Results are shown in Table 16. Model 5 yielded a reduction in between-school variance ranging from 18% to 41%, compared to Models 2-4. Within schools, the reduction in variance ranged from 5% to

9%. Overall, Model 5 with the combined home-related variables was more efficient than Models 2-4 with singular home-related variables in predicting mathematics achievement for students in Chinese Taipei.

$$Pseudo\ R^2 = \frac{(\hat{\sigma}^2_{\text{previous}} - \hat{\sigma}^2_{\text{current}})}{\hat{\sigma}^2_{\text{previous}}} \qquad \text{(Eq. 41)}$$

Table 16

Comparison of Pseudo R^2 between Chinese Taipei Model 5 and Models 2-4

Model	Predictor	Between-School Variance	Within-School Variance
2	Home possessions for learning	.18	.05
3	Parent education	.22	.05
4	Parent expectations and involvement	.41	.09

All three fixed effects in Model 5 had statistically significant relationships with mathematics achievement, shown in Table 17. Because all predictors were grand-mean centered, the fixed effect coefficient estimate for home possessions for learning (γ = 13.03, $SE = 1.12$, $p <.001$) indicates that for each unit increase in the home possessions scale, eighth-grade students in Chinese Taipei with mean values for parent education and parent expectations and involvement would be expected to have 13.03 points increase in their TIMSS mathematics scores. Similarly, the fixed effect coefficient estimate for parent education (γ = 16.37, $SE = 1.71$, $p < .001$) indicates that for each unit increase in level of parent education (e.g., from associate’s degree to bachelor’s degree), students with mean values on the home possessions for learning and parent expectations and involvement scales would be expected to increase 16.37 points in their mathematics scores. The fixed effect coefficient estimate for parent expectations and involvement (γ =

2.66, *SE* = 0.86, *p* = .002) indicates that for each unit increase in the parents' expectations and involvement scale, students in Chinese Taipei with mean values for home possessions for learning and parent education would be expected to increase 2.66 points in their mathematics scores.

Although the fixed effect coefficient estimates in Model 5 indicated that schools varied significantly in their relationships with mathematics achievement, the random effects estimations indicate not any of the three home-related variables varied across schools. This means that the positive relationship between each of the three home-related variables and mathematics achievement was similar across schools in Chinese Taipei. The variance of 1,256.10 (*SE* = 194.93, *p* < .001) for the intercept indicates mathematics scores varied significantly across schools after accounting for the three home-related variables in the model.

Table 17

Parameter Estimates for Chinese Taipei Model 5 (Combined Home Variables)

Effect	Parameters	Estimates	*SE*	*p*
Fixed	Intercept	612.90	3.56	<.001
	Home possessions for learning	13.03	1.12	<.001
	Parent education	16.37	1.71	<.001
	Parent expectations and involvement	2.66	0.86	.002
Random	Between-school	1,256.10	194.93	<.001
	Home possessions for learning	10.85	16.05	.38
	Parent education	60.96	44.16	.28
	Parent expectations and involvement	19.67	11.04	.08
	Within-school	7,238.49	224.27	

Student Beliefs

Research Question 2 for each country in this study is the extent to which student beliefs of self-confidence in mathematics and value of mathematics predict eighth-grade mathematics achievement. To address this question, the two variables related to student beliefs were entered separately as Models 6 and 7 into Model 1 as single predictors of eighth-grade mathematics achievement in Chinese Taipei. Then, both variables, having been found to contribute significantly to mathematics achievement, were entered into a combined model of student beliefs to predict mathematics achievement as a group.

Deviances. The first analysis of Models 6 and 7 was an evaluation of goodness-of-fit of each model in comparison to Model 1 by comparing the deviance of each model. Results of the significance tests for change in deviance, shown in Table 18, indicate that each of Models 6 and 7 had statistically significant lower deviances than Model 1, and therefore were better fitting models than the unconditional model.

Table 18

Deviances for Chinese Taipei Student Beliefs Models Compared to Model 1

Model	Predictor	Deviance	χ^2	p
1	Unconditional	48,696.03		
6	Self-confidence in mathematics	47,271.70	1,425.39	<.001
7	Value mathematics	47,801.50	894.92	<.001

Pseudo R^2. To further evaluate model fit, a pseudo R^2 was calculated for Models 6 and 7 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by each of the student beliefs variables compared to Model 1. Results of pseudo R^2 calculations, shown in Table 19, indicate that the entering of self-confidence in mathematics to Model 1 as a predictor of mathematics achievement reduced the between-school variance by 28% and the within-school variance by 29%.

The entering of value mathematics as a predictor by itself to Model 1 reduced the between-school variance by 19% and the within-school variance by 20%.

Table 19

Comparison of Pseudo R^2 between Chinese Taipei Models 6-7 and Model 1

Model	Predictor	Between-School Variance	Within-School Variance
6	Self-confidence in mathematics	.28	.29
7	Value mathematics	.19	.20

Fixed and random effects. Fixed effects of both self-confidence in mathematics ($\gamma = 21.49$, $SE = 0.65$, $p < .001$) and value mathematics ($\gamma = 0.70$, $SE = 0.03$, $p < .001$) had a statistically significant relationship with eighth-grade mathematics achievement. Random effects of both self-confidence in mathematics ($\hat{\boldsymbol{\tau}} = 21.49$, $SE = 0.65$, $p < .001$) and value mathematics ($\hat{\boldsymbol{\tau}}= 0.71$, $SE =0\ .03$, $p < .001$) indicate that both student-beliefs variables varied significantly across schools. Estimations of coefficients for fixed effects terms are shown in Table 20, and estimations of random effects are shown in Table 21.

Table 20

Estimation of Fixed Effects for Chinese Taipei Models 6-7

Model	Parameter	Coefficient	*SE*	*p*
6	Intercept	611.61	3.80	<.001
	Self-confidence in mathematics	21.49	0.65	<.001
7	Intercept	610.86	4.05	<.001
	Value mathematics	0.71	0.03	<.001

Table 21

Estimation of Random Effects for Chinese Taipei Models 6-7

Model	Parameter	Variance Components	*SE*	*p*
6	Between-schools	2,538.72	228.02	<.001
	Self-confidence in Mathematics	6.00	3.17	.002
	Within-schools	1,858.40	63.99	
7	Between-schools	2,820.57	255.69	<.001
	Value mathematics	0.004	0.005	.03
	Within-schools	2,249.36	74.46	

Combined model. After both student-belief variables were found to singularly reduce variance compared to Model 1, they were combined to predict mathematics achievement in Model 8. Goodness of fit was evaluated by calculating a pseudo R2 and comparing Model 8 to Models 6 and 7 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by Model 8 compared to the previous models. Results are shown in Table 22. Model 8 yielded a reduction in variance of 1% both between schools and within schools compared to Model 6. Model 8 yielded a reduction in between-school variance of 11% and 18% within-school variance compared to Model 7. Overall, Model 8 with the combined student-belief variables was more efficient than previous models with singular student-belief variables in predicting mathematics achievement for students in Chinese Taipei.

Table 22

Comparison of Pseudo R^2 between Chinese Taipei Model 8 and Models 6-7

Model	Predictor	Between-School Variance	Within-School Variance
6	Self-confidence in mathematics	.01	.01
7	Value mathematics	.11	.18

Both predictors combined in Model 8 had statistically significant relationships with mathematics achievement, shown in Table 23. Because the predictor variables were grand-mean centered, the fixed effect coefficient estimate for self-confidence in mathematics ($\gamma = 17.96$, $SE = 0.84$, $p < .001$) indicates that for each unit increase in the self-confidence in mathematics scale, students with mean values on the value mathematics scale would be expected to have 17.96 points increase in their mathematics scores. The fixed effect coefficient estimate for value mathematics ($\gamma = 0.22$, $SE = 0.04$, $p < .001$) indicates that for each unit increase in the value mathematics scale, students with mean values on the self-confidence in mathematics scale would be expected to increase .22 points in their TIMSS mathematics scores. It should be kept in mind that the value mathematics scale's standard deviation of 65 is much greater than the standard deviation of two for most of the other scales in this study. This means that the absolute differences in scores relating to the value mathematics variable are not directly comparable to differences in scores relating to other variables. For example, if the value mathematics scale had a standard deviation of two rather than 65, the fixed effect coefficient estimate for value mathematics would be greater than 0.22 and would be more easily compared to the parameter estimates relating to the self-confidence in mathematics variable.

The two student-belief variables—self-confidence in mathematics ($\hat{\tau}$= 13.81, *SE* = 11.76, *p* = .04) and value mathematics ($\hat{\tau}$ = 0.06, *SE* = 0.02, *p* = .04)—varied significantly across schools in Chinese Taipei. The variance of 1,622.51 (*SE* = 235.70, *p* < .001) for the intercept indicates there were statistically significant differences in mathematics achievement across schools after accounting for the two student-belief variables in the model.

Table 23

Parameter Estimates for Chinese Taipei Model 8 (Combined Student-Belief Variables)

Effect	Parameters	Estimates	*SE*	*p*
Fixed	Intercept	612.20	3.77	<.001
	Self-confidence in mathematics	17.96	0.85	<.001
	Value mathematics	0.22	0.04	<.001
Random	Between schools	1,622.51	235.70	<.001
	Self-confidence in mathematics	13.81	11.76	.001
	Value mathematics	0.06	0.02	.04
	Within schools	5,604.80	177.07	

Combined Level-1 Model

Based on the results of Models 5 (combined home-related variables) and 8 (combined student-belief variables), all five student-level variables were entered into Model 1, the unconditional model, to create Model 9, the combined Level-1 model.

As shown in Table 24, Model 9 appeared more efficient than Model 5 in that it accounted for 19% more variance between schools and 29% more variance within schools. Compared to Model 8, Model 9 accounted for 38% more variance between schools and 8% more variance between schools. As a result of these comparisons, Model

9 was selected as the foundational Level-1 model for further examination of the relationships between Level-2 predictors and mathematics achievement.

Table 24

Comparison of Pseudo R^2 between Chinese Taipei Model 9 and Previous Combined Models

Model	Predictor	Between-school variance	Within-school variance
5	Combined home-related variables	.19	.29
8	Combined student beliefs	.38	.08

Parameter estimates for Chinese Taipei Model 9 are shown in Table 25. Four of the combined five student-level variables had statistically significant fixed effects on mathematics achievement. Specifically, home possessions for learning ($\gamma = 9.79$, $SE = 1.05$, $p < .001$), parent education ($\gamma = 12.11$, $SE = 1.48$, $p < .001$), self-confidence in mathematics ($\gamma = 16.62$, $SE = 0.84$, $p < .001$) and value mathematics ($\gamma = 0.19$, $SE = 0.04$, $p < .001$) were positively related to mathematics achievement in the presence of the other Level-1 predictors. These results indicate that the more possessions to support learning students have at home, the more education their parents have, the more confidence they have in doing mathematics, and the more they value mathematics, the higher their mathematics scores tended to be.

Table 25

Parameter Estimates for Chinese Taipei Model 9 (Combined Level-1 Variables)

Effect	Parameters	Estimates	*SE*	*p*
Fixed	Intercept	613.96	3.17	<.001
	Home possessions for learning	9.79	1.05	<.001
	Parent education	12.11	1.48	<.001
	Parent expectations and involvement	-0.62	0.68	.37
	Self-confidence in mathematics	16.62	0.84	<.001
	Value mathematics	0.19	0.04	<.001
Random	Between-schools	1,013.73	160.93	<.001
	Home possessions for learning	13.22	12.83	.20
	Parent education	48.01	32.16	.16
	Parent expectations and involvement	5.99	7.20	<.50
	Self-confidence in mathematics	15.84	10.77	.07
	Value mathematics	0.07	0.02	<.001
	Within-schools	5,142.85	161.82	

In regard to random effects, only value mathematics ($\hat{\tau}$ =0 .07, *SE* = 0.02, *p* < .001) of the five student-level variables varied significantly across schools in Chinese Taipei. The relationships between mathematics achievement and the remaining student-level variables—home possessions, parent education, and parent expectations and involvement, and self-confidence in mathematics—were similar across schools. These results imply that in Chinese Taipei, the positive relationships between these four variables and mathematics achievement tend to be similar across schools.

School-Related Variables

Research Question 3 for each country in this study is the extent to which school-related variables (school climate, school resources, administrator leadership, and school socioeconomic status) predict eighth-grade mathematics achievement. After selecting the best-fitting model of those examined for the Level-1 variables, each school-related variable was entered separately into the combined Level-1 model, Model 9. First, school climate variables were entered separately as Models 10-12, and then the statistically significant school climate variables were combined and entered into Model 9 to create Model 13. Next, school resources variables were entered separately into Model 9 as Models 14-16. Only one of the school resources variables was found to be statistically significant, so Model 14 was selected as the school resources model, and Model 17, intended to be used as a combined school resources model, was omitted. Model 18 contained the single variable for administrator leadership. Variables measuring school socioeconomic status were entered separately as Models 19 and 20, and then the statistically significant school socioeconomic status variables were combined and entered into Model 9 to create Model 21. Finally, all the school-level variables that were found to individually contribute significantly to mathematics achievement were selected to be entered into a combined model (Model 22) of school-related variables to predict mathematics achievement as a group.

School climate. To what extent are school-climate variables (school emphasis on academic success—reported by teachers and principals separately—and school discipline and safety) associated with eighth-grade mathematics achievement in Chinese Taipei? To address this question, each of the Level-2 school climate variables was added to the combined Level-1 model (Model 9) to create Models 10-12. Then, those variables with significant fixed effects in Models 10-12 were included in the combined school climate model, Model 13.

Pseudo R^2. To evaluate model fit, a pseudo R^2 was calculated for Models 10-13 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by each of the school climate variables compared to the combined Level-1 model, Model 9. Results of pseudo R^2 calculations, shown in Table 26, indicate that the entering of each of the three school climate variables to predict mathematics achievement actually increased the between-school variance in Chinese Taipei. The entering of school emphasis on academic success - teacher reports as a predictor by itself into Model 9 increased the between-school variance by 6%. The entering of school emphasis on academic success - principal reports as a predictor by itself into Model 9 increased the between-school variance by 4%. The entering of school discipline and safety into Model 9 to predict mathematics achievement increased the between-school variance by 36%. However, Model 13 with the combined statistically significant school climate variables was more efficient than Models 10-12, reducing the between-school variance compared to Model 9 by 10%.

Table 26

Comparison of Pseudo R^2 between Chinese Taipei Models 10-13 and Model 9

Model	Predictor	Between-School Variance	Within-School Variance
10	Emphasis on academic success - teachers	-.06	.03
11	Emphasis on academic success - principals	-.04	.03
12	School discipline and safety	-.36	.03
13	Combined school climate	.10	.03

Fixed and random effects. Fixed effects coefficient estimates for two of the three variables measuring school climate had a statistically significant relationship with eighth-grade mathematics achievement. Model 10 with school emphasis on academic success -

teacher reports as a Level-2 predictor of mathematics achievement yielded a statistically significant fixed effect ($\gamma = 8.99$, $SE = 1.86$, $p < .001$). This means that with every unit increase in the school emphasis on academic success - teacher reports scale, the mathematics scores of students with mean Level-1 variable values would be expected to increase by 8.99 points. The fixed effect coefficient estimate for school emphasis on academic success - principal reports was found statistically significant in Model 11 ($\gamma = 8.65$, $SE = 1.54$, $p < .001$). This means that with every unit increase in the school emphasis on academic success - principal reports scale, mathematics scores of students would be expected to increase by 8.65 points after accounting for student-level variables. The fixed effect coefficient estimate for school discipline and safety in Model 12 was not found to have a statistically significant relationship with eighth-grade mathematics achievement in Chinese Taipei. The two statistically significant school climate variables were combined and entered into Model 9 to create Model 13. The fixed effects of both school emphasis on academic success - teacher reports ($\gamma = 6.43$, $SE = 2.41$, $p = .01$) and school emphasis on academic success - principal reports ($\gamma = 6.59$, $SE = 2.25$, $p = .004$) were found to have a statistically significant relationship with eighth-grade mathematics achievement. The results of Models 10-13 are shown in Table 27.

Table 27

Estimation of Fixed Effects for Chinese Taipei Models 10-13

Model	Parameter	Coefficient	*SE*	*p*
10	Intercept	607.61	3.23	<.001
	Emphasis on academic success - teachers	8.99	1.86	<.001
11	Intercept	609.67	3.27	<.001
	Emphasis on academic success - principals	8.65	1.54	<.001
12	Intercept	605.42	3.52	<.001
	School discipline and safety	-2.55	2.01	.21
13	Intercept	610.19	3.09	<.001
	Emphasis on academic success - teachers	6.43	1.93	.001
	Emphasis on academic success - principals	6.59	1.65	<.001

Random effects coefficient estimates for Models 10-13 are shown in Table 28. In Model 13 with the combined school climate variables, the random effects of Level-1 home possessions for learning ($\hat{\tau}$ = 15.55, *SE* = 16.90, *p* = .03), parent education ($\hat{\tau}$ = 48.87, *SE* = 34.20, *p* = .004), self-confidence in mathematics ($\hat{\tau}$ = 22.87, *SE* = 13.00, *p* < .001), and value mathematics ($\hat{\tau}$ = .29, *SE* = .03, *p* < .001) were statistically significant, meaning that the relationships between each of them and mathematics achievement varied across schools in Chinese Taipei. The slope variance of parent expectations and involvement was not statistically significant, meaning that the relationship between it and mathematics achievement tended to be similar across schools in Chinese Taipei. These relationships remained consistent for the remaining Level-2 models.

Table 28

Estimation of Random Effects for Chinese Taipei Models 10-13

Model	Parameter	Variance Components	*SE*	*p*
10	Between schools	1,072.62	168.77	<.001
	Within schools	4,984.46	204.52	
11	Between schools	1,055.55	162.94	<.001
	Within schools	4,986.83	205.46	
12	Between schools	1,378.03	207.47	<.001
	Within schools	4,978.46	200.50	
13	Between schools	911.70	144.28	<.001
	Within schools	4,988.62	207.34	

School resources. To what extent are school resources variables (computer availability for instruction, resources for general instruction, and resources for mathematics instruction) associated with eighth-grade mathematics achievement in Chinese Taipei? To address this question, each of the Level-2 school resources variables was added to the combined Level-1 model (Model 9) to create Models 14-16. Then, those variables with significant fixed effects in Models 14-16 were included in the combined school resources model, Model 17.

Pseudo R^2. To evaluate model fit, a pseudo R^2 was calculated for Models 14-16 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by each of the school resources variables compared to Model 9, the combined Level-1 model. Results of pseudo R^2 calculations, shown in Table 29, indicate that the entering of computers available for instruction to Model 9 to predict mathematics achievement increased the between-school variance by a range of 35-39%. Each of the three school resources variables reduced the within-school variance by 3%.

Table 29

Comparison of Pseudo R^2 between Chinese Taipei Models 14-17 and Model 9

Model	Predictor	Between-School Variance	Within-School Variance
14	Computer availability for instruction	-.39	.03
15	Resources for general instruction	-.35	.03
16	Resources for mathematics instruction	-.39	.03

Fixed and random effects. Of the three variables measuring school resources, the fixed effect coefficient estimate for a shortage of computers available for instruction (γ = 11.13, *SE* = 4.07, *p* = .01) in Model 14 was the only one that had a statistically significant relationship with eighth-grade mathematics achievement. This means that with every unit increase in a shortage of computers available for instruction, mathematics scores of Chinese Taipei students with mean Level-1 variable values would be expected to increase by 11.13 points. The results of Models 14-16 are shown in Table 30. Because only Model 14 of the three fixed effects measuring school resources had a statistically significant relationship with mathematics achievement, Model 14 was selected to measure overall school resources, and Model 17, intended to be a combined school resources model was omitted for Chinese Taipei.

Table 30

Estimation of Fixed Effects for Chinese Taipei Models 14-16

Model	Parameter	Coefficient	*SE*	*p*
14	Intercept	610.76	3.51	<.001
	Computer availability for instruction	11.13	1.68	.01

Table 30 (Continued)

15	Intercept	605.61	3.66	<.001
	Shortage of resources for general instruction	2.15	1.38	.20
16	Intercept	605.55	3.55	<.001
	Shortage of resources for mathematics instruction	-0.97	1.76	.58

Random effects coefficient estimates for Models 14-16 are shown in Table 31. In Model 14, the one that contained the single statistically significant school resources predictor of mathematics achievement, the random effects of Level-1 home possessions for learning ($\hat{\tau} = 17.95$, $SE = 15.61$, $p = .03$), parent education ($\tau = 44.29$, $SE = 32.97$, $p = .004$), self-confidence and mathematics ($\tau = 24.13$, $SE = 13.18$, $p < .001$), and value mathematics ($\tau = 0.09$, $SE = 0.03$, $p < .001$) were statistically significant, meaning that the relationships between them and mathematics achievement varied across schools in Chinese Taipei. The slope variance of parent expectations and involvement was not statistically significant, meaning that the relationship between it and mathematics achievement tended to be similar across schools in Chinese Taipei.

Table 31

Estimation of Random Effects for Chinese Taipei Models 14-16

Model	Parameter	Variance Components	*SE*	*p*
14	Between schools	1,389.68	206.91	<.001
	Within schools	4,974.70	201.57	
15	Between schools	1,373.44	206.96	<.001
	Within schools	4,978.93	201.05	
16	Between schools	1,412.36	211.33	<.001
	Within schools	4,979.12	200.66	

Administrator leadership. To what extent is school administrator leadership associated with eighth-grade mathematics achievement in Chinese Taipei? To address this question, the singular administrator leadership variable was entered into the combined Level-1 model (Model 9) to create Model 18.

Pseudo R^2. To evaluate model fit, a pseudo R^2 was calculated for Model 18 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by school administrator leadership compared to the combined Level-1 model. Results of the pseudo R^2 calculation, shown in Table 32, indicate that the entering of administrator leadership into the combined Level-1 model to predict mathematics achievement increased the between-school variance by 39%.

Table 32

Comparison of Pseudo R^2 between Chinese Taipei Model 18 and Model 9

Model	Predictor	Between-School Variance	Within-School Variance
18	Administrator leadership	-.39	.03

Fixed and random effects. The fixed effect coefficient estimate for administrator leadership did not have a statistically significant relationship with mathematics achievement. The results of Model 18 are shown in Table 33.

Table 33

Parameter Estimates for Chinese Taipei Model 18 (Administrator Leadership)

Effect	Parameter	Coefficient	*SE*	*p*
Fixed	Intercept	605.61	3.56	<.001
	Administrator leadership	1.00	1.95	.61
Random	Between-schools	1,411.86	211.29	<.001
	Within-schools	4,978.69	201.14	

School socioeconomic status. To what extent are school socioeconomic status variables (students economically disadvantaged and home resources limiting teaching) associated with eighth-grade mathematics achievement in Chinese Taipei? To address this question, each of the Level-2 school socioeconomic status variables was entered into Model 9 to create Models 19 and 20. Then, the two variables, both separately having statistically significant fixed effects, were included in the combined school socioeconomic status model, Model 21.

Pseudo R^2. To evaluate model fit, a pseudo R^2 was calculated for Models 19-21 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by each of the school socioeconomic status variables compared to Model 9. Results of pseudo R^2 calculations, shown in Table 34, indicate that the entering of students economically disadvantaged to Model 9 to predict mathematics achievement increased the between-school variance by 4%. The entering of home resources limiting teaching as a predictor by itself to Model 9 increased the between-school variance by an even greater amount, 27%. Even though the two school socioeconomic status variables separately increased between-school variance, Model 21 with the two variables in combination reduced between-school variance 6% in predicting mathematics achievement for students in Chinese Taipei.

Table 34

Comparison of Pseudo R^2 between Chinese Taipei Models 19-21 and Model 9

Model	Predictor	Between-School Variance	Within-School Variance
19	Students economically disadvantaged	-.04	.03
20	Home resources limiting teaching	-.27	.03
21	Combined school socioeconomic status	.06	.03

Fixed and random effects. Fixed effects coefficient estimates for both variables measuring school socioeconomic status had a statistically significant relationship with eighth-grade mathematics achievement. Model 19 with students economically disadvantaged as a Level-2 predictor of mathematics achievement yielded a statistically significant fixed effect ($\gamma = -26.88$, $SE = 4.64$, $p < .001$). This means that with every unit increase in the students economically disadvantaged scale, mathematics scores of students with mean Level-1 variable values would be expected to decrease by 26.88 points. The fixed effect coefficient estimate for home resources limiting teaching was found statistically significant in Model 20 ($\gamma = -4.22$, $SE = 1.98$, $p = 04$). This means that with every unit increase in the home resources limiting teaching scale, mathematics scores of students with mean Level-1 variable values would be expected to decrease by 4.22 points.

Both school socioeconomic status variables still had a statistically significant negative relationship with mathematics achievement when combined in Model 21. The results of Models 19-21 are shown in Table 35.

Table 35

Estimation of Fixed Effects for Chinese Taipei Models 19-21

Model	Parameter	Coefficient	*SE*	*p*
19	Intercept	608.75	3.20	<.001
	Students economically disadvantaged	-26.88	4.64	<.001
20	Intercept	605.55	3.42	<.001
	Home resources limiting teaching	-4.22	1.98	.04
21	Intercept	608.87	3.08	<.001
	Students economically disadvantaged	-26.89	4.58	<.001
	Home resources limiting teaching	-4.16	1.73	.02

Random effects coefficient estimates for Models 19-21 are shown in Table 36. In Model 21 with the combined school climate variables, the random effects of four of the five Level-1 variables, all except parent expectations and involvement, were statistically significant. This means that the relationships between mathematics achievement and home possessions for learning ($\hat{\tau} = 15.81$, *SE* = 16.84, *p* = .03), parent education ($\hat{\tau} = 45.43$, *SE* = 32.42, *p* = .004), self-confidence in mathematics ($\hat{\tau} = 22.88$, *SE* = 13.11, *p* < .001), and value mathematics ($\hat{\tau} = 0.09$, *SE* = 0.03, *p* < .001) varied across schools in Chinese Taipei. The slope variance of the parent expectations and involvement tended to be similar across schools in Chinese Taipei, meaning that the relationship between parent expectations and involvement and mathematics achievement tended to be similar across schools.

Table 36

Estimation of Random Effects for Chinese Taipei Models 19-21

Model	Parameter	Variance Components	*SE*	*p*
19	Between-schools	1,052.08	170.70	<.001
	Within-schools	4,980.39	203.31	
20	Between-schools	1,867.95	180.26	<.001
	Within-schools	1,706.48	62.97	
21	Between-schools	1,650.72	218.47	
	Within-schools	1,721.18	55.38	

Combined school-related variables model. Based on the results of Models 10-22, containing theory-based combinations of school-related variables, five variables (emphasis on academic success - teacher reports, emphasis on academic success - principal reports, computer availability for instruction, students economically disadvantaged, and home resources limiting teaching) were selected to enter into Model 9, the combined Level-1 model, as the combined school-related variables to predict mathematics achievement in Model 22.

Pseudo $\boldsymbol{R^2}$**.** To evaluate model fit, a pseudo R^2 was calculated for Model 22 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by the combined school-related variables compared to Model 9. Results of the pseudo R^2 calculation, shown in Table 37, indicate that the combination of the four school-related variables being entered into Model 9 to predict mathematics achievement reduced the between-school variance by 26%.

Table 37 *Comparison of Pseudo R^2 between Chinese Taipei Model 22 and Model 9*

Model	Predictor	Between-School Variance	Within-School Variance
22	Combined school-related variables	.26	.03

Fixed and random effects. Two fixed effects from the domain of school climate and one from school socioeconomic status showed statistically significant relationships with Chinese Taipei eighth-grade mathematics achievement in a combined school-related variables model. Results of Model 22 are shown in Table 38. Because the predictor variables were grand-mean centered, the fixed effect coefficient estimate for school emphasis on academic success - teacher reports ($\gamma = 4.34$, $SE = 1.92$, $p = .03$) indicates that for each unit increase in that scale, students with mean values on all other predictors would be expected to have 4.34 points increase in their mathematics scores. The fixed effect coefficient estimate for school emphasis on academic success - principal reports ($\gamma = 4.57$, $SE = 1.98$, $p = .02$) indicates that for each unit increase in that scale, students with mean values on all the other predictors in the model would be expected to have 4.57 points increase in their mathematics scores. The fixed effect coefficient estimate for students economically disadvantaged was found statistically significant ($\gamma = -17.69$, $SE = 5.81$, $p = .003$). This means that with every unit increase in the students economically disadvantaged scale, mathematics scores of students with mean values on all the other predictors in the model would be expected to decrease by 17.69 points.

Table 38

Parameter Estimates for Chinese Taipei Model 22 (Combined School Variables)

Effect	Parameter	Estimate	*SE*	*p*
Fixed	Intercept	612.98	3.24	<.001
	School emphasis on academic success-teacher reports	4.34	1.92	.03
	School emphasis on academic success-principal reports	4.57	1.73	.01
	Computer availability for instruction	4.22	3.69	.26
	Students economically disadvantaged	-17.69	4.63	<.001
	Home resources limiting teaching	-2.65	1.63	.11
Random	Between-schools	747.97	131.80	<.001
	Within-schools	4,988.00	207.91	

Teacher-related variables

Research Question 4 for each country in this study is the extent to which teacher- or classroom-related variables (access and equity, curriculum, tools and technology, classroom assessment, and teacher professionalism) predict eighth-grade mathematics achievement in each of three countries. The approach toward investigating this question was to enter the teacher-related variables into the combined Level-1 model, Model 9. First, variables measuring access and equity were entered separately as Models 23 and 24, and then because only mathematics instructional hours per year of those two was a statistically significant predictor of eighth-grade mathematics achievement, Model 23 was selected to represent the access and equity model for Chinese Taipei, and Model 25, which was intended to combine both access and equity variables if they were statistically significant, was omitted. Next, variables measuring the construct of curriculum were entered separately into Model 9 as Models 26 and 27, and then because neither of those two was a statistically significant predictor of eighth-grade mathematics achievement, Model 28, which was intended to combine both curriculum variables if they were statistically significant, was omitted. Variables measuring classroom assessment were entered separately as predictors of eighth-grade mathematics achievement into Model 9 to create Models 29 and 30. Then, because only assessment question types of those two was a statistically significant predictor of eighth-grade mathematics achievement, it was selected to represent classroom assessment; and Model 31, which was intended to combine both assessment variables if they were statistically significant, was omitted. The six variables measuring teacher professionalism were entered separately in Model 9 as predictors of eighth-grade mathematics achievement. Those variables with significant fixed effects in Models 32-37 were included in the combined teacher professionalism model, Model 38. All the teacher-level variables that were found to contribute significantly to mathematics achievement were selected to be entered into a combined model (Model 39) of teacher-related variables to predict mathematics achievement as a group.

Access and equity. To what extent are mathematics classroom access and equity variables (mathematics instructional hours per year and mathematics topics taught) associated with eighth-grade mathematics achievement in Chinese Taipei? To address this question, each of the Level-2 access and equity variables was added to the combined Level-1 model (Model 9) to create Models 23 and 24. Because only mathematics instructional hours per year of the two fixed effects measuring access and equity had a statistically significant relationship with mathematics achievement, Model 23 was selected to measure overall access and equity, and Model 25, intended to be a combined access and equity model was omitted for Chinese Taipei.

Pseudo R^2. To evaluate model fit, a pseudo R^2 was calculated for Models 23 and 24 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by each of the access and equity variables compared to Model 9. Results of pseudo R^2 calculations, shown in Table 39, indicate that the entering of mathematics instructional hours per year to Model 9 to predict mathematics achievement reduced the between-school variance by 6%. The entering of mathematics topics taught as a predictor by itself to Model 9 reduced the between-school variance by 3%.

Table 39

Comparison of Pseudo R^2 between Chinese Taipei Models 23-24 and Model 9

Model	Predictor	Between-School Variance	Within-School Variance
23	Mathematics instructional hours per year	.06	.00
24	Mathematics topics taught	.03	.00

Fixed and random effects. Model 24 with mathematics instructional hours per year as a Level-2 predictor of mathematics achievement yielded a statistically significant fixed effect ($\gamma = 0.23$, $SE = 0.10$, $p = .02$). This means that with every hour increase in mathematics instructional hours per year, mathematics scores of students with mean Level-1 variable values would be expected to increase by 0.23 points. The results of Models 23 and 24 are shown in Tables 40 and 41.

Table 40

Estimation of Fixed Effects for Chinese Taipei Models 23-24

Model	Parameter	Coefficient	*SE*	*p*
23	Intercept	614.22	3.10	<.001
	Mathematics instructional hours per year	0.23	0.10	.02
24	Intercept	613.82	3.14	<.001
	Mathematics topics taught	2.96	2.37	.21

Table 41

Estimation of Random Effects for Chinese Taipei Models 23-24

Model	Parameter	Variance Components	*SE*	*p*
23	Between schools	949.14	211.25	<.001
	Within schools	5,145.51	161.80	
24	Between schools	986.17	152.95	<.001
	Within schools	5,149.30	161.73	

Curriculum. To what extent are classroom curriculum variables (instructional materials and instruction) associated with eighth-grade mathematics achievement in Chinese Taipei? To address this question, each of the Level-2 classroom instruction variables was entered into Model 9 to create Models 26 and 27.

Scores from the composite variables derived from teacher questionnaire items to measure teachers' instructional materials were not included in this analysis because they were found to be unreliable, as shown in Table 5. In addition, the Wright maps for the two variables derived to measure instructional materials showed mismatches of response thresholds and scale scores, as indicated in Appendix B. So, rather than create multilevel models with unreliable scales or completely disregard the variables, descriptive statistics of each of the instructional materials items was investigated.

The descriptive statistics are shown in Table 42, as well as in Tables C85-C88 in Appendix C. Descriptive statistics indicate that eighth-grade students in Chinese Taipei whose teachers use concrete objects or materials as bases for instruction had higher mathematics scores than students whose teachers used them as supplements for instruction or not at all. Further, students whose teachers used textbooks to supplement instruction had higher mathematics scores than students whose teachers used them as either a basis for instruction or not at all. Finally, students whose teachers did not use workbooks or worksheets or computer software at all had higher mathematics scores than students whose teachers used them as either a basis for instruction to supplement instruction.

Table 42

Descriptive Statistics for Chinese Taipei Instructional Materials and Mathematics Achievement

Instructional materials	Basis for instruction %	Supplement %	Not used %	Basis for instruction mean	Supplement mean	Not used mean
Textbooks	91.9	6.6	1.6	607.0	640.0	611.5
Workbooks / worksheets	48.5	50.3	1.2	602.6	613.1	714.9
Concrete objects / materials	5.5	90.3	4.2	628.1	609.3	584.6
Computer software	0.7	52.2	47.1	507.3	608.3	611.9

Pseudo R^2. To evaluate model fit, a pseudo R^2 was calculated for Models 26 and 27 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by each of the classroom instruction variables compared to Model 9. Results of pseudo R^2 calculations, shown in Table 43, indicate that the entering of instruction to engage students into Model 9 to predict mathematics achievement reduced the between-school variance by 2%; however the entering of research-based instructional practices to Model 9 did not reduce the variance any discernable amount.

Table 43

Comparison of Pseudo R^2 between Chinese Taipei Models 26-27 and Model 9

Model	Predictor	Between-School Variance	Within-School Variance
26	Instruction to engage students	.02	.00
27	Research-based practices	.00	.00

Fixed and random effects. The results of Models 26 and 27 are shown in Table 44 and 45. Fixed effects coefficient estimates for neither variable measuring classroom instruction had a statistically significant relationship with eighth-grade mathematics achievement; hence, no curriculum variables were selected for Chinese Taipei, and the intended combined curriculum model, Model 28, was omitted in the Chinese Taipei analysis.

Table 44

Estimation of Fixed Effects for Chinese Taipei Model 26-27

Model	Parameter	Coefficient	*SE*	*p*
26	Intercept	613.68	3.14	<.001
	Instruction to engage students	1.89	1.10	.09
27	Intercept	613.80	3.17	<.001
	Research-based practices	-0.07	1.62	.97

Table 45

Estimation of Random Effects for Chinese Taipei Model 26-27

Model	Parameter	Variance Components	*SE*	*p*
26	Between schools	2,925.34	446.30	<.001
	Within schools	3,834.84	129.91	
27	Between schools	1,015.86	160.76	<.001
	Within schools	5,147.31	161.52	

Classroom assessment. To what extent are classroom assessment variables (assessment question types and class emphasis on assessment) associated with eighth-grade mathematics achievement in Chinese Taipei? To investigate this question, each of the Level-2 classroom assessment variables was entered into Model 9 to create Models 29 and 30. Only one fixed effect, assessment question types in Model 29, was found to have a statistically significant relationship with mathematics achievement. Therefore, Model 29 was selected to represent classroom assessment, and the intended combined classroom assessment model, Model 31, was omitted from analysis for Chinese Taipei.

Pseudo R^2. To evaluate model fit, a pseudo R^2 was calculated for Models 29 and 30 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by each of the classroom assessment variables compared to Model 9. Results of pseudo R^2 calculations, shown in Table 46, indicate that the entering of assessment question types to the combined Level-1 model to predict mathematics achievement reduce the between-school variance by 5%. The entering of class emphasis on assessment as a predictor by itself to Model 9 reduced the between-school variance by 1%.

Table 46

Comparison of Pseudo R^2 between Chinese Taipei Models 29-30 and Model 9

Model	Predictor	Between-School Variance	Within-School Variance
29	Assessment question types	.05	.00
30	Class emphasis on assessment	.01	.00

Fixed and random effects. Fixed effects coefficient estimates for only one of the two variables measuring classroom assessment had a statistically significant relationship with eighth-grade mathematics achievement. Model 29 with assessment question types as a Level-2 predictor of mathematics achievement yielded a statistically significant fixed effect ($\gamma = 3.11$, $SE = 1.35$, $p = .02$). This means that with every unit increase in the assessment question types scale, mathematics scores of students with mean Level-1 variable values would be expected to increase by 3.11 points. For example, as shown in Tables C107-C109, the more frequently teachers in Chinese Taipei require their students to include explanations or justifications on classroom assessments, the higher their TIMSS mathematics score.

Because Model 30 did not yield a statistically significant fixed effect, Model 29 was selected to represent classroom assessment, and the intended combined model for classroom assessment, Model 31, was omitted from Chinese Taipei analysis. The results of Models 29 and 30 are shown in Tables 47 and 48.

Table 47

Estimation of Fixed Effects for Chinese Taipei Model 29-30

Model	Parameter	Coefficient	*SE*	*p*
29	Intercept	613.98	3.11	<.001
	Assessment question types	3.11	1.35	.02
30	Intercept	613.82	3.16	<.001
	Class emphasis on assessment	.79	1.36	.56

Table 48

Estimation of Random Effects for Chinese Taipei Model 29-30

Model	Parameter	Variance Components	*SE*	*p*
29	Between schools	967.27	155.04	<.001
	Within schools	5,152.76	157.93	
30	Between schools	1,007.37	159.94	<.001
	Within schools	5,147.36	161.64	

Teacher professionalism. To what extent are teacher professionalism variables (professional development, professional collaboration, teacher experience, teacher knowledge, teacher preparation, and teacher efficacy) associated with eighth-grade mathematics achievement in Chinese Taipei? To address this question, each of the Level-2 teacher professionalism variables was entered into Model 9 to create Models 32-37. However, not any of the fixed effects coefficient estimates had statistically significant relationships with mathematics achievement, so no teacher professionalism variables were selected to include in a combined teacher professionalism model, and Model 38 was omitted.

Pseudo R^2. To evaluate model fit, a pseudo R^2 was calculated for Models 32-37 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by each of the teacher professionalism variables compared to Model 9. Results of pseudo R^2 calculations, shown in Table 49, indicate that the entering of teacher professional development and teacher experience into Model 9 to predict mathematics achievement each reduced the between-school variance by 1%. The entering of the remaining variables into Model 9 did not reduce between-school variance by any discernable amount.

Table 49

Comparison of Pseudo R^2 between Chinese Taipei Models 32-38 and Model 9

Model	Predictor	Between-School Variance	Within-School Variance
32	Professional development	.00	.00
33	Professional collaboration	.00	.00
34	Teacher experience	.03	.00
35	Teacher knowledge	.02	.00
36	Teacher preparation	.01	.00
37	Teacher efficacy	.03	.00

Fixed and random effects. The results of Models 32-37 are shown in Table 50 and 51. Fixed effects coefficient estimates for not any of the variables measuring teacher professionalism had a statistically significant relationship with eighth-grade mathematics achievement; hence, the intended combined teacher professionalism model, Model 38, was omitted in the Chinese Taipei analysis.

Table 50

Estimation of Fixed Effects for Chinese Taipei Model 32-38

Model	Parameter	Coefficient	*SE*	*p*
32	Intercept	613.77	3.16	<.001
	Professional development	1.14	1.67	.50
33	Intercept	613.70	3.16	<.001
	Professional collaboration	1.09	1.40	.44
34	Intercept	614.01	3.15	<.001
	Teacher experience	0.56	0.35	.11
35	Intercept	613.64	3.16	<.001
	Teacher knowledge	-4.39	2.66	.10
36	Intercept	613.80	3.16	<.001
	Teacher preparation	0.98	1.84	.60
37	Intercept	613.77	3.14	<.001
	Teacher self-efficacy	1.62	1.46	.27

Table 51

Estimation of Random Effects for Chinese Taipei Models 32-38

Model	Parameter	Variance Components	*SE*	*p*
32	Between schools	1,010.81	160.22	<.001
	Within schools	5,147.33	161.54	
33	Between schools	1,008.47	160.18	<.001
	Within schools	5,146.68	161.45	
34	Between schools	987.61	156.69	<.001
	Within schools	5,147.94	161.63	
35	Between schools	996.07	160.54	<.001
	Within schools	5,146.41	161.82	
36	Between schools	1,004.39	158.42	<.001
	Within schools	5,147.77	161.65	
37	Between schools	991.47	155.94	<.001
	Within schools	5,149.44	161.61	

Combined teacher-related variables. Based on the results of Models 23-37 composed of teacher- and classroom-related Level-2 predictors, the two variables (mathematics instructional hours per year and assessment question types) that were found to have individually statistically significant relationships with mathematics achievement were entered as a group of teacher-related variables into Model 9, the combined Level-1 model, to predict mathematics achievement in Model 39.

Pseudo R^2. To evaluate model fit, a pseudo R^2 was calculated for Model 39 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by the combined teacher-related variables compared to the combined Level-1 model. Results of pseudo R^2 calculations, shown in Table 52, indicate that the entering of the two teacher-related variables into Model 9 to predict mathematics achievement reduced the between-school variance by 11%.

Table 52

Comparison of Pseudo R^2 between Chinese Taipei Model 39 and Model 9

Model	Predictor	Between-School Variance	Within-School Variance
39	Combined teacher variables	.11	.00

Fixed and random effects. Both predictors in Model 39, the combined teacher-related variables model, had statistically significant fixed effects, shown in Table 53. Because the predictor variables were grand-mean centered, the fixed effect coefficient estimate for mathematics instructional hours per year ($\gamma = 0.22$, $SE = 0.09$, $p = .02$) indicates that for each hour increase in mathematics instruction, students with mean values on all other predictors in the model would be expected to have .22 points increase in their mathematics scores. The fixed effect coefficient estimate for assessment question types ($\gamma = 2.95$, $SE = 1.32$, $p = .03$) indicates that for each unit increase in that scale, students with mean values on all other predictors in the model would be expected to increase 2.95 points in their TIMSS mathematics scores.

Table 53

Parameter Estimates for Chinese Taipei Model 39 (Combined Teacher Variables)

Effect	Parameter	Estimate	*SE*	*p*
Fixed	Intercept	614.40	3.04	<.001
	Mathematics instructional hours per year	0.22	0.09	.02
	Assessment question types	2.94	1.32	.03
Random	Between-schools	906.00	147.34	<.001
	Within-schools	5,146.37	161.61	

Chinese Taipei Full Model

The five Level-2 fixed effects that were found in Models 22 (combined school-related variables) and 39 (combined teacher-related variables) to have statistically significant relationships with mathematics achievement were entered into Model 9 (combined Level-1 model) to create an efficient model for predicting eighth-grade mathematics achievement in Chinese Taipei. The three school-related variables were school emphasis on academic success - teacher reports, school emphasis on academic success - principal reports, and school students economically disadvantaged. The two teacher-related variables were mathematics instructional hours per year and classroom assessment question types.

Pseudo R^2. To evaluate model fit, a pseudo R^2 was calculated for Model 40 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by each of the Level-2 variables compared to the combined Level-1 model. Results of pseudo R^2 calculations, shown in Table 54, indicate that the entering of school emphasis on academic success - teacher reports, school emphasis on academic success - principal reports, students economically disadvantaged, mathematics instructional hours per year, and classroom assessment question types, into Model 9 to predict mathematics achievement reduced the between-school variance by 24%. Overall, Model 40 with the combined school-related variables was more efficient than any of the previous models in predicting mathematics achievement for students in Chinese Taipei.

Table 54

Comparison of Pseudo R^2 between Chinese Taipei Model 40 and Model 9

Model	Predictor	Between-School Variance	Within-School Variance
40	Full model	.24	.03

Fixed and random effects. The three school-related Level-2 predictors in Model 40 had statistically significant fixed effects, and the two teacher-related variables did not, as shown in Table 55. Because the predictor variables were grand-mean centered, the fixed effect coefficient estimate for school emphasis on academic success - teacher reports ($\gamma = 4.45$, $SE = 2.05$, $p = .03$) indicates that for each unit increase in that scale, students with mean values on all other predictors in the model would be expected to have 4.45 points increase in their mathematics scores. The fixed effect coefficient estimate for school emphasis on academic success - principal reports ($\gamma = 5.55$, $SE = 1.60$, $p < .001$) indicates that for each unit increase in that scale, students with mean values on all other predictors in the model would be expected to increase 5.55 points in their TIMSS mathematics scores. The fixed effect coefficient estimate for students economically disadvantaged was found to be statistically significant ($\gamma = -15.88$, $SE = 5.18$, $p = .003$).

This means that with every unit increase in the students economically disadvantaged scale, mathematics scores of students with mean on all other predictors in the model would be expected to decrease by 15.88 points.

In addition, four of the five fixed effects of Level-1 variables were statistically significant. The fixed effect coefficient estimates for home possessions for learning (γ = 8.08, *SE* = 1.04, $p < .001$), parent education (γ = 11.78, *SE* = 1.66, $p < .001$), self-confidence in mathematics (γ = 15.40, *SE* = .87, $p < .001$), and value mathematics (γ = .22, *SE* = .05, $p < .001$) had positive relationships with eighth-grade mathematics achievement in Chinese Taipei.

Table 55

Estimation of Fixed Effects for Chinese Taipei Model 40

Parameter	Coefficient	*SE*	*p*
Intercept	610.76	3.06	<.001
School emphasis on academic success - teacher reports	4.45	2.05	.03
School emphasis on academic success - principal reports	5.55	1.60	<.001
Students economically disadvantaged	-15.88	5.18	.003
Mathematics instructional hours per year	0.07	0.09	.41
Assessment question types	0.31	1.48	.83
Home possessions for learning	8.08	1.04	<.001
Parent education	11.78	1.66	<.001
Parent expectations and involvement	0.31	0.80	.70
Self-confidence in mathematics	15.40	0.87	<.001
Value mathematics	0.22	0.05	<.001

Four of the five random effects of Level-1 variables were statistically significant as shown in Table 56. The relationships between mathematics achievement and each of home possessions for learning ($\hat{\tau}$ = 15.93, *SE* = 17.81, $p < .001$), parent education ($\hat{\tau}$ = 50.01, *SE* = 34.33, $p < .001$), self-confidence in mathematics ($\hat{\tau}$ = 22.08, *SE* = 12.79, $p <$

.001), and value mathematics ($\hat{\tau} = .09$, $SE = .03$, $p < .001$) varied across schools in Chinese Taipei. The slope variance of parent expectations and involvement was not statistically significant, meaning that the relationship between it and mathematics achievement tended to be similar across schools in Chinese Taipei.

Table 56

Estimation of Random Effects for Chinese Taipei Model 40

Model	Parameter	Variance Components	*SE*	*p*
39	Between-schools	772.70	131.31	<.001
	Within-schools	4.987.41	208.25	

Summary

For Chinese Taipei, variables in this study that were statistically significant predictors of mathematics achievement in the final model included variables from the domains of home resources, student beliefs, school climate, and school socioeconomic status. The domains of school administrator leadership, school resources, nor any of the teacher-related domains including access and equity, curriculum, classroom assessment, or teacher professionalism had statistically significant predictors in the final model. Chinese Taipei has a rigorous national curriculum for mathematics and compulsory attendance of 200 days per school year for grades one through nine (Jen, Lee, Chen, Lin, & Lo, 2012). These standards and adherence to them by schools, teachers, and students may explain the lack of variability in the teacher-level domains of access and equity and curriculum.

Results for Ghana

Descriptive Statistics

In contrast to Chinese Taipei, in which eighth-grade students achieved the third highest mathematics scores out of 42 countries that participated in the TIMSS 2011, Ghana achieved the lowest overall eighth-grade mathematics scores (*M* = 344.72, *SD* = 85.02). Descriptive statistics for the dependent variable of mathematics achievement and student-level independent variables for Ghana are shown in Table 57. Of the three countries studied for this dissertation, Ghana had the lowest values on the home possessions for learning (*M* = 7.91, *SD* = 1.68) and parent education (*M* = 2.68, *SD* = 1.24) scales with Ghanaian students' parents having an average attainment of lower secondary education. However, at the same time they had levels of parent expectations and involvement (*M* = 10.42, *SD* = 2.07) and self-confidence in mathematics (*M* = 10.59, *SD* = 1.85) similar to students in Chinese Taipei and the U.S. Perhaps most noteworthy, Ghanaian eighth-grade students reported greater personal value for mathematics (*M* = 63.36, *SD* = 57.48) than did students from either Chinese Taipei or the U.S.

Table 57

Level 1 Descriptive Statistics for Ghana (N = 4,016)

Domain	Variable	*M*	*SD*	Min	Max
	Mathematics achievement	344.72	85.02	39.33	621.34
Home resources	Home possessions for learning	7.91	1.68	5.08	13.42
	Parent education	2.68	1.24	1	5
	Parent expectations and involvement	10.42	2.07	4.99	13.19
Student beliefs	Self-confidence in mathematics	10.59	1.85	3.18	15.82
	Value mathematics	63.36	57.48	-196.87	134.18

Descriptive statistics for the school-level independent variables for Ghana are shown in Table 58. Schools in Ghana reported typically one computer available for approximately for every 3-5 students (*M* = 2.03, *SD* = 1.11). This is between the computer availability for students in Chinese Taipei which had less computer availability and the U.S. which had more. Schools in Ghana also reported that a higher percentage of their students were from economically disadvantaged homes (*M* = 2.74, *SD* = 0.58) than did schools in either Chinese Taipei or the U.S. Regarding access to instruction, schools in Ghana reported students having a number of hours of mathematics instruction (*M* = 164.57, *SD* = 79.84) close to that of Chinese Taipei but with much greater variation. Both Ghana and Chinese Taipei reported greater number of hours of mathematics instruction than schools in the U.S. did. Teachers in Ghana reported having approximately half the years of experience teaching (*M* = 7.13, *SD* = 6.27) than did teachers in Chinese Taipei or the U.S. For the predictor teacher education (*M* = 2.69, *SD* = 1.41), teachers in Ghana typically had majored in mathematics, but not mathematics education.

Table 58

Level 2 Descriptive Statistics for Ghana (N = 97)

Domain	Variable	*M*	*SD*	Min	Max
School climate	School emphasis on academic achievement-teachers	10.68	1.83	4.99	14.58
	School emphasis on academic achievement-principals	10.17	1.77	4.91	14.17
	School discipline and safety	10.15	1.39	3.98	13.94
School resources	Computer availability for instruction	2.03	1.11	1	4
	Resources for general instruction	9.04	1.05	5.3	11.28
	Resources for mathematics instruction	9.44	2.18	6.44	15.93
Administrator leadership	Administrator leadership	10.28	1.91	5.87	12.91

Table 58 (Continued)

School socioeconomic status	Students economically disadvantaged	2.74	0.58	1	3
	Home resources limiting teaching	9.86	1.69	6.24	16.19
Access and equity	Mathematics hours per year	164.57	79.84	0	410.67
	Mathematics topics taught	9.48	1.41	6.29	14.18
Curriculum	Textbooks or workbooks for instruction	9.75	2.36	3.64	13.34
	Tools or technology for instruction	9.58	1.66	5.07	12.99
	Instruction to engage students	10.8	1.51	6.43	11.94
	Research-based instruction	10.32	1.96	5.67	14.73
Assessment	Classroom assessment question types	9.82	1.9	5.91	12.99
	Classroom emphasis on assessment	10.5	2.01	2.77	12.47
Teacher professionalism	Professional development	9.95	2.16	6.2	12.9
	Professional collaboration	10.26	2.21	4.85	15.77
	Teacher experience	7.13	6.27	1	30
	Teacher education	2.69	1.41	1	5
	Teacher preparation	10.33	1.82	6.99	11.99
	Teacher self-efficacy	11.26	1.33	5.07	11.99

Assumptions

Residuals of both Level-1 and -2 intercepts and predictors of the final model for Ghana were examined to check the multilevel regression assumptions of normality and homoscedasticity. First, scatter plots of mathematics achievement by standardized Level-1 and -2 residuals were examined to check for the assumption of homoscedasticity. Visual examination of the scatter plots in Figures 15-18 found no major violations of the assumption of homoscedasticity.

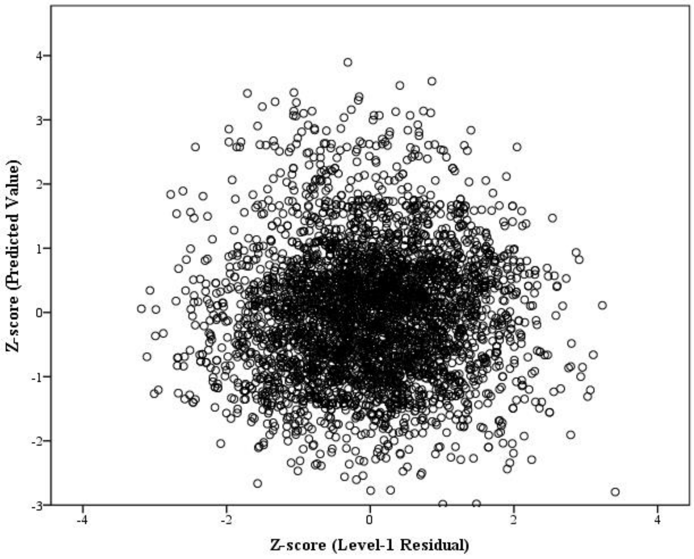

Figure 15. Predicted Ghana mathematics achievement standardized by Level-1 residuals.

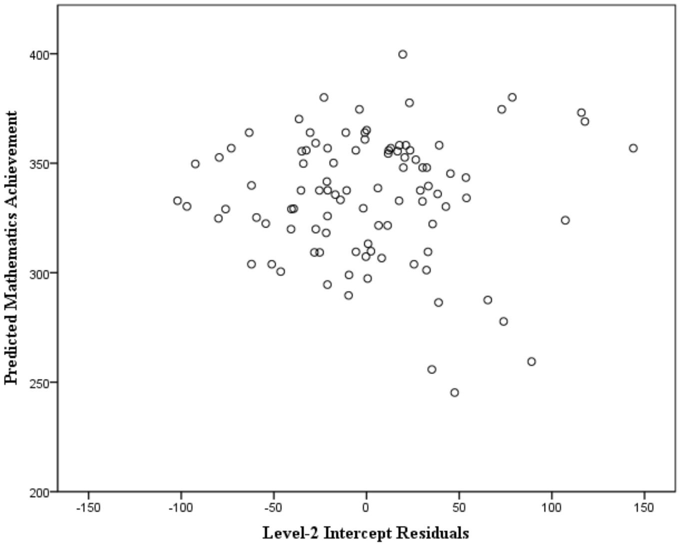

Figure 16. Predicted Ghana mathematics achievement by Level-2 intercept residuals.

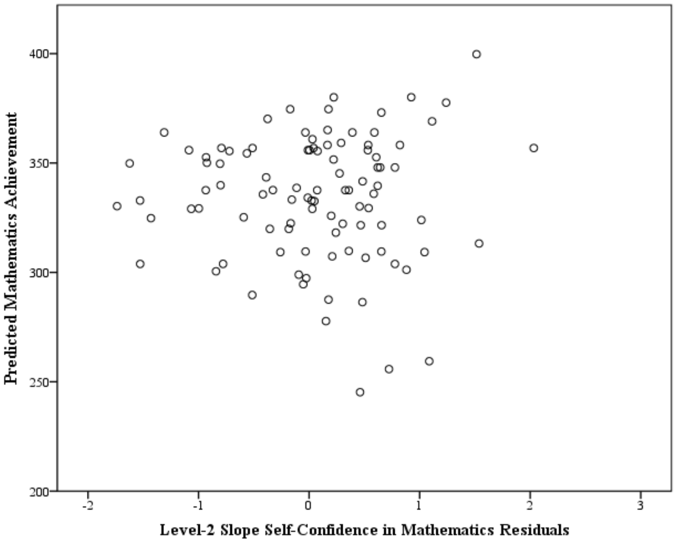

Figure 17. Predicted Ghana mathematics achievement by Level-2 slope self-confidence in mathematics residuals.

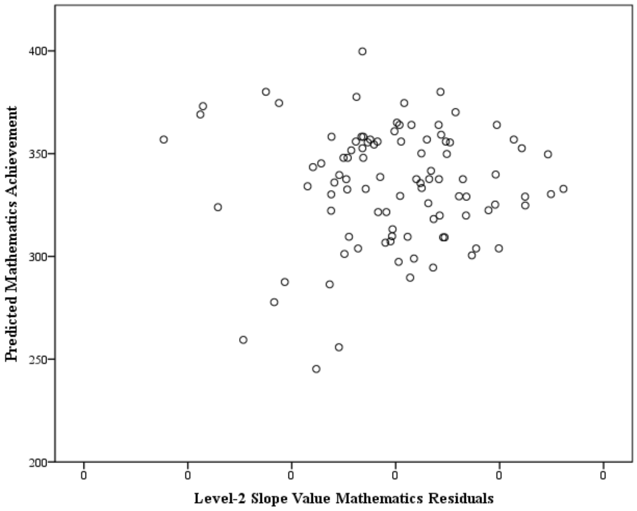

Figure 18. Predicted Ghana mathematics achievement by Level-2 slope value mathematics residuals.

The assumption of normality was checked by examining plots of predicted normal values by both Level-1 and Level-2 standardized residuals, shown in Figures 19-22. No major violations of the normality were found.

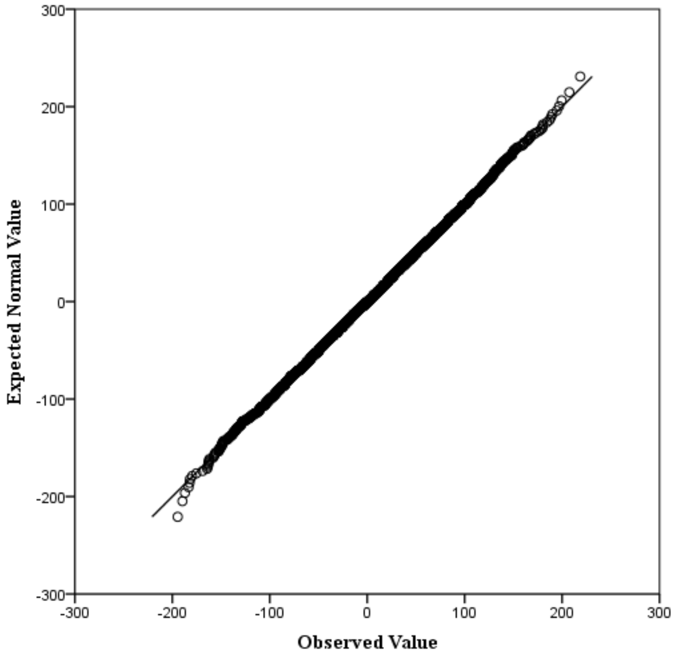

Figure 19. Normal Q-Q plot of Ghana Level-1 residuals.

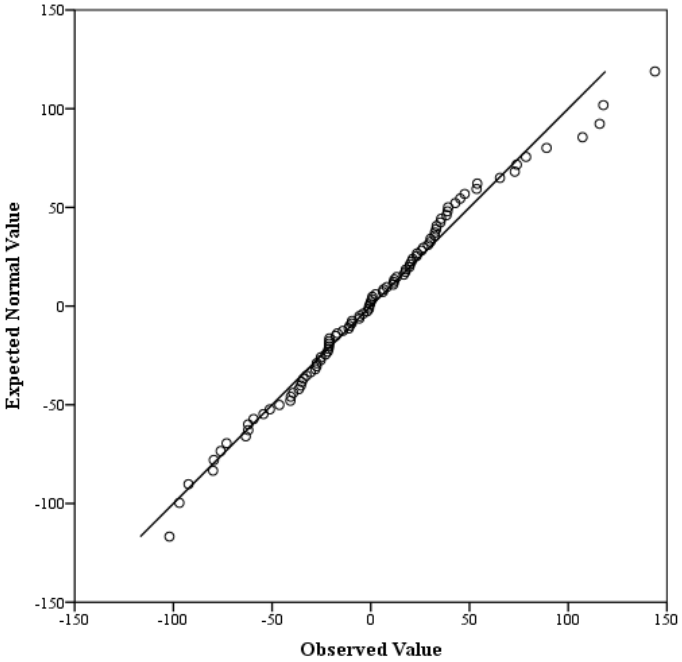

Figure 20. Normal Q-Q plot of Ghana Level-2 intercept residuals.

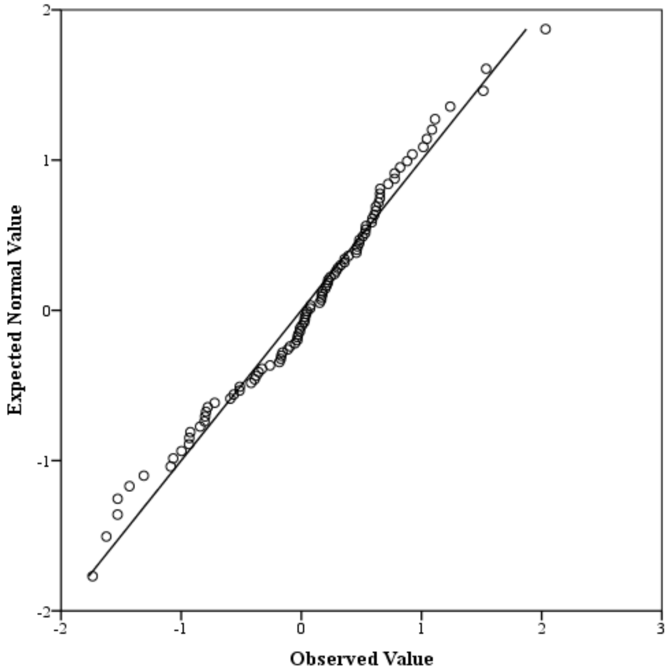

Figure 21. Normal Q-Q plot of Ghana Level-2 self-confidence in mathematics residuals.

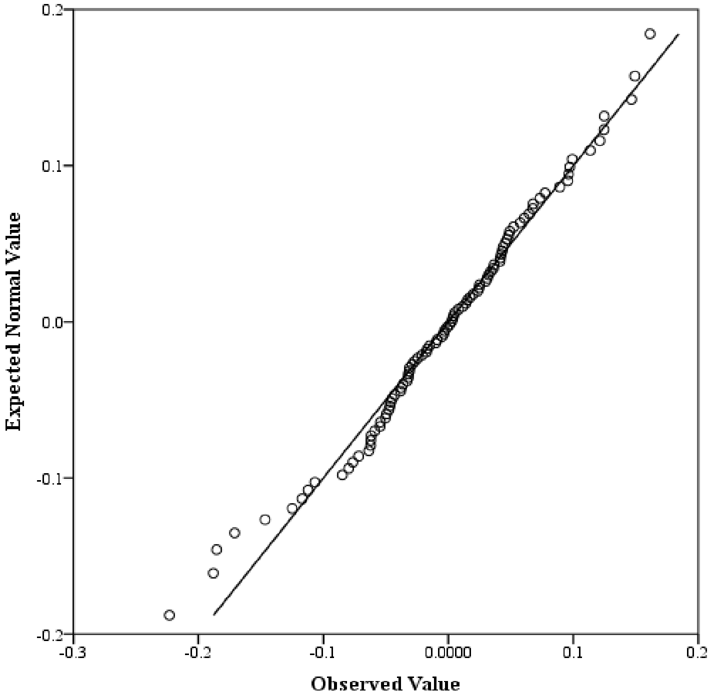

Figure 22. Normal Q-Q plot of U.S. Level-2 value mathematics residuals.

Unconditional model

Model 1 was an unconditional model containing only the dependent variable, composed of the five plausible values of student mathematics achievement, and the grouping variable of schools. For the Ghana unconditional model, the estimated fixed effect value for the intercept was 333.54 ($SE = 6.24$ $p < .001$). The average level of mathematics achievement was significantly different across schools in Ghana ($\hat{\tau}_{00} =$ 3,268.37, $SE = 502.45$, $p <.001$). The amount of unexplained variance within schools, ($\hat{\sigma}^2$ = 4,327.91, $SE = 157.30$) was somewhat greater than that between schools. The ICC of .43 indicates that approximately 43% of the total variance in mathematics scores occurred between schools, and 57% occurred within schools.

Home-Related Variables

Research Question 1 for each country in this study is the extent to which home-related variables (home possessions for learning, parent educational attainment, and parent expectations for and involvement in their children's education) predict eighth-grade mathematics achievement. To address this question, the three variables were entered separately as Models 2-4 into the unconditional model as singular predictors of eighth-grade mathematics achievement in Ghana. Not any of the three home-related variables was found to be a statistically significant predictor of mathematics achievement; therefore, Model 5, the intended model of combined home-related variables to predict mathematics achievement as a group, was omitted.

Deviances. The first analysis of Models 2-4 was an evaluation of goodness-of-fit of each model in comparison to the unconditional model by comparing the deviance of each model. Results of the significance tests for change in deviance, shown in Table 59, indicate that Models 2 ($\chi2 = 24.70$, $p < .001$) and 3 ($\chi2 = 10.30$, $p = .02$) each had statistically significant lower deviances than the unconditional model, and therefore were better fitting models than the unconditional model. The chi-squared statistic for parent expectations and involvement was not statistically different, indicating Model 4 is not necessarily a better fitting model than the unconditional model.

Table 59

Deviances for Ghana Home Variables Models

Model	Predictor	Deviance	χ^2	p
1	Unconditional	45,435.43		
2	Home possessions for learning	45,410.72	24.70	<.001
3	Parent education	45,425.13	10.30	.02
4	Parent expectations and involvement	45,425.13	7.28	.06

Pseudo R^2. To further evaluate model fit, a pseudo R^2 was calculated for Models 2-4 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by each of the home-related variables compared to the unconditional model. Results, shown in Table 60, indicate that home possessions for learning as a single predictor increased the between-school variance very slightly and reduced the within-school variance from the unconditional model by 2%. Models 3 and 4 each reduced both between-school and within-school variances by 1%.

Table 60

Comparison of Pseudo R^2 between Ghana Models 2-4 and Model 1

Model	Predictor	Between-School Variance	Within-School Variance

Table 60 (Continued)

2	Home possessions for learning	-.004	.02
3	Parent education	.01	.01
4	Parent expectations and involvement	.01	.01

Fixed and random effects. Not any of the fixed effects coefficient estimates for the three home-related variables had a statistically significant relationship with eighth-grade mathematics achievement in Ghana. So, a combined model of home-related variables to predict mathematics achievement as a group, Model 5, was omitted. However, random effects coefficient estimates for home possessions for learning ($\hat{\tau}$ = 42.61, *SE* = 20.33, $p < .001$), parent educational attainment ($\hat{\tau}$ = 40.85, *SE* = 26.17, $p < .001$), and parent expectations and involvement ($\hat{\tau}$ = 9.90, *SE* = 8.38, $p < .001$) were statistically significant, indicating the relationships between each of these variables and mathematics achievement varied across schools in Ghana. Estimations of fixed effects are shown in Table 61, and estimation of random effects are shown in Table 62.

Table 61

Estimation of Fixed Effects for Ghana Models 2-4

Model	Parameter	Coefficient	*SE*	*p*
2	Intercept	332.52	6.30	<.001
	Home possessions for learning	-1.75	1.47	.25
3	Intercept	333.40	7.17	<.001
	Parent educational attainment	0.44	1.52	.77
4	Intercept	334.01	6.24	<.001
	Parent expectations and involvement	1.62	0.84	.06

Table 62

Estimation of Random Effects for Ghana Models 2-4

Model	Parameter	Variance Components	*SE*	*p*
2	Between-schools	3,281.89	506.37	<.001
	Home possessions for learning	42.61	20.33	<.001
	Within-schools	4,235.08	149.59	
3	Between-schools	3,222.60	495.71	<.001
	Parent educational attainment	40.85	26.17	<.001
	Within-schools	4,277.65	165.16	
4	Between-schools	3,245.57	500.48	<.001
	Parent expectations and involvement	9.90	8.38	<.001
	Within-schools	4,286.67	170.61	

Student Beliefs

Research Question 2 for each country in this study is the extent to which student beliefs of self-confidence in mathematics and value of mathematics predict eighth-grade mathematics achievement. To address this question, the two variables related to student beliefs were entered separately as Models 6 and 7 into the unconditional model as single predictors of eighth-grade mathematics achievement in Ghana. Then, because both variables were found to contribute significantly to mathematics achievement, they were both entered into a combined model of student beliefs to predict mathematics achievement as a group.

Deviances. The first analysis of Models 6 and 7 was an evaluation of goodness-of-fit of each model in comparison to Model 1 by comparing the deviance of each model. Results of the significance tests for change in deviance, shown in Table 63, indicate that each of Models 6 and 7 with the two student-belief variables had statistically significant lower deviances than Model 1, and therefore were better fitting models than Model 1.

Table 63

Deviances for Ghana Student Beliefs Models

Model	Predictor	Deviance	χ^2	*p*
1	Unconditional	45,435.43		
6	Self-confidence in mathematics	45,024.54	410.89	<.001
7	Value mathematics	45,170.67	264.76	<.001

Pseudo R^2. To further evaluate model fit, a pseudo R^2 was calculated for Models 6-7 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by each of the student beliefs variables compared to Model 1. Results of pseudo R^2 calculations, shown in Table 64, indicate that the entering of self-confidence in mathematics to the unconditional model to predict mathematics achievement reduced the between-school variance by 6% and within-school variance by 10%. The entering of value mathematics as a predictor by itself to the unconditional model reduced the between-school variance by 4% and within-school variance by 7%.

Table 64

Comparison of Pseudo R^2 between Ghana Models 6-7 and Model 1

Model	Predictor	Between-School Variance	Within-School Variance
6	Self-confidence in mathematics	.06	.10
7	Value mathematics	.04	.07

Fixed and Random Effects. Fixed effects of both self-confidence in mathematics ($\gamma = 11.82$, SE = 0.75, p < .001) and value mathematics ($\gamma = 0.29$, $SE = 0.02$, $p < .001$)

had statistically significant relationships with eighth-grade mathematics achievement. Random effects of both self-confidence in mathematics ($\hat{\boldsymbol{\tau}}$ = 2.89, *SE* = 4.26, *p* = .03) and value mathematics ($\hat{\boldsymbol{\tau}}$ = 0.004, *SE* = 0.005, *p* = .01) had statistically significant relationships with eighth-grade mathematics achievement, as well. Estimations of coefficients for fixed effects are shown in Table 65, and estimations of random effects are shown in Table 66.

Table 65

Estimation of Fixed Effects for Ghana Models 6-7

Model	Parameter	Coefficient	*SE*	*p*
6	Intercept	334.91	6.07	<.001
	Self-confidence in mathematics	11.82	0.75	<.001
7	Intercept	334.76	6.16	<.001
	Value mathematics	0.29	0.02	<.001

Table 66

Estimation of Random Effects for Ghana Models 6-7

Model	Parameter	Variance Components	*SE*	*p*
6	Between-schools	3,079.65	470.58	<.001
	Self-confidence in mathematics	2.89	4.26	.03
	Within-schools	3,902.78	138.02	
7	Between-schools	3,145.83	480.93	<.001
	Value mathematics	0.004	0.005	.01
	Within-schools	4.044.09	141.69	

Combined Model. After both student-belief variables were found to reduce variance compared to Model 1, they were combined to predict mathematics achievement in Model 8. Goodness of fit was evaluated by calculating pseudo R^2 and comparing

Model 8 to Models 6 and 7 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by Model 8 compared to the previous models. Results are shown in Table 67. Model 8 yielded a reduction in variance of 6% between schools and 10% within schools, compared to Model 6. Compared to Model 7, Model 8 reduced between-school variance 4% and within-school variance 7%, Overall, Model 8 with the combined student-belief variables was more efficient than previous models with singular student-belief variables in predicting mathematics achievement for students in Ghana.

Table 67

Comparison of Pseudo R^2 between Ghana Model 8 and Models 6-7

Model	Predictor	Between-School Variance	Within-School Variance
6	Self-confidence in mathematics	.06	.10
7	Value mathematics	.04	.07

Both predictors together in Model 8 had statistically significant relationships with mathematics achievement, shown in Table 68. Because the predictor variables were grand-mean centered, the fixed effect coefficient estimate for self-confidence in mathematics ($\gamma = 9.51$, $SE = 0.85$, $p < .001$) indicates that for each unit increase in the self-confidence in mathematics scale, students with mean values on the value mathematics scale would be expected to have 9.51 points increase in their mathematics scores. The fixed effect coefficient estimate for value mathematics ($\gamma = 0.14$, $SE = 0.03$, $p < .001$) indicates that for each unit increase in the value mathematics scale, students with mean values on the self-confidence in mathematics scale would be expected to increase

0.14 points in their TIMSS mathematics scores. Again, it should be kept in mind that the value mathematics scale's standard deviation of 65 is much greater than the standard deviation of two for most of the other scales in this study. This means that the absolute differences in scores relating to the value mathematics variable are not directly comparable to differences in scores relating to other variables. For example, if the value mathematics scale had a standard deviation of two rather than 65, the fixed effect coefficient estimate for value mathematics would be greater than 0.14 and would be more easily compared to the parameter estimates relating to the self-confidence in mathematics variable.

The random effects of both student-belief variables—self-confidence in mathematics ($\hat{\tau} = 2.54$, *SE* = 4.16, $p = .05$) and value mathematics ($\hat{\tau} = 0.01$, *SE* = 0.01, $p = .003$) —indicate that these predictors varied significantly across schools in Ghana. The variance of 3,054.75 (*SE* = 464.83, $p < .001$) for the intercept indicates there were statistically significant differences in mathematics achievement across schools after accounting for the two student-belief variables in the model.

Table 68

Parameter Estimates for Ghana. Model 8 (Combined Student-Belief Variables)

Effect	Parameters	Estimates	*SE*	*p*
Fixed	Intercept	335.27	6.06	<.001
	Self-confidence in mathematics	9.51	0.85	<.001
	Value mathematics	0.14	0.03	<.001
Random	Between schools	3,054.75	464.83	<.001
	Self-confidence in mathematics	2.54	4.16	.05
	Value mathematics	0.01	0.01	.003
	Within schools	3,817.96	130.73	

Combined Level-1 Model

Because not any of the singular home-related variables in Models 2-4 had a statistically significant relationship with mathematics achievement and both student belief variables combined in Model 8 did, Model 8 with the combined two Level-1 variables was selected to also represent Model 9 as the combined Level-1 model. That is, in Ghana, the home-related variables of home possessions for learning, parent educational attainment, and parent expectations and involvement do not have a statistically significant relationship with mathematics achievement for students in the eighth grade; however, student beliefs of self-confidence in mathematics and value of mathematics do have a statistically significant relationship with eighth-grade mathematics achievement. This perhaps surprising result prompted a visual examination of the questionnaire items comprising the three home-related composite variables, the summary responses to those items from students in the three countries studied in this dissertation, and the corresponding mathematics achievement scores. As shown in Tables C1-C11, mathematics scores for students in Ghana varied little compared to scores for students in Chinese Taipei and the U.S. across the responses for most of the items comprising the home-related composite variables. This visual examination may facilitate interpretation of Models 2-4 that indicated that the home-related variables in this study do not have a statistically significant relationship with mathematics achievement in Ghana.

School-Related Variables

Research Question 3 for each country in this study is the extent to which school-related variables (school climate, school resources, administrator leadership, and school socioeconomic status) predict eighth-grade mathematics achievement. To address this question, school climate variables were first entered separately as Models 10-12, and then the statistically significant school climate variables were combined and entered into Model 9 to create Model 13. Next, school resources variables were entered separately into Model 9 as Models 14-16. Only one of the school resources variables was found statistically significant, so Model 15 was selected as the representative school resources model, and the intended combined school resources model, Model 17, was omitted. Model 18 contained the single variable for administrator leadership. Variables measuring school socioeconomic status were entered separately as Models 19 and 20, and then both school socioeconomic status variables which were statistically significant were combined and entered into Model 9 to create Model 21. Then, all the school-level variables that were found to individually predict mathematics achievement were selected to be entered into a combined model (Model 22) of school-related variables to predict mathematics achievement as a group.

School climate. To what extent are school-climate variables (school emphasis on academic success—reported by teachers and principals separately—and school discipline and safety) associated with eighth-grade mathematics achievement in Ghana? To address this question, each of the Level-2 school climate variables was added to the combined Level-1 model (Model 9) to create Models 10-12. Then, all three of these variables had statistically significant fixed effects, so they were all included in the combined school climate model, Model 13.

Pseudo R^2. To evaluate model fit, a pseudo R^2 was calculated for Models 10-13 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by each of the school climate variables compared to Model 9. Results of pseudo R^2 calculations, shown in Table 69, indicate that the entering of school emphasis on academic success - teacher reports into Model 9 to predict mathematics achievement reduced the between-school variance by 9%. The entering of school emphasis on academic success - principal reports as a predictor by itself into Model 9 reduced the between-school variance by 7%. The entering of school discipline and safety to Model 9 to predict mathematics achievement reduced the between-school variance by 11%. Overall, Model 13 with the combined school climate variables was more efficient, reducing the between-school variance compared to Model 9 by 17%, than Models 10-12 with singular school climate variables in predicting mathematics achievement for students in Ghana.

Table 69

Comparison of Pseudo R^2 between Ghana Models 10-13 and Model 9

Model	Predictor	Between-School Variance	Within-School Variance
10	Emphasis on academic success - teachers	.09	.00
11	Emphasis on academic success- principals	.07	.00
12	School discipline and safety	.11	.00
13	Combined school climate	.17	.00

Fixed and random effects. Fixed effects coefficient estimates for all three variables measuring school climate had a statistically significant relationship with eighth-grade mathematics achievement in Ghana. Model 10 with school emphasis on academic success - teacher reports as a Level-2 predictor of mathematics achievement yielded a statistically significant fixed effect ($\gamma = 10.25$, $SE = 3.03$, $p = .001$). This means that with every unit increase in the school emphasis on academic success - teacher reports scale, the mathematics scores of students with mean Level-1 variable values would be expected to increase by 10.25 points. The fixed effect coefficient estimate for school emphasis on academic success - principal reports was found statistically significant in Model 11 ($\gamma = 9.18$, $SE = 3.22$, $p = .005$). This means that with every unit increase in the school emphasis on academic success - principal reports scale, mathematics scores of students would be expected to increase by 9.18 points after accounting for Level-1 variables. The fixed effect coefficient estimate for school discipline and safety was found statistically significant in Model 12 ($\gamma = 13.72$, $SE = 3.95$, $p < .001$). This means that with every unit increase in school discipline and safety scale, mathematics scores of students would be expected to increase by 13.72 points after accounting for Level-1 variables. However, when the three school climate variables were combined in Model 13, the fixed effect coefficient estimate for only school emphasis on academic success - teacher reports (γ = 7.28, SE = 3.53, p = .04) and school discipline and safety (γ = 10.55, SE = 4.35, p = .02) were found to have statistically significant relationships with eighth-grade mathematics achievement in Ghana. The results of Models 10-13 are shown in Table 70.

Table 70

Estimation of Fixed Effects for Ghana Models 10-13

Model	Parameter	Coefficient	*SE*	*p*
10	Intercept	334.79	5.89	<.001
	Emphasis on academic success - teachers	10.25	3.03	.001
11	Intercept	337.36	5.95	<.001
	Emphasis on academic success - principals	9.18	3.22	.005
12	Intercept	335.35	5.84	<.001
	School discipline and safety	13.72	3.95	<.001
13	Intercept	334.87	5.71	<.001
	Emphasis on academic success - teachers	7.28	3.53	.04
	Emphasis on academic success - principals	1.27	4.12	.76
	School discipline and safety	10.55	4.35	.02

Random effects coefficient estimates for Models 10-13 are shown in Table 71. In Model 13 with the combined school climate variables, the random effects of Level-1 self-confidence in mathematics ($\hat{\tau}$ = 2.35, *SE* = 4.17, *p* = .03) and value mathematics ($\hat{\tau}$ = 0.01, *SE* = 0.01, *p* = .002) were statistically significant, meaning that the relationships between mathematics achievement and self-confidence in mathematics and value mathematics varied across schools in Ghana. These relationships remained consistent for the remaining Level-2 models.

Table 71

Estimation of Random Effects for Ghana Models 10-13

Model	Parameter	Variance Components	*SE*	*p*
10	Between schools	2,766.08	427.80	<.001
	Within schools	3,801.69	121.98	
11	Between schools	2,849.73	436.50	<.001
	Within schools	3,802.80	120.77	
12	Between schools	2,730.94	427.39	<.001
	Within schools	3,803.15	120.95	
13	Between schools	2,533.23	398.16	<.001
	Within schools	3,801.93	121.46	

School resources. To what extent are school resources variables (computer availability for instruction, resources for general instruction, and resources for mathematics instruction) associated with eighth-grade mathematics achievement in Ghana? To address this question, each of the Level-2 school resources variables was entered into Model 9 to create Models 14-16. Because only Model 15 of the three, with the singular variable resources for general instruction, showed statistically significant fixed effects, Model 15 was selected to represent overall school resources, and Model 17, intended to be a combined school resources model was omitted for Ghana.

Pseudo R^2. To evaluate model fit, a pseudo R^2 was calculated for Models 14-16 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by each of the school resources variables compared to Model 9, the combined Level-1 model. Results of pseudo R^2 calculations, shown in Table 72, indicate that the entering of computers available for instruction into Model 9 to predict mathematics achievement actually increased the between-school variance by 2%. The entering of resources for general instruction as a predictor by itself to Model 9 reduced the between-school variance by 3%. The entering of resources for mathematics instruction to Model 9 also increased the between-school variance by 3%.

Table 72

Comparison of Pseudo R^2 between Ghana Models 14-17 and Model 9

Model	Predictor	Between-School Variance	Within-School Variance
14	Computer availability for instruction	-.02	.00
15	Resources for general instruction	.03	.00
16	Resources for mathematics instruction	-.03	.00

Fixed and random effects. Of the three variables measuring school resources, the fixed effect coefficient estimate for a shortage of resources for general instruction ($\gamma = 0.18$, $SE = 1.38$, $p = .04$) in Model 15 was the only one that had a statistically significant relationship with eighth-grade mathematics achievement. This means that with every unit increase in shortage of resources for mathematics instruction scale, mathematics scores of Ghana students with mean Level-1 variable values would be expected to increase by 0.18 points after accounting for Level-1 variables. The results of Models 14-16 are shown in Table 73. Because only Model 15 of the three fixed effects measuring school resources had a statistically significant relationship with mathematics achievement, Model 15 was selected to measure overall school resources, and Model 17, intended to be a combined school resources model was omitted for Ghana.

Table 73

Estimation of Fixed Effects for Ghana Models 14-16

Model	Parameter	Coefficient	*SE*	*p*
14	Intercept	335.97	6.17	<.001
	Computer availability for instruction	-3.60	5.34	.50
15	Intercept	336.10	6.06	<.001
	Shortage of resources for general instruction	0.18	1.38	.04
16	Intercept	335.69	6.23	<.001
	Shortage of resources for mathematics instruction	-1.73	2.55	.50

Random effects coefficient estimates for Models 14-16 are shown in Table 74. In Model 15, the most efficient of the school resources models, the random effects of Level-1 self-confidence in mathematics ($\hat{\tau}$ = 2.72, *SE* = 4.05, *p* = .03) and value mathematics ($\hat{\tau}$ = 0.01, *SE* = 0.01, *p* = .002) were statistically significant, meaning that the relationships between mathematics achievement and self-confidence in mathematics and value mathematics varied across schools in Ghana.

Table 74

Estimation of Random Effects for Ghana Models 14-16

Model	Parameter	Variance Components	*SE*	*p*
14	Between schools	3,104.07	475.30	<.001
	Within schools	3,802.64	121.58	
15	Between schools	2,977.33	456.54	<.001
	Within schools	3,802.11	119.89	
16	Between schools	3,144.89	484.97	<.001
	Within schools	3,803.28	120.73	

Administrator leadership. To what extent is school administrator leadership associated with eighth-grade mathematics achievement in Ghana? To address this question, the singular administrator leadership variable was entered into the combined Level-1 model (Model 9) to create Model 18.

Pseudo R^2. To evaluate model fit, a pseudo R^2 was calculated for Model 18 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by school administrator leadership compared to the combined Level-1 model. Results of the pseudo R^2 calculation, shown in Table 75, indicate that the entering of administrator leadership into the combined Level-1 model to predict mathematics achievement increased the between-school variance by 2%.

Table 75

Comparison of Pseudo R^2 between Ghana Model 18 and Model 9

Model	Predictor	Between-School Variance	Within-School Variance
18	Administrator leadership	-.02	.00

Fixed and random effects. The fixed effect coefficient estimate for administrator leadership did not have a statistically significant relationship with mathematics achievement. The results of Models 18 are shown in Table 76.

Table 76

Parameter Estimates for Ghana Model 18 (Administrator Leadership)

Effect	Parameter	Coefficient	*SE*	*p*
Fixed	Intercept	335.98	6.20	<.001
	Administrator leadership	-0.36	3.01	.91
Random	Between-schools	3,124.59	477.76	<.001
	Within-schools	3,802.82	120.87	

School socioeconomic status. To what extent are school socioeconomic status variables (students economically disadvantaged and home resources limiting teaching) associated with eighth-grade mathematics achievement in Ghana? To address this question, each of the Level-2 school socioeconomic status variables was entered into Model 9 to create Models 19 and 20. Then, both variables, having statistically significant fixed effects separately, were included in the combined school socioeconomic status model, Model 21.

Pseudo R^2. To evaluate model fit, a pseudo R^2 was calculated for Models 19-21 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by each of the school socioeconomic status variables compared to Model 9. Results of pseudo R^2 calculations, shown in Table 77, indicate that the entering of students economically disadvantaged into Model 9 to predict mathematics achievement reduced the between-school variance by 6%. The entering of home resources limiting teaching as a predictor by itself into Model 9 reduced the between-school variance by 17%. Overall, Model 21 with the combined school socioeconomic variables was more efficient than Models 19 or 20 with singular school socioeconomic status variables in predicting mathematics achievement for students in Ghana.

Table 77

Comparison of Pseudo R^2 between Ghana Models 19-21 and Model 9

Model	Predictor	Between-School Variance	Within-School Variance
19	Students economically disadvantaged	.06	.00
20	Home resources limiting teaching	.17	.00
21	Combined school socioeconomic status	.24	.00

Fixed and random effects. Fixed effects coefficient estimates for both variables measuring school socioeconomic status had a statistically significant relationship with eighth-grade mathematics achievement. Model 19 with students economically disadvantaged as a Level-2 predictor of mathematics achievement yielded a statistically significant fixed effect ($\gamma = -26.85$, $SE = 5.47$, $p < .001$). This means that with every unit increase in the students economically disadvantaged scale, mathematics scores of students with mean Level-1 variable values would be expected to decrease by 26.85 points. The fixed effect coefficient estimate for home resources limiting teaching was found statistically significant in Model 20 ($\gamma = -13.29$, $SE = 3.10$, $p = .01$). This means that with every unit increase in the home resources limiting teaching scale, mathematics scores of students with mean Level-1 variable values would be expected to decrease by 13.29 points.

Both school socioeconomic status variables still had statistically significant negative relationships with mathematics achievement when combined in Model 21. The results of Models 19-21 are shown in Table 78.

Table 78

Estimation of Fixed Effects for Ghana Models 19-21

Model	Parameter	Coefficient	*SE*	*p*
19	Intercept	336.98	5.98	<.001
	Students economically disadvantaged	-26.85	5.47	.01
20	Intercept	335.67	2.97	<.001
	Home resources limiting teaching	-13.29	3.10	<.001
21	Intercept	336.60	5.48	<.001
	Students economically disadvantaged	-24.31	9.52	.01
	Home resources limiting teaching	-12.77	3.01	<.001

Random effects coefficient estimates for Models 19-21 are shown in Table 79. In Model 21 with the combined school climate variables, the random effects of Level-1 self-confidence in mathematics ($\hat{\tau} = 2.53$, *SE* = 3.96, *p* = .03) and value mathematics ($\hat{\tau} = 0.01$, *SE* = 0.01 *p* = .002) were statistically significant, meaning that the relationships between mathematics achievement and self-confidence in mathematics and value mathematics varied across schools in Ghana.

Table 79

Estimation of Random Effects for Ghana Models 19-21

Model	Parameter	Variance Components	*SE*	*p*
19	Between-schools	2,874.86	443.31	<.001
	Within-schools	3,803.88	120.72	
20	Between-schools	2,523.77	398.19	<.001
	Within-schools	3,804.05	121.46	
21	Between-schools	2,332.10	372.32	<.001
	Within-schools	3,804.13	121.02	

Combined school-related variables model. Based on the results of Models 10-21, containing theory-driven combinations of school-related variables, five variables (emphasis on academic success - teacher reports, school discipline and safety, resources for general instruction, students economically disadvantaged, and home resources limiting teaching) were selected to enter into Model 9, the combined Level-1 model, as the school-related variables to predict mathematics achievement in Model 22.

Pseudo R^2. To evaluate model fit, a pseudo R^2 was calculated for Model 22 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by the combined school-related variables compared to Model 9. Results of the pseudo R^2 calculation, shown in Table 80, indicate that the combination of the five school-related variables being entered into Model 9 to predict mathematics achievement reduced the between-school variance by 32%.

Table 80

Comparison of Pseudo R^2 between Ghana Model 22 and Model 9

Model	Predictor	Between-School Variance	Within-School Variance
22	Combined school-related variables	.32	.00

Fixed and random effects. Two fixed effect coefficient estimates of the school-related variables—one of the school climate variables, not any of the school resources, and one of the school socioeconomic status—showed statistically significant relationships with eighth-grade mathematics achievement in Ghana in a combined school-related variables model. Results of Model 22 are shown in Table 81. Because the predictor variables were grand-mean centered, the fixed effect coefficient estimate for school discipline and safety ($\gamma = 8.80$, $SE = 3.69$, $p = .02$) indicates that for each unit increase in that scale, students with mean values on all other predictors in the model would be expected to have 8.80 points increase in their mathematics scores. The fixed effect coefficient estimate for home resources limiting teaching was also found statistically significant ($\gamma = -10.09$, $SE = 2.96$, $p < .001$). This means that with every unit increase in the home resources limiting teaching scale, mathematics scores of students with mean values on all other predictors in the model would be expected to decrease by 10.09 points.

Table 81

Parameter Estimates for Ghana Model 22 (Combined School Variables)

Effect	Parameter	Estimate	*SE*	*p*
Fixed	Intercept	335.56	5.24	<.001
	School emphasis on academic success-teachers report	3.97	3.02	.19
	School discipline and safety	8.80	3.69	.02
	Shortage of resources for general instruction	-5.12	4.79	.29
	Students economically disadvantaged	-15.75	9.61	.11
	Home resources limiting teaching	-10.09	2.96	<.001
Random	Between-schools	2,088.94	341.81	<.001
	Within-schools	3,802.94	120.74	

Teacher-related variables

Research Question 4 for each country in this study is the extent to which teacher- or classroom-related variables (access and equity, curriculum, tools and technology, classroom assessment, and teacher professionalism) predict eighth-grade mathematics achievement. The approach toward answering this question was to enter the teacher-related variables into the combined Level-1 model, Model 9. First, variables measuring access and equity were entered separately as Models 23 and 24, and then because only

Model 24 of the two was a statistically significant predictor of eighth-grade mathematics achievement, Model 25, which was intended to combine both access and equity variables if they were statistically significant, was omitted. Next, variables measuring the construct of curriculum were entered separately into Model 9 as Models 26 and 27, and then because neither of those two was a statistically significant predictor of eighth-grade mathematics achievement, Model 28, which was intended to combine both curriculum variables if they were statistically significant, was omitted. Variables measuring classroom assessment were entered separately as predictors of eighth-grade mathematics achievement into Model 9 to create Models 29 and 30. Then, because only Model 30 of those two was a statistically significant predictor of eighth-grade mathematics achievement, Model 31, which was intended to combine both assessment variables if they were statistically significant, was omitted. The six variables measuring teacher professionalism were entered separately into Model 9 as predictors of eighth-grade mathematics achievement. Those variables with significant fixed effects in Models 32-37 were included in the combined teacher professionalism model, Model 38. The teacher-level variables that were found to contribute significantly to mathematics achievement were selected to be entered into a combined model (Model 39) of teacher-related variables to predict mathematics achievement as a group.

Access and equity. To what extent are mathematics classroom access and equity variables (mathematics instructional hours per year and mathematics topics taught) associated with eighth-grade mathematics achievement in Ghana? To address this question, each of the Level-2 access and equity variables was added to Model 9 to create Models 23 and 24. Because neither of the two fixed effects measuring access and equity had a statistically significant relationship with mathematics achievement, no access and equity variables was selected for Ghana, and Model 25, intended to be a combined access and equity model was omitted.

***Pseudo R^2*.** To evaluate model fit, a pseudo R^2 was calculated for Models 23 and 24 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by each of the access and equity variables compared to Model 9. Results of pseudo R^2 calculations, shown in Table 82, indicate that the entering of mathematics instructional hours per year into Model 9 to predict mathematics achievement did not reduce the between-school variance by any discernable amount. The entering of mathematics topics taught as a predictor by itself to the combined Level-1 model reduced the between-school variance by 4%.

Table 82

Comparison of Pseudo R^2 between Ghana Models 23-24 and Model 9

Model	Predictor	Between-School Variance	Within-School Variance
23	Mathematics instructional hours per year	.00	.00
24	Mathematics topics taught	.04	.00

Fixed and random effects. Neither variable representing access and equity yielded a statistically significant fixed effect on eighth-grade mathematics achievement in Ghana. The results of Models 23 and 24 are shown in Tables 83 and 84.

Table 83

Estimation of Fixed Effects for Ghana Models 23-24

Model	Parameter	Coefficient	*SE*	*p*
23	Intercept	334.59	6.08	<.001
	Mathematics instructional hours per year	0.09	0.08	.27
24	Intercept	335.28	5.96	<.001
	Mathematics topics taught	6.84	4.31	.12

Table 84

Estimation of Random Effects for Ghana Models 23-24

Model	Parameter	Variance Components	*SE*	*p*
23	Between schools	3,058.09	463.75	<.001
	Within schools	3,835.70	129.59	
24	Between schools	1,885.15	175.96	<.001
	Within schools	1,705.15	62.49	

Curriculum. To what extent are classroom curriculum variables (instructional materials and instruction) associated with eighth-grade mathematics achievement in Ghana? To address this question, each of the Level-2 classroom instruction variables was entered into Model 9 to create Models 26 and 27. The composite variables derived from teacher questionnaire items to measure teachers' instructional materials were not included in this analysis because they were found to be unreliable, as shown in Table 5. In addition, the Wright maps for the two variables derived to measure instructional materials showed mismatches of response thresholds and scale scores, as indicated in Appendix B.

Rather than create models with unreliable scales or completely disregard the variables, descriptive statistics of each of the instructional materials questionnaire items was examined. The descriptive statistics for Ghana are shown in Table 85, as well as in

Tables C85-C88. Descriptive statistics indicate that eighth-grade students in Ghana whose teachers use concrete objects or materials as bases for instruction or supplements to instruction had higher mathematics scores than students whose teachers did not use them at all. Further, students whose teachers used textbooks and computer software to supplement instruction had higher scores than students whose teachers used them as either a basis for instruction or not at all. Finally, students whose teachers did not use workbooks or worksheets at all had higher scores than students whose teachers used them as either a basis for instruction to supplement instruction.

Table 85

Descriptive Statistics for Ghana Instructional Materials and Mathematics Achievement

Instructional materials	Basis for instruction %	Supplement %	Not used %	Basis for instruction mean	Supplement mean	Not used mean
Textbooks	56.3	41.6	2.1	328.5	334.7	319.4
Workbooks / worksheets	26.6	50.6	22.8	330.9	327.4	338.6
Concrete objects / materials	50.2	42.1	7.7	331.5	332.1	320.2
Computer software	0.9	7.4	91.7	300.8	352.6	329.4

Pseudo R^2. To evaluate model fit, a pseudo R^2 was calculated for Models 26 and 27 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by each of the classroom instruction variables compared to Model 9. Results of pseudo R^2 calculations, shown in Table 86, indicate that instruction to engage students reduced the between-school variance by 4%, and research-based instructional practices reduced the between-school variance by 1%.

Table 86

Comparison of Pseudo R^2 between Ghana Models 26-27 and Model 9

Model	Predictor	Between-School Variance	Within-School Variance
26	Instruction to engage students	.04	.00
27	Research-based practices	.01	.00

Fixed and random effects. The results of Models 26 and 27 are shown in Table 87 and 88. Fixed effects coefficient estimates for neither singular variable measuring classroom instruction had a statistically significant relationship with eighth-grade mathematics achievement; hence, the intended combined curriculum model, Model 28, was omitted in Ghana analysis.

Table 87 *Estimation of Fixed Effects for Ghana Model 26-27*

Model	Parameter	Coefficient	*SE*	*p*
26	Intercept	334.89	5.97	<.001
	Instruction to engage students	-6.30	3.71	.09
27	Intercept	335.21	6.05	<.001
	Research-based practices	-2.58	0.03	.35

Table 88

Estimation of Random Effects for Ghana Model 26-27

Model	Parameter	Variance Components	*SE*	*p*
26	Between schools	2,925.34	446.30	<.001
	Within schools	3,834.84	129.91	
27	Between schools	3,034.71	463.54	<.001
	Within schools	3,835.37	129.78	

Classroom assessment. To what extent are classroom assessment variables (assessment question types and class emphasis on assessment) associated with eighth-grade mathematics achievement in Ghana? To address this question, each of the Level-2 classroom assessment variables was entered into Model 9 to create Models 29 and 30. Neither fixed effect was found to have a statistically significant relationship with mathematics achievement. Therefore, the intended combined classroom assessment model, Model 31, was omitted from analysis for Ghana.

Pseudo R^2. To evaluate model fit, a pseudo R^2 was calculated for Models 29 and 30 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by each of the classroom assessment variables compared to Model 9l. Results of pseudo R^2 calculations, shown in Table 89, indicate that the entering of assessment question types into Model 9 to predict mathematics achievement reduced the between-school variance by 2%. The entering of class emphasis on assessment as a predictor by itself into Model 9 did not reduce the between-school variance by any discernable amount.

Table 89

Comparison of Pseudo R^2 between Ghana Models 29-30 and Model 9

Model	Predictor	Between-School Variance	Within-School Variance
29	Assessment question types	.02	.00
30	Class emphasis on assessment	.00	.00

Fixed and random effects. Fixed effects coefficient estimates for neither of the two variables measuring classroom assessment had a statistically significant relationship with eighth-grade mathematics achievement. Because neither Model 29 nor Model 30 yielded a statistically significant fixed effect, the combined classroom assessment model,

Model 31, was omitted from Ghana analysis. The results of Models 29 and 30 are shown in Tables 90 and 91.

Table 90

Estimation of Fixed Effects for Ghana Model 29-30

Model	Parameter	Coefficient	*SE*	*p*
29	Intercept	334.47	6.02	<.001
	Assessment question types	-3.24	2.92	.27
30	Intercept	335.11	6.08	<.001
	Class emphasis on assessment	-1.86	2.81	.51

Table 91

Estimation of Random Effects for Ghana Model 29-30

Model	Parameter	Variance Components	*SE*	*p*
29	Between schools	2,993.40	455.35	<.001
	Within schools	3,835.22	129.60	
30	Between schools	3,045.35	464.42	<.001
	Within schools	3,835.94	129.45	

Teacher professionalism. To what extent are teacher professionalism variables (professional development, professional collaboration, teacher experience, teacher knowledge, teacher preparation, and teacher self-efficacy) associated with eighth-grade mathematics achievement in Ghana? To address this question, each of the Level-2 teacher professionalism variables was entered into Model 9 to create Models 32-37. Because not any of the variables yielded statistically significant fixed effects, the combined teacher professionalism model, Model 38, was omitted from the Ghana analysis.

Pseudo R^2. To evaluate model fit, a pseudo R^2 was calculated for Models 32-37 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by each of the teacher professionalism variables compared to Model 9. Results of pseudo R^2 calculations, shown in Table 92, indicate that the entering of teacher professional development and teacher preparation into Model 9 to predict mathematics achievement each change the between-school variance by less than 1%. The entering of teacher professional collaboration, teacher experience, and teacher self-efficacy to the combined Level-1 model to predict mathematics achievement each reduce the between-school variance by 2%. The entering of teacher knowledge into Model 9 reduced between-school variance by 5%.

Table 92

Comparison of Pseudo R^2 between Ghana Models 32-38 and Model 9

Model	Predictor	Between-School Variance	Within-School Variance
32	Professional development	.00	.00
33	Professional collaboration	.02	.00
34	Teacher experience	.02	.00
35	Teacher knowledge	.05	.00
36	Teacher preparation	.00	.00
37	Teacher efficacy	.02	.00

Fixed and random effects. Not any fixed effects coefficient estimates of the six variables measuring teacher professionalism had a statistically significant relationship with eighth-grade mathematics achievement. Because none of Models 32 through Model 37 yielded a statistically significant fixed effect, the combined teacher professionalism model, Model 38, was omitted from Ghana analysis. The parameter estimates of Models 32-37 are shown in Tables 93 and 94.

Table 93

Estimation of Fixed Effects for Ghana Model 32-37

Model	Parameter	Coefficient	*SE*	*p*
32	Intercept	334.64	6.06	<.001
	Professional development	0.49	2.62	.85
33	Intercept	334.33	6.06	<.001
	Professional collaboration	-4.50	2.70	.10
34	Intercept	335.31	6.03	<.001
	Teacher experience	1.26	1.08	.25
35	Intercept	334.55	5.94	<.001
	Teacher knowledge	6.48	4.11	.12
36	Intercept	334.72	6.06	<.001
	Teacher preparation	0.74	3.05	.81
37	Intercept	334.37	7.08	<.001
	Teacher self-efficacy	-3.87	0.94	.48

Table 94

Estimation of Random Effects for Ghana Models 32-37

Model	Parameter	Variance Components	*SE*	*p*
32	Between schools	3,044.20	462.46	<.001
	Within schools	3,835.61	129.42	
33	Between schools	3,007.88	458.62	<.001
	Within schools	3,834.81	129.87	
34	Between schools	3,005.92	459.07	<.001
	Within schools	3,835.47	130.01	
35	Between schools	2,897.21	441.76	<.001
	Within schools	3,835.63	130.06	
36	Between schools	3,049.59	463.18	<.001
	Within schools	3,835.39	129.71	
37	Between schools	3,004.32	459.35	<.001
	Within schools	3,835.40	129.55	

Combined teacher-related variables. Based on the results of Models 23-37, none of the teacher- and classroom-related variables were found to have individually statistically significant relationships with mathematics achievement. Therefore, no variables were selected for a combined teacher-related variables model for Ghana, and Model 39 was omitted.

Ghana Full Model

The two Level-2 fixed effects that were found in Model 22 (combined school-related variables) to have statistically significant relationships with mathematics achievement were entered into Model 9, the combined Level-1 model, to create an efficient model for predicting eighth-grade mathematics achievement in Ghana. The two school-related variables were school discipline and safety and home resources limiting teaching.

Pseudo R^2. To evaluate model fit, a pseudo R^2 was calculated for Model 40 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by each of the Level-2 variables compared to Model 9. Results of pseudo R^2 calculations, shown in Table 95, indicate that the entering of school discipline and safety and home resources limiting teaching into Model 9 to predict mathematics achievement reduced the between-school variance by 25%. Overall, Model 40 with the combined school-related variables was more efficient than any of the previous models in predicting mathematics achievement for students in Ghana.

Table 95

Comparison of Pseudo R^2 between Ghana Model 40 and Model 9

Model	Predictor	Between-School Variance	Within-School Variance
40	Full model	.25	.00

Fixed and random effects. Both Level-2 predictors in Model 40 had statistically significant fixed effects, shown in Table 96. Because the predictor variables were grand-mean centered, the fixed effect coefficient estimate for school discipline and safety ($\gamma = 11.19$, $SE = 3.74$, $p = .004$) indicates that for each unit increase in that scale, students with mean values on all other predictors in the model would be expected to have 11.19 points increase in their mathematics scores. The fixed effect coefficient estimate for home resources limiting teaching ($\gamma = -11.54$, $SE = 3.00$, $p < .001$) indicates that for each unit increase in that scale, students with mean values on all other predictors in the model would be expected to decrease 11.54 points in their TIMSS mathematics scores. In addition, fixed effects coefficient estimates of both Level-1 self-confidence in mathematics and value in Model 40 were found to have statistically significant relationships with mathematics achievement in combination with the Level-2 variables.

Table 96

Estimation of Fixed Effects for Ghana Model 40

Parameter	Coefficient	*SE*	*p*
Intercept	335.23	5.42	<.001
School discipline and safety	11.19	3.74	.004
Home resources limiting teaching	-11.54	3.00	<.001
Self-confidence in mathematics	9.57	0.84	<.001
Value mathematics	0.15	0.03	<.001

Table 97

Estimation of Random Effects for Ghana Model 40

Model	Parameter	Variance Components	*SE*	*p*
39	Between-schools	2,293.62	369.78	<.001
	Within-schools	3,803.80	121.01	

Summary. Of the three countries studied in this dissertation, Ghana had the fewest statistically significant predictors of mathematics achievement from the variables in the study. At Level 1, none of the home-related variables but both of the student-beliefs variables had statistically significant relationships with mathematics achievement. At Level 2, one school climate and one school socioeconomic status variable each was found statistically significant. Not any of school administrator leadership, school resources, nor any of the teacher-related variables had statistically significant relationships with mathematics in Ghana. A possible explanation for so few predictors of mathematics achievement for Ghana is that Ghana had extremely low mathematics achievement scores, by far the lowest of the 42 countries who participated in the TIMSS 2011 for eighth-grade mathematics, and relatively small variability in many of the variables in the study, including the dependent variable of mathematics achievements, as seen in Tables C1-C141 in Appendix C.

Results for U.S.

Descriptive Statistics

Descriptive statistics for the dependent variable of mathematics achievement and five student-level independent variables for the U.S. are shown in Table 98. The U.S. had the ninth highest mean scale score of mathematics achievement (*M* = 509.92 *SD* = 76.11) of the 42 countries that participated in the TIMSS 2011 eighth-grade mathematics assessment. Scale scores of three of the five Level-1 predictors were transformed to have a mean of 10 and standard deviation of two across the countries included in this study. An exception is the variable value mathematics for which scores have a mean of 10 and a standard deviation of 65. Scores for parent education were not transformed because they were already relatively easy to interpret. For example, in the U.S, (*M* = 4.05, *SD* = 1.16) students' parents typically had postsecondary but not university educational attainment, the highest parent educational attainment of the three countries in this study. Students in the U.S. reported the second greatest (or least) score of the three countries in this study on the value mathematics scale (*M* = -2.23, *SD* = 58.89). Interestingly, students in Ghana reported the greatest value of mathematics as a field of study, and Chinese Taipei reported the least.

Table 98

Level 1 Descriptive Statistics for U.S. (N = 4,140)

Domain	Variable	*M*	*SD*	Min	Max
	Mathematics achievement	509.92	76.11	267.44	738.32
Home resources	Home possessions for learning	10.83	1.64	5.08	13.42
	Parent education	4.05	1.16	1	5
	Parent expectations and involvement	9.86	1.96	4.99	13.19
Student beliefs	Self-confidence in mathematics	10.67	2.3	3.18	15.82
	Value mathematics	-2.23	58.89	-196.87	134.18

Descriptive statistics for the 23 school-level independent variables for the U.S. are shown in Table 99. Like the Level-1 predictors, most scale scores for Level-2 predictors were transformed to have a mean of 10 and standard deviation of two to facilitate interpretation. Exceptions to this were computer availability for instruction, students economically disadvantaged, mathematics instructional hours per year, teacher experience, and teacher education. The scale for computer availability for instruction corresponds to fewer computers per students as the value increases from one to four, and results for computer availability for instruction (*M* = 1.47, *SD* = .63) in the U.S. indicate that computer availability typically approached one computer for every one to two students, the highest availability of the three countries studied for this dissertation. School administrators in the U.S, reported that more of their students typically were economically disadvantaged (*M* = 2.43, *SD* = 0.78) than administrators in Chinese Taipei did, but less than administrators in Ghana did. Eighth-grade students in the U.S. typically had about 156 hours of yearly mathematics instruction. In comparison, schools in Ghana reported an average 165 hours of yearly mathematics instruction and Chinese Taipei 168. Eighth-grade mathematics teachers in the U.S. typically had taught for approximately 14 years (*M* = 13.87, *SD* = 9.56)—about the same as teachers in Chinese Taipei, but almost twice as many years as teachers in Ghana. For the predictor teacher education (*M* = 2.47, *SD* = 1.18), teachers typically had majored in mathematics education, but not mathematics.

Table 99

Level 2 Descriptive Statistics for U. S (N = 266)

Domain	Variable	*M*	*SD*	Min	Max
School climate	School emphasis on academic achievement-teacher reports	10.64	2.17	4.99	16.21
	School emphasis on academic achievement-principal reports	10.94	1.99	6.6	15.57
	School discipline and safety	10.06	1.41	6.68	13.94
School resources	Computer availability for instruction	1.47	0.63	1	3
	Resources for general instruction	11.08	1.95	3.74	13.63

Table 99 (Continued)

	Resources for mathematics instruction	9.6	1.89	6.44	15.933
Administrator leadership	Administrator leadership	9.83	1.92	4.94	12.91
School socioeconomic status	Students economically disadvantaged	2.43	0.78	1	
	Home resources limiting teaching	10.26	1.54	3.61	16.19
Access and equity	Mathematics hours per year	155.81	59.5	0	339
	Mathematics topics taught	9.79	1.44	4.09	14.18
Curriculum	Textbooks or workbooks for instruction	9.36	1.88	3.64	13.34
	Tools or technology for instruction	10.59	2.26	5.07	15.43
	Instruction to engage students	10.9	1.48	5.61	11.94
	Research-based instruction	10.04	1.76	0.39	14.73
Assessment	Classroom assessment question types	9.85	2.19	2	12.99
	Classroom emphasis on assessment	9.69	1.77	5.17	12.47
Teacher professionalism	Professional development	10.8	1.87	6.2	12.94
	Professional collaboration	9.98	2.48	4.85	15.77
	Teacher experience	13.9	9.56	0	40
	Teacher education	2.47	1.18	1	
	Teacher preparation	10.84	1.76	3.24	11.99
	Teacher self-efficacy	10.49	1.69	5.07	11.99

Assumptions

Residuals of both Level-1 and -2 intercepts and predictors of the final model for the U.S. were examined to check the multilevel regression assumptions of normality and homoscedasticity. First, scatter plots of mathematics achievement by standardized Level-1 and -2 residuals were examined to check for the assumption of homoscedasticity. Homoscedasticity is indicated if the plotted points have no strong structure and are evenly divided above and below their mean value of zero (Hox, 2002). Visual examination of the scatter plots in Figures 23-29 found no major violations of the assumption of homoscedasticity.

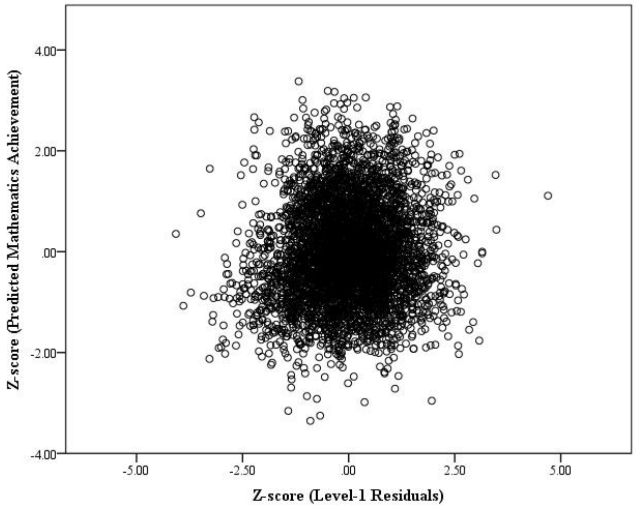

Figure 23. Predicted U.S. Mathematics Achievement Standardized by Level-1 Residuals.

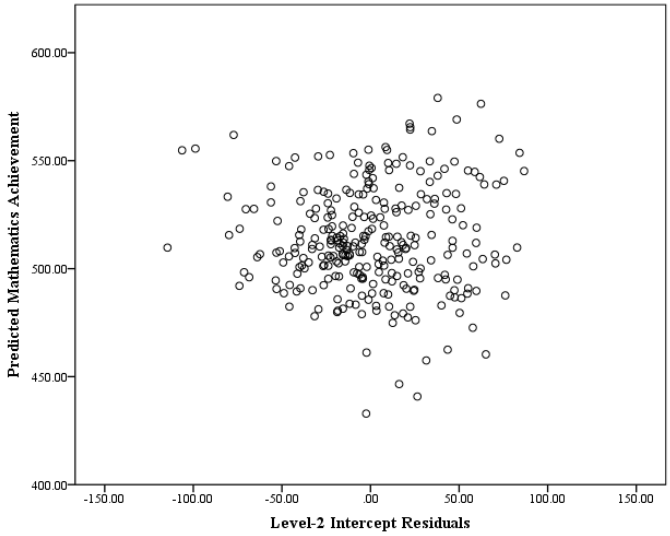

Figure 24. Predicted U.S Mathematics Achievement by Level-2 Intercept Residuals.

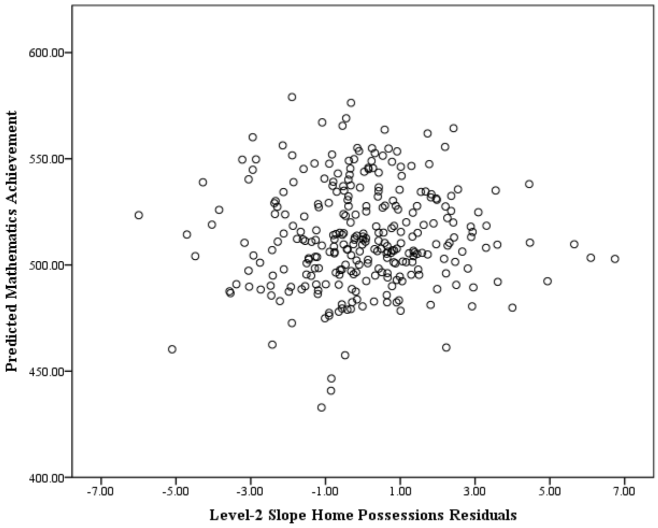

Figure 25. Predicted U.S. Mathematics by Level-2 Slope Home Possessions Residuals.

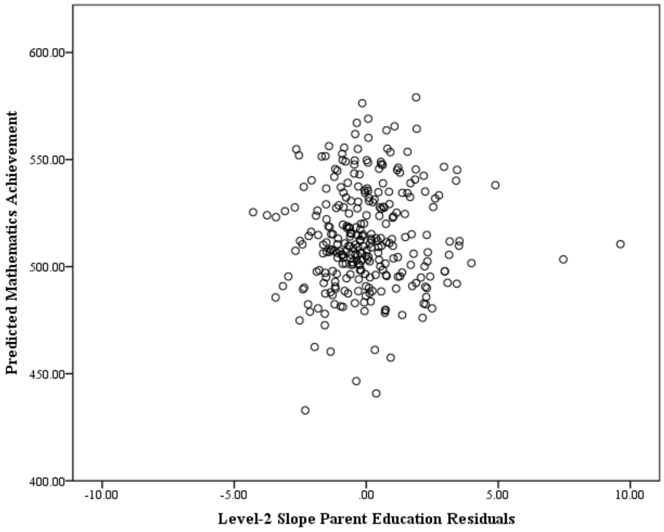

Figure 26. Predicted U.S. Mathematics Achievement by Level-2 Parent Education Residuals.

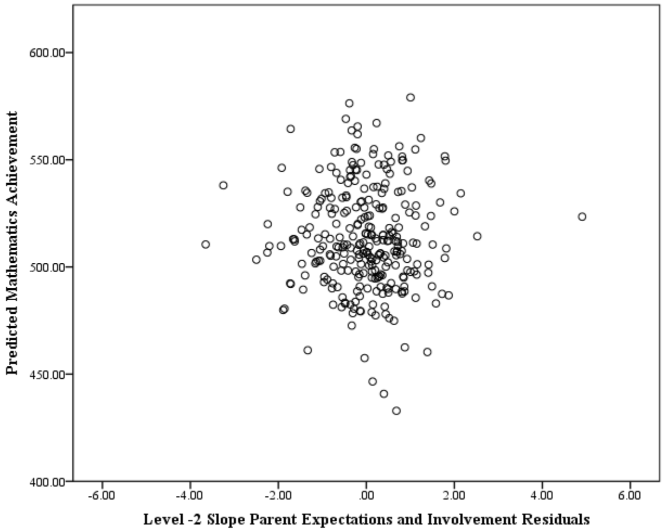

Figure 27. Predicted U.S. Mathematics Achievement by Level-2 Slope Parent Expectations and Involvement Residuals.

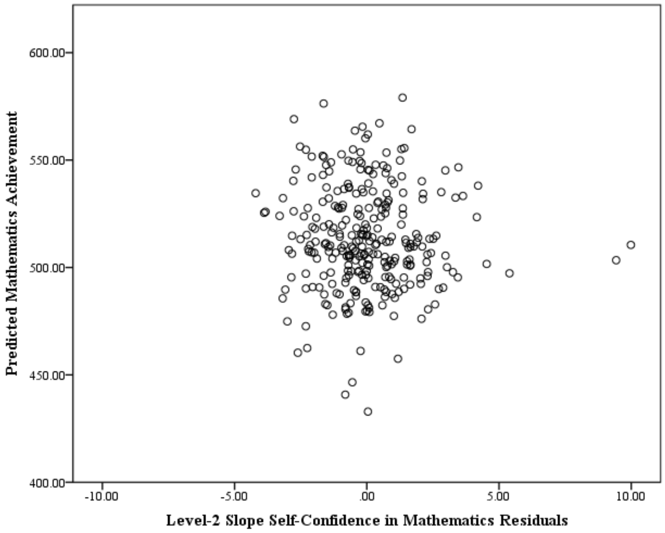

Figure 28. Predicted U.S. Mathematics Achievement by Level-2 Slope Self-Confidence in Mathematics Residuals.

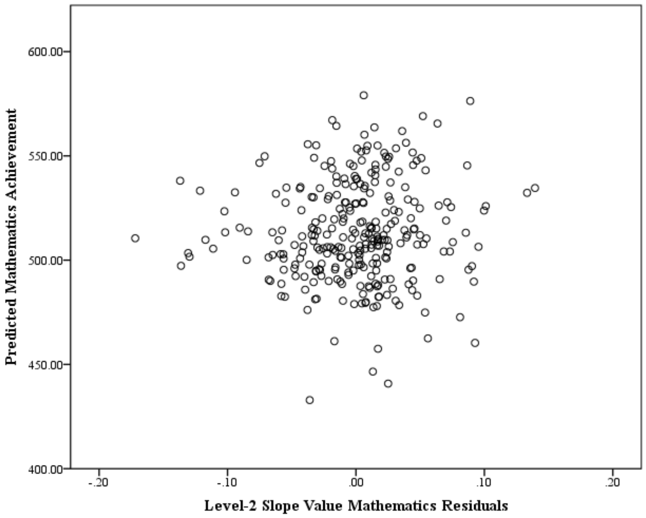

Figure 29. Predicted U.S. Mathematics Achievement by Level-2 Slope Value Mathematics Residuals.

The assumption of normality was checked by examining plots of predicted normal values by both Level-1 and Level-2 standardized residuals, shown in Figures 30-36. Residuals with a normal distribution are indicated by a straight diagonal line (Hox, 2002). No major violations of the normality were found despite indication of a slight positive skew in self-confidence in mathematics in Figure 35.

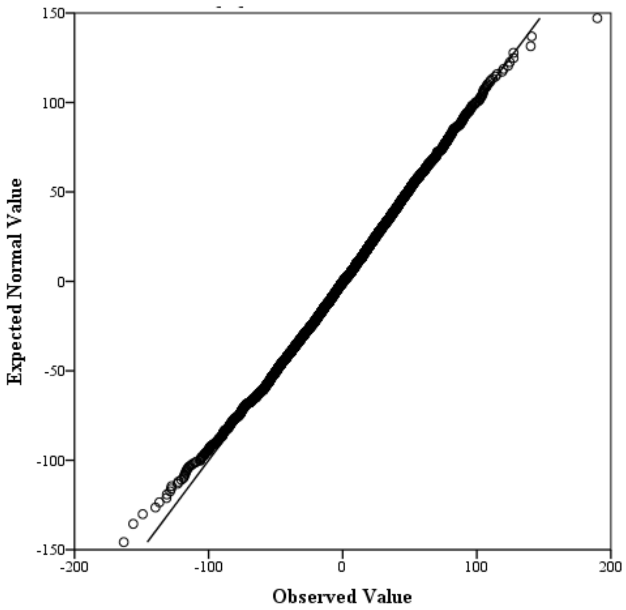

Figure 30. Normal Q-Q plot of U.S. Level-1 residuals.

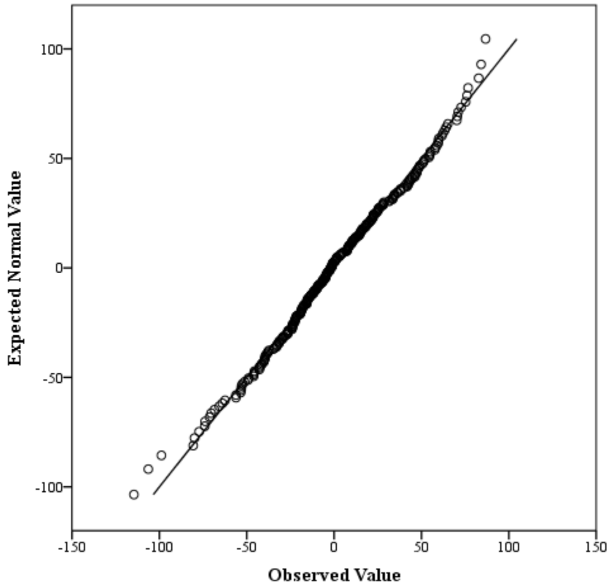

Figure 31. Normal Q-Q plot of U.S. Level-2 intercept residuals.

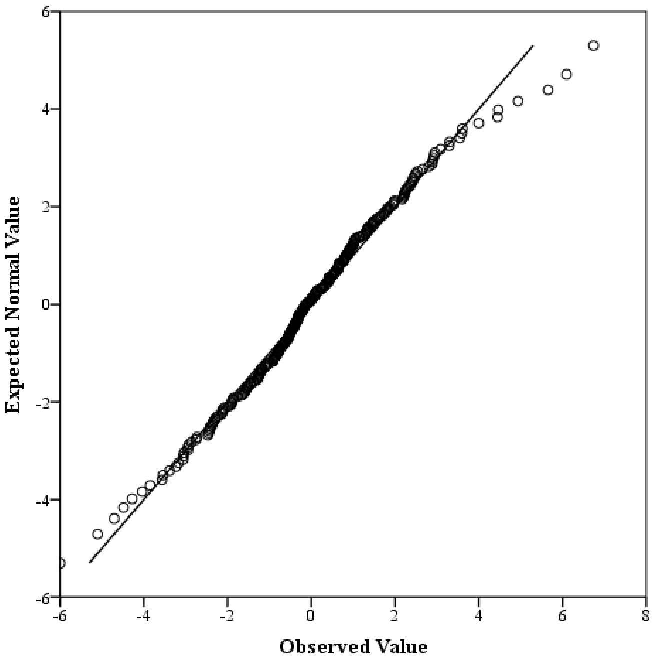

Figure 32. Normal Q-Q plot of U.S. Level-2 home possessions residuals.

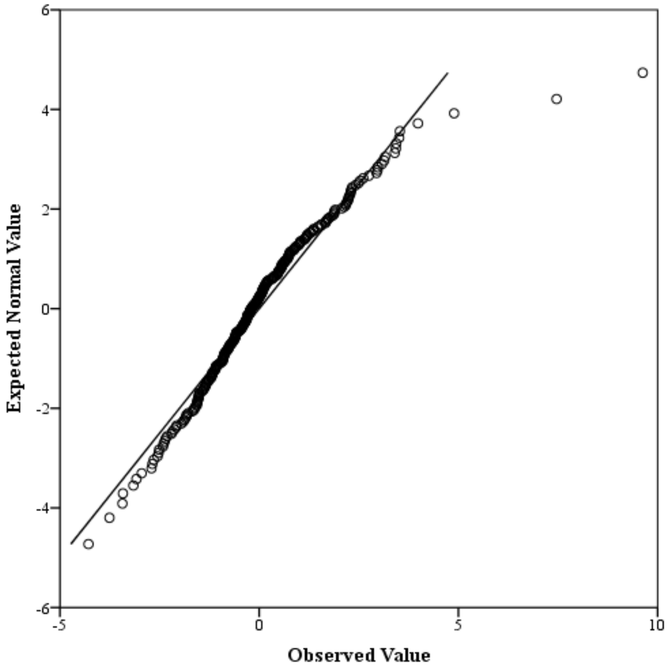

Figure 33. Normal Q-Q plot of U.S. Level-2 parent education residuals.

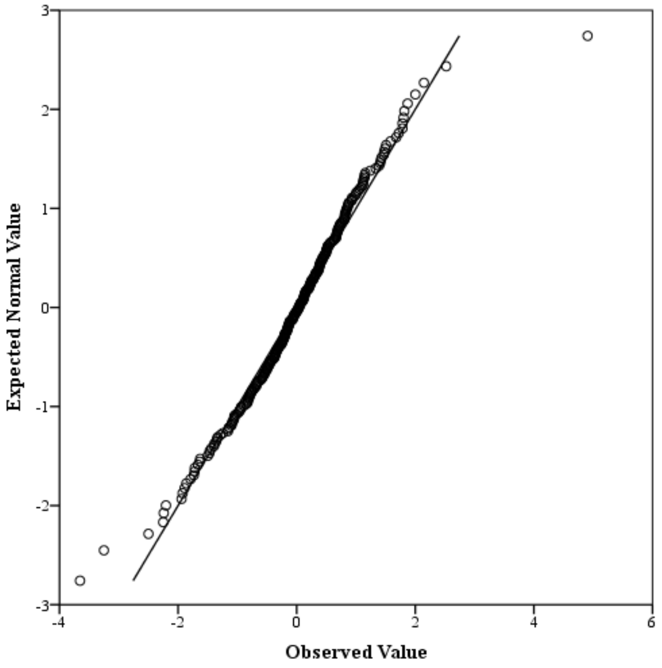

Figure 34. Normal Q-Q plot of U.S. Level-2 parent expectations and involvement residuals.

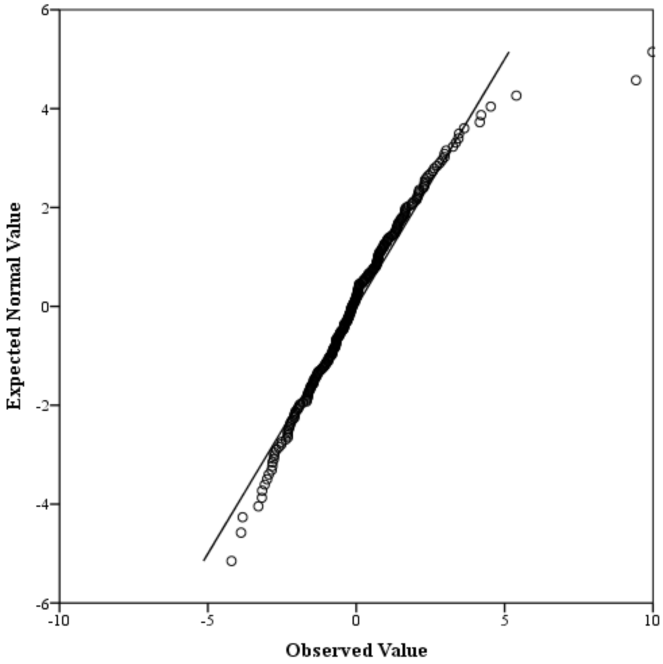

Figure 35. Normal Q-Q Plot of U.S. Level-2 Self-Confidence in Mathematics Residuals.

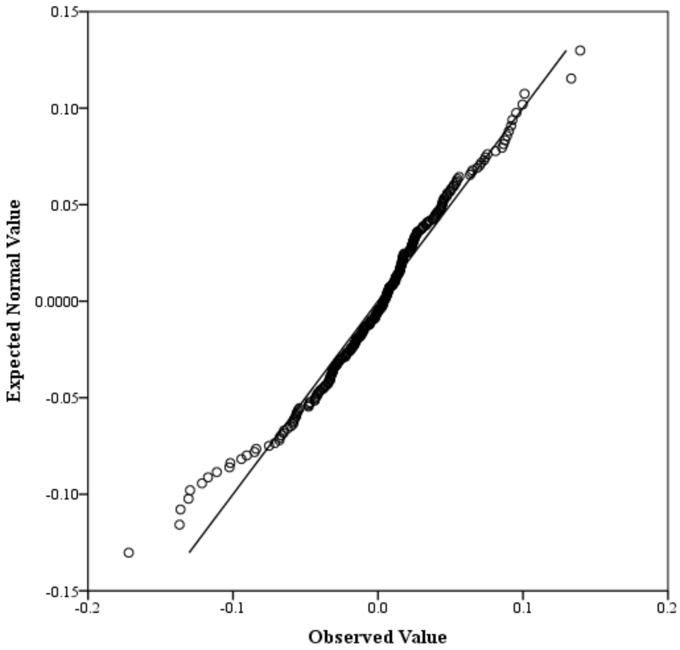

Figure 36. Normal Q-Q plot of U.S. Level-2 value mathematics residuals.

Unconditional model

Model 1 was an unconditional model containing only the dependent variable, composed of the five plausible values of student mathematics achievement, and the grouping variable of schools. For the U.S. unconditional model, the estimated fixed effect value for the intercept was 512.06 (*SE* = 3.54, $p < .001$). The average level of mathematics achievement was significantly different across schools in the U.S. ($\hat{\tau}_{00}$ = 2,928.12, *SE* = 266.22, $p <.001$). The amount of unexplained variance between schools was somewhat greater than that within schools ($\hat{\sigma}^2$ = 2,372.31, *SE* = 79.00). The ICC of .55 indicates that approximately 55% of the total variance in mathematics scores occurred between schools.

Home-Related Variables

Research Question 1 for each country in this study is the extent to which home-related variables (home possessions for learning, parent educational attainment, and parent expectations for and involvement in their children's education) predict eighth-grade mathematics achievement. To address this question, the three variables related to the student's home were entered separately as Models 2-4 into Model 1 as single predictors of eighth-grade mathematics achievement in the U.S. Then, the three variables, having been found to contribute significantly to mathematics achievement, were entered into a combined model of home-related variables to predict mathematics achievement as a group.

Deviances. The first analysis of Models 2-4 was an evaluation of goodness-of-fit of each model in comparison to Model 1 by comparing the deviance of each model. Deviances are compared as relative statistics, and lower deviances indicate better fitting models. The deviance of Model 1 was used as a baseline from which to compare the subsequent models. Results of the significance tests for change in deviance, shown in Table 100, indicate that each of Models 2-4 had a statistically significant lower deviance than Model 1, and therefore all were better fitting models than Model 1.

Table 100

Deviances for U.S. Home Variables Models

Model	Predictor	Deviance	χ^2	p
1	Unconditional	48,718.39		
2	Home possessions for learning	48,562.35	156.27	<.001
3	Parent education	48,658.23	60.16	<.001
4	Parent expectations and involvement	48,703.94	14.45	.003

Pseudo R^2. To further evaluate model fit, a pseudo R^2 was calculated for Models 2-4 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by each of the home-related variables compared to Model 1 (Anderson, 2012).

Results of pseudo R^2 calculations, shown in Table 101, indicate that the entering of home possessions for learning into Model 1 to predict mathematics achievement reduced the between-school variance 13% and the within-school variance 3%. The entry of parent educational attainment into Model 1 reduced the between-school variance 9% and the within-school variance 1%. However, in Model 4, parent expectations and involvement increased between-school variance very slightly by .2%.

Table 101

Comparison of Pseudo R^2 between U.S. Models 2-4 and Model 1

Model	Predictor	Between-School Variance	Within-School Variance
2	Home possessions for learning	.13	.03
3	Parent education	.09	.01
4	Parent expectations and involvement	-.002	.02

Fixed and random effects. Of the three home-related variables, fixed effects coefficient estimates for home possessions ($\gamma = 5.92$, $SE = 0.79$, $p < .001$) and parent educational attainment ($\gamma = 5.87$, $SE = 0.80$, $p < .001$) had a statistically significant relationship with U.S. eighth-grade mathematics achievement while parent expectations and involvement did not. However, random effects coefficient estimates for only parent expectations and involvement ($\hat{\boldsymbol{\tau}} = 11.61$, $SE = 5.44$, $p = .02$) was statistically significant, indicating the relationship between that variable and mathematics achievement varied across schools in the U.S. The relationships between the two other home-related variables, home possessions for learning and parent education, and mathematics achievement appear to be similar across schools in the U.S. Estimations of fixed effects are shown in Table 102, and estimations of random effects are shown in Table 103.

Table 102

Estimation of Fixed Effects for U.S. Models 2-4

Model	Parameter	Coefficient	*SE*	*p*
2	Intercept	513.09	3.25	<.001
	Home possessions for learning	5.92	0.79	<.001
3	Intercept	510.24	3.30	<.001
	Parent education	5.87	0.80	<.001
4	Intercept	510.06	3.46	<.001
	Expectations and involvement	-0.64	0.45	.16

Table 103 *Estimation of Random Effects for U.S. Models 2-4*

Model	Parameter	Variance Components	*SE*	*p*
2	Between-schools	2,556.76	236.00	<.001
	Possessions	3.93	6.47	.21
	Within-schools	2,311.36	76.74	
3	Between-schools	2,674.30	244.03	<.001
	Parent education	18.51	15.65	.11
	Within-schools	2,342.22	76.36	
4	Between-schools	2,933.95	265.06	<.001
	Expectations and Involvement	11.61	5.44	.02
	Within-schools	2,336.53	88.89	

Combined model. After each of home-related variables was found to reduce variance compared to Model 1, all three were combined to predict mathematics achievement in Model 5. Goodness of fit for Model 5 was evaluated by calculating pseudo R^2 and comparing the result to pseudo R^2 in previously constructed Models 2-4. Results are shown in Table 104. Compared to Models 2-4, Model 5 yielded a reduction in variance within schools from 1% to 3%. Between schools, the reduction in variance ranged from 5% to 20%. Overall, Model 5 with the combined home-related variables was more efficient than previous models with singular home-related variables in predicting mathematics achievement for students in the U.S.

Table 104

Comparison of Pseudo R^2 between U.S. Model 5 and Models 2-4

Model	Predictor	Between-school variance	Within-school variance ^{2}
2	Home possessions for learning	.05	.03
3	Parent education	.11	.01
4	Parent expectations and involvement	.20	.01

All three fixed effects in Model 5 had statistically significant relationships with mathematics achievement, shown in Table 105. Because all predictors were grand-mean centered, the fixed effect coefficient estimate for home possessions for learning ($\gamma = 5.82$, *SE* = 0.83, $p < .001$) indicates that for each unit increase in the home possessions for learning scale, eighth-grade students in the U.S. with mean values for parent educational attainment and parent expectations and involvement would be expected to have 5.82 points increase in their TIMSS mathematics scores. Similarly, the fixed effect coefficient estimate for parent educational attainment ($\gamma = 3.88$, *SE* = 0.92, $p < .001$) indicates that for each unit increase in level of parent education (e.g., from associate's degree to bachelor's degree), students with mean values on the home possessions for learning and parent expectations and involvement scales would be expected to increase 3.88 points in their mathematics scores. Perhaps surprisingly, the fixed effect coefficient estimate for parent expectations and involvement ($\gamma = -2.13$ $SE = 0.50$, $p < .001$) indicates that for each unit increase in the parents' expectations and involvement scale, students in the U.S. with mean values for home possessions and parent educational attainment would be expected to decrease 2.13 points in their mathematics scores.

The negative relationship between parent expectations and involvement and mathematics achievement prompted an examination of the individual questionnaire items that comprised the parent expectations and involvement scale, shown in Tables C8-C11 in Appendix C. Indeed, increased parent expectations and involvement was found to not consistently result in increased mathematics achievement scores. Rather, mathematics achievement fluctuated, both within and across the items in the scale.

Random effects estimations in Model 5 indicated that schools varied significantly in their relationships between mathematics achievement and two of the three home-related variables—home possessions ($\hat{\tau} = 8.68$, $SE = 7.54$, $p = .05$) and parent expectations and involvement ($\hat{\tau} = 7.66$, $SE = 5.16$, $p = .02$), but not parent educational attainment. This implies that the positive relationship between parent education and mathematics achievement was similar across schools in the U.S. The variance of 2,419.57 ($SE = 224.40$, $p < .001$) for the intercept indicates that variance in mathematics scores across schools was statistically significant after accounting for the three home-related variables in the model.

Table 105

Parameter Estimates for U.S. Model 5 (Combined Home Variables)

Effect	Parameters	Estimates	*SE*	*p*
Fixed	Intercept	512.96	3.14	<.001
	Home possessions	5.82	0.83	<.001
	Parent education	3.88	0.92	<.001
	Parent expectations and involvement	-2.13	0.50	<.001
Random	Between-school	2,419.57	224.40	<.001
	Home possessions	8.68	7.54	.05
	Parent education	15.95	13.79	.34
	Parent expectations and involvement	7.66	5.16	.02
	Within-school	2,244.78	81.08	

Student Beliefs

Research Question 2 for each country in this study is the extent to which student beliefs of self-confidence in mathematics and value of mathematics predict eighth-grade mathematics achievement. To address this question, the two variables related to student beliefs were entered separately as Models 6 and 7 into Model 1 as single predictors of eighth-grade mathematics achievement in the U.S. Then, the variables that were found to contribute significantly to mathematics achievement were entered into a combined model of student beliefs to predict mathematics achievement as a group.

Deviances. The first analysis of Models 6 and 7 was an evaluation of goodness-of-fit of each model in comparison to Model 1 by comparing the deviance of each model. Results of the significance tests for change in deviance, shown in Table 106, indicate that each of Models 6 and 7 with the two student-belief variables had statistically significant lower deviances than Model 1, and therefore were better fitting models than Model 1.

Table 106

Deviances for U.S. Student Beliefs Models

Model	Predictor	Deviance	χ^2	p
1	Unconditional	48,718.39		
6	Self-confidence in mathematics	47,679.70	1,038.69	<.001
7	Value mathematics	48,503.80	48,455.80	<.001

Pseudo R^2. To further evaluate model fit, a pseudo R^2 was calculated for Models 6-7 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by each of the student beliefs variables compared to Model 1. Results of pseudo R^2 calculations, shown in Table 107, indicate that the entering of self-confidence in mathematics to Model 1 to predict mathematics achievement reduced the between-school variance by 22% and the within-school variance by 22%, and the entering of value mathematics as a predictor by itself into Model 1 reduced the between-school variance by 4% and the within-school variance by 5%.

Table 107

Comparison of Pseudo R^2 between U.S. Models 6-7 and Model 1

Model	Predictor	Between-School Variance	Within-School Variance
6	Self-confidence in mathematics	.13	.22
7	Value mathematics	.04	.05

Fixed and random effects. Fixed effects of both self-confidence in mathematics ($\gamma = 10.24$, $SE = 0.41$, $p < .001$) and value mathematics ($\gamma = 0.19$, $SE = 0.02$, $p < .001$) had a statistically significant relationship with eighth-grade mathematics achievement. Random effects of both self-confidence in mathematics ($\hat{\tau} = 6.00$, $SE = 3.17$, $p = .002$)

and value mathematics ($\hat{\tau}$ = 0.005, *SE* = 0.005, *p* = .03) had a statistically significant relationship with eighth-grade mathematics achievement as well, indicating that those relationships varied across schools in the U.S. Estimations of coefficients for fixed effects are shown in Table 108, and estimations of random effects are shown in Table 109.

Table 108

Estimation of Fixed Effects for U.S. Models 6-7

Model	Parameter	Coefficient	*SE*	*p*
6	Intercept	512.88	3.31	<.001
	Self-confidence in mathematics	10.24	0.41	<.001
7	Intercept	512.24	3.47	<.001
	Value mathematics	0.19	0.02	<.001

Table 109

Estimation of Random Effects for U.S. Models 6-7

Model	Parameter	Variance Components	*SE*	*p*
6	Between-schools	2,538.72	228.02	<.001
	Self-confidence in mathematics	6.00	3.17	.002
	Within-schools	1,858.40	63.99	
7	Between-schools	2,820.57	255.69	<.001
	Value mathematics	0.005	0.005	.03
	Within-schools	2,249.36	74.46	

Combined model. After each of student-belief variables was found to reduce variance compared to Model 1, both were combined to predict mathematics achievement in Model 8. Goodness of fit was evaluated by calculating pseudo R^2 and comparing Model 8 to Models 6 and 7 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by Model 8 compared to the previous models.

Results are shown in Table 110. Model 8 reduced both the between-school and within-school variances by 1% compared to Model 6. Model 8 yielded an even greater reduction of 11% in the between- school variance and 18% in the within-school variances compared to Model 7. Overall, Model 8 with the combined student-belief variables was more efficient than previous models with singular student-belief variables in predicting mathematics achievement for students in the U.S.

Table 110

Comparison of Pseudo R^2 between U.S. Model 8 and Models 6-7

Model	Predictor	Between-School Variance	Within-School Variance
6	Self-confidence in mathematics	.01	.01
7	Value mathematics	.11	.18

Both predictors together in Model 8 had statistically significant relationships with mathematics achievement, shown in Table 111. Because the predictor variables were grand-mean centered, the fixed effect coefficient estimate for self-confidence in mathematics ($\gamma = 11.28$, $SE = 0.45$, $p < .001$) indicates that for each unit increase in the self-confidence in mathematics scale, students with mean values on the values mathematics scale would be expected to have 11.28 points increase in their mathematics scores. The fixed effect coefficient estimate for value mathematics ($\gamma = -0.07$, $SE = 0.02$, $p < .001$) indicates that for each unit increase in the value mathematics scale, students with mean values on the self-confidence in mathematics scale would be expected to decrease 0.07 points in their TIMSS mathematics scores. This result, in which the direction of the relationship between valuing mathematics and mathematics achievement changed from Model 7 to Model 8, prompted an examination of the correlation between self-confidence in mathematics and value of mathematics. It was found that the Pearson product-moment correlation between these two variables is high with $r = .59$. The high correlation indicates that self-confidence in mathematics and value of mathematics influence each other and is a plausible explanation for the change in relationship between value of mathematics and mathematics achievement from Model 7 to Model 8.

The random effects of the two student-belief variables—self-confidence in mathematics ($\hat{\tau} = 10.86$, $SE = 4.50$, $p = .001$) and value mathematics ($\hat{\tau} = 0.01$, $SE = 0.01$, $p = .04$) — were both statistically significant across schools. The variance of 2,521.23 ($SE = 227.41$, $p < .001$) for the intercept indicates there were statistically significant differences in mathematics achievement across schools after accounting for the two student-belief variables in the model.

Table 111

Parameter Estimates for U.S. Model 8 (Combined Student-Belief Variables)

Effect	Parameters	Estimates	*SE*	*p*
Fixed	Intercept	512.91	3.31	<.001
	Self-confidence in mathematics	11.28	0.45	<.001
	Value mathematics	-0.07	0.02	<.001
Random	Between schools	2,521.23	227.41	<.001
	Self-confidence in mathematics	10.86	4.50	.001
	Value mathematics	0.01	0.01	.04
	Within schools	1,833.32	61.26	

Combined Level-1 Model

Based on the results of Models 5 (combined home-related variables) and 8 (combined student-belief variables), all five Level-1 variables were entered into Model 1, the unconditional model, to create Model 9, the combined Level-1 model.

As shown in Table 112, Model 9 appeared more efficient than Model 5 in that it accounted for 11% more variance between schools and 24% more variance within schools. Compared to Model 8, Model 9 accounted for 14% more variance between schools and 6% of the variance between schools. As a result of these comparisons, Model 9 was selected as the foundational Level-1 model for further examination of the relationships between Level-2 predictors and mathematics achievement.

Table 112

Comparison of Pseudo R^2 between Model 9 and Previous Combined Models for U.S.

Model	Predictor	Between-school variance	Within-school variance
5	Combined home-related variables	.11	.24
8	Combined student beliefs	.14	.06

Parameter estimates for Model 9 in the U.S. are shown in Table 113. All five student-level variables in the combined model had statistically significant fixed effects on mathematics achievement. Specifically, home possessions ($\gamma = 4.97$, $SE = 0.82$, $p < .001$), parent education ($\gamma = 2.40$, $SE = 0.86$, $p < .001$), and self-confidence in mathematics ($\gamma = 10.98$, $SE = 0.43$, $p < .001$) were positively related to mathematics achievement; however, parent expectations and involvement ($\gamma = -3.12$, $SE = 0.47$, $p < .001$) and student valuing of mathematics ($\gamma = -0.05$, $SE = 0.02$, $p = .005$) were negatively related to mathematics achievement in the presence of the other Level-1 predictors. These results indicate that the more possessions to support learning students have at home, the more education their parents have, and the more confidence they have in their ability in mathematics, the higher their mathematics scores tended to be. At the same time, the greater their parents' expectations and involvement in their education and the more they valued mathematics, the lower their mathematics scores tended to be after accounting for home possessions for learning, parent educational attainment, and self-confidence in mathematics. This perhaps surprising result of negative relationships of parent expectations and involvement and student valuing mathematics with mathematics achievement is an example of the potential complications of including many independent variables in a regression research design (Reichwein Zientek & Thompson, 2006).

Table 113

Parameter Estimates for U.S. Model 9 (Combined Level-1 Variables)

Effect	Parameters	Estimates	*SE*	*p*
Fixed	Intercept	513.57	2.98	<.001
	Home possessions	4.97	0.82	<.001
	Parent education	2.40	0.86	.008
	Parent expectations and involvement	-3.12	0.47	<.001
	Self-confidence in mathematics	10.98	0.43	<.001
	Value mathematics	-0.05	0.02	.005
Random	Between-schools	2,162.63	200.49	<.001
	Home possessions	8.46	6.07	0.26
	Parent education	17.24	12.47	0.20
	Parent expectations and involvement	8.79	5.49	0.05
	Self-confidence in mathematics	9.00	4.06	0.02
	Value mathematics	0.01	0.01	0.24
	Within-schools	1,714.68	63.25	

In regard to random effects, only parent expectations and involvement ($\hat{\tau} = 8.79$, *SE* = 5.49, $p = .05$) and self-confidence in mathematics ($\hat{\tau} = 9.00$, *SE* = 4.06, $p = .02$) of the five student-level variables varied significantly across schools in the U.S. The relationships between mathematics achievement and home possessions for learning, parent educational attainment, and value mathematics were similar across schools.

School-Related Variables

Research Question 3 for each country in this study is the extent to which school-related variables (school climate, school resources, administrator leadership, and school socioeconomic status) predict eighth-grade mathematics achievement. After selecting the best-fitting model of the ones examined for the Level-1 variables, each school-related variable was entered separately into Model 9. First, school climate variables were entered separately as Models 10-12, and then the statistically significant school climate variables were combined and entered into Model 9 to create Model 13. Next, school resources variables were entered separately into Model 9 as Models 14-16. Because only Model 16 of the school resources variables had a statistically significant relationship with mathematics achievement, it was selected as the school resources model, and Model 17, intended to be the model for the combined school resources, was omitted. Model 18 contained the single variable for administrator leadership. Variables measuring school socioeconomic status were entered separately as Models 19 and 20, and then the statistically significant school socioeconomic status variables were combined and entered into Model 9 to create Model 21. Then, all the school-level variables that were found to individually predict mathematics achievement were selected to be entered into a combined model (Model 22) of school-related variables to predict mathematics achievement as a group.

School climate. To what extent are school-climate variables (school emphasis on academic success - reported by teachers and principals separately—and school discipline and safety) associated with eighth-grade mathematics achievement in the U.S.? To address this question, each of the Level-2 school climate variables was entered into the Model 9 to create Models 10-12. Then, those variables with significant fixed effects in Models 10-12 were included in the combined school climate model, Model 13.

***Pseudo R^2*.** To evaluate model fit, a pseudo R^2 was calculated for Models 10-13 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by each of the school climate variables compared to Model 9. Results of pseudo R^2 calculations, shown in Table 114, indicate that the entering of school emphasis on academic success - teacher reports into Model 9 to predict mathematics achievement reduced the between-school variance by 15%. The entering of school emphasis on academic success - principal reports as a predictor by itself into Model 9 reduced the between-school variance by 16%. The entering of school discipline and safety into Model 9 to predict mathematics achievement reduced the between-school variance by 12%. Overall, Model 13 with the combined school climate variables was more efficient than Models 10-12 with singular school climate variables in predicting mathematics achievement for students in the U.S.

Table 114

Comparison of Pseudo R^2 between U.S. Models 10-13 and Model 9

Model	Predictor	Between-School Variance	Within-School Variance
10	Emphasis on academic success - teachers	.15	.00
11	Emphasis on academic success--principals	.16	.00
12	School discipline and safety	.12	.00
13	Combined school climate	.18	.00

Fixed and random effects. Fixed effects coefficient estimates for all three variables measuring school climate had a statistically significant relationship with eighth-grade mathematics achievement. Model 10 with school emphasis on academic success - teacher reports as a Level-2 predictor of mathematics achievement yielded a statistically significant fixed effect ($\gamma = 4.37$, SE = 1.23, $p < .001$). This means that with every unit increase in the school emphasis on academic success - teacher reports scale, the mathematics scores of students with mean Level-1 variable values would be expected to increase by 4.37 points. The fixed effect coefficient estimate for school emphasis on academic success - principal reports was found statistically significant in Model 11 ($\gamma = 6.68$, SE = 1.65, $p < .001$). This means that with every unit increase in the school emphasis on academic success - principal reports scale, mathematics scores of students would be expected to increase by 6.68 points after accounting for Level-1 variables. The fixed effect coefficient estimate for school discipline and safety was found statistically significant in Model 12 ($\gamma = 5.43$, SE = 1.99, $p = .01$). This means that with every unit increase in school discipline and safety scale, mathematics scores of students would be expected to increase by 5.43 points after accounting for Level-1 variables. However, when the three school climate variables were combined in Model 13, the fixed effect coefficient estimate for only school emphasis on academic success - principal reports (γ = 5.46, SE = 3.28, p = .01) was found to have a statistically significant relationship with eighth-grade mathematics achievement. The results of Models 10-13 are shown in Table 115.

Table 115

Estimation of Fixed Effects for U.S. Models 10-13

Model	Parameter	Coefficient	*SE*	*p*
10	Intercept	509.42	3.49	<.001
	Emphasis on academic success - teachers	4.37	1.23	<.001
11	Intercept	509.99	3.60	<.001
	Emphasis on academic success - principals	6.68	1.65	<.001
12	Intercept	508.55	3.76	<.001
	School discipline and safety	5.43	1.99	.01
13	Intercept	509.35	5.38	<.001
	Emphasis on academic success - teachers	2.22	2.08	.11
	Emphasis on academic success - principals	5.46	3.28	.01
	School discipline and safety	0.82	2.51	.69

Random effects coefficient estimates for Models 10-13 are shown in Table 116. In Model 13 with the combined school climate variables, the random effects of Level-1 parent expectations and involvement ($\hat{\tau}$ = 15.34, *SE* = 6.16, $p < .001$) and self-confidence in mathematics ($\hat{\tau}$ = 9.56, *SE* = 4.69, $p = .01$) were statistically significant, meaning that the relationships between mathematics achievement and parent expectations and involvement and self-confidence in mathematics varied across schools in the U.S. The slope variance of the remaining Level-1 variables (home possessions for learning, parent educational attainment, and value mathematics) were not statistically significant, meaning that the relationship between them and mathematics achievement tended to be similar across schools in the U.S. These relationships remained consistent for the remaining Level-2 models.

Table 116

Estimation of Random Effects for U.S. Models 10-13

Model	Parameter	Variance Components	*SE*	*p*
10	Between schools	1,830.30	257.29	<.001
	Within schools	1,722.92	55.80	
11	Between schools	1,817.24	238.09	<.001
	Within schools	1,720.44	55.77	
12	Between schools	1,899.37	267.22	<.001
	Within schools	1,721.93	55.71	
13	Between schools	1,781.97	241.52	<.001
	Within schools	1,720.61	55.73	

School resources. To what extent are school resources variables (computer availability for instruction, resources for general instruction, and resources for mathematics instruction) associated with eighth-grade mathematics achievement in the U.S.? To address this question, each of the Level-2 school resources variables was entered into Model 9 to create Models 14-16. Because only Model 16 of the school resources variables had a statistically significant relationship with mathematics achievement, it was selected as the school resources model, and Model 17, intended to be the model for the combined school resources, was omitted.

Pseudo R^2. To evaluate model fit, a pseudo R^2 was calculated for Models 14-16 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by each of the school resources variables compared to Model 9, the combined Level-1 model. Results of pseudo R^2 calculations, shown in Table 117, indicate that the entering of computers available for instruction into Model 9 to predict mathematics achievement reduced the between-school variance by 11%. The entering of resources for general instruction as a predictor by itself into Model 9 reduced the between-school variance by 11%, also. The entering of resources for mathematics instruction into Model 9 reduced the between-school variance by 13%.

Table 117

Comparison of Pseudo R^2 between U.S. Models 14-17 and Model 9

Model	Predictor	Between-School Variance	Within-School Variance
14	Computer availability for instruction	.11	.00
15	Resources for general instruction	.11	.00
16	Resources for mathematics instruction	.13	.00

Fixed and random effects. Of the three variables measuring school resources, the fixed effect coefficient estimate for a shortage of resources for mathematics instruction ($\gamma = -3.47$, $SE = 1.41$, $p = .02$) in Model 16 was the only one that had a statistically significant relationship with eighth-grade mathematics achievement in the U.S. This means that with every unit increase in the shortage of resources for mathematics instruction scale, mathematics scores of U.S. students with mean Level-1 variable values would be expected to decrease by 3.47 points. The results of Models 14-16 are shown in Table 118. Because only resources for mathematics instruction of the three fixed effects measuring school resources had a statistically significant relationship with mathematics achievement, Model 16 was selected to measure overall school resources, and Model 17, intended to be a combined school resources model was omitted for the U.S.

Table 118

Estimation of Fixed Effects for U.S. Models 14-16

Model	Parameter	Coefficient	*SE*	*p*
14	Intercept	510.88	5.38	<.001
	Computer availability for instruction	3.41	2.08	.53
15	Intercept	510.27	3.66	<.001
	Shortage of resources for general instruction	0.18	1.38	.90
16	Intercept	511.02	3.53	<.001
	Shortage of resources for mathematics instruction	-3.47	1.41	.02

Random effects coefficient estimates for Models 14-16 are shown in Table 119. In Model 16, the most efficient of the school resources models, the random effects of Level-1 parent expectations and involvement ($\hat{\tau} = 15.26$, $SE = 6.15$, $p < .001$) and self-confidence in mathematics ($\hat{\tau} = 9.91$, $SE = 4.90$, $p = .01$) were statistically significant, meaning that the relationships between mathematics achievement and parent expectations and involvement and self-confidence in mathematics varied across schools in the U.S. The slope variances of the remaining Level-1 variables (home possessions for learning, parent educational attainment, and value mathematics) were not statistically significant, meaning that the relationship between them and mathematics achievement tended to be similar across schools in the U.S.

Table 119

Estimation of Random Effects for U.S. Models 14-16

Model	Parameter	Variance Components	*SE*	*p*
14	Between schools	1,929.70	270.04	<.001
	Within schools	1,723.05	55.86	
15	Between schools	1,929.00	273.09	<.001
	Within schools	1,723.11	55.90	
16	Between schools	1,889.01	256.92	<.001
	Within schools	1,722.74	55.81	

Administrator leadership. To what extent is school administrator leadership associated with eighth-grade mathematics achievement in the U.S.? To address this question, the singular administrator leadership variable was entered into Model 9 to create Model 18.

***Pseudo R^2*.** To evaluate model fit, a pseudo R^2 was calculated for Model 18 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by school administrator leadership compared to Model 9. Results of the pseudo R^2 calculation, shown in Table 120, indicate that the entering of administrator leadership to the combined Level-1 model to predict mathematics achievement reduced the between-school variance by 11%.

Table 120

Comparison of Pseudo R^2 between U.S. Model 18 and Model 9

Model	Predictor	Between-School Variance	Within-School Variance
18	Administrator leadership	.11	.00

Fixed and random effects. The fixed effect coefficient estimate for administrator leadership did not have a statistically significant relationship with mathematics achievement. The results of Models 18 are shown in Table 121.

Table 121

Parameter Estimates for U.S. Model 18 (Administrator Leadership)

Effect	Parameter	Coefficient	*SE*	*p*
Fixed	Intercept	510.02	3.62	<.001
	Administrator leadership	1.86	1.69	.28
Random	Between-schools	1,932.85	270.89	<.001
	Within-schools	1,722.99	55.70	

School socioeconomic status. To what extent are school socioeconomic status variables (students economically disadvantaged and home resources limiting teaching) associated with eighth-grade mathematics achievement in the U.S.? To address this question, each of the Level-2 school socioeconomic status variables was entered into Model 9 to create Models 19 and 20. Then, both variables, having statistically significant fixed effects separately, were included in the combined school socioeconomic status model, Model 21.

Pseudo R^2. To evaluate model fit, a pseudo R^2 was calculated for Models 19-21 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by each of the school socioeconomic status variables compared to Model 9. Results of pseudo R^2 calculations, shown in Table 122, indicate that the entering of students economically disadvantaged into Model 9 to predict mathematics achievement reduced the between-school variance by 16%. The entering of home resources limiting teaching as a predictor by itself into Model 9 reduced the between-school variance by 14%. Overall, Model 21 with the combined school socioeconomic variables was more efficient than Models 19 or 20 with singular school socioeconomic status variables in predicting mathematics achievement for students in the U.S.

Table 122

Comparison of Pseudo R^2 between U.S. Models 19-21 and Model 9

Model	Predictor	Between-School Variance	Within-School Variance
19	Students economically disadvantaged	.16	.00
20	Home resources limiting teaching	.14	.00
21	Combined school socioeconomic status	.24	.00

Fixed and random effects. Fixed effects coefficient estimates for both variables measuring school socioeconomic status had a statistically significant relationship with eighth-grade mathematics achievement. Model 19 with students economically disadvantaged as a Level-2 predictor of mathematics achievement yielded a statistically significant fixed effect ($\gamma = -16.28$, $SE = 5.47$, $p = .003$). This means that with every unit increase in the students economically disadvantaged scale, mathematics scores of students with mean Level-1 variable values would be expected to decrease by 16.28 points. The fixed effect coefficient estimate for home resources limiting teaching was found statistically significant in Model 20 ($\gamma = -11.71$, $SE = 1.81$, $p < .001$). This means that with every unit increase in the home resources limiting teaching scale, mathematics scores of students with mean Level-1 variable values would be expected to decrease by 11.71 points.

Both school socioeconomic status variables still had a statistically significant negative relationship with mathematics achievement when combined in Model 21. The results of Models 19-21 are shown in Table 123.

Table 123

Estimation of Fixed Effects for U.S. Models 19-21

Model	Parameter	Coefficient	*SE*	*p*
19	Intercept	510.02	3.62	<.001
	Students economically disadvantaged	-16.28	5.47	.003
20	Intercept	512.39	2.97	<.001
	Home resources limiting teaching	-11.71	1.81	<.001
21	Intercept	510.21	3.40	<.001
	Students economically disadvantaged	-8.91	1.99	<.001
	Home resources limiting teaching	-11.28	3.70	.05

Random effects coefficient estimates for Models 19-21 are shown in Table 124. In Model 21 with the combined school climate variables, the random effects of Level-1 parent expectations and involvement ($\hat{\tau} = 15.59$, *SE* = 6.24, $p < .001$) and self-confidence in mathematics ($\hat{\tau} = 9.83$, *SE* = 4.77, $p = .01$) were statistically significant, meaning that the relationships between mathematics achievement and parent expectations and involvement and self-confidence in mathematics varied across schools in the U.S. The slope variances of the remaining Level-1 variables (home possessions for learning, parent educational attainment, and value mathematics) were not statistically significant, meaning that the relationship between them and mathematics achievement tended to be similar across schools in the U.S.

Table 124

Estimation of Random Effects for U.S. Models 19-21

Model	Parameter	Variance Components	*SE*	*p*
19	Between-schools	1,807.71	242.96	<.001
	Within-schools	1,720.47	55.41	
20	Between-schools	1,867.95	180.26	<.001
	Within-schools	1,706.48	62.97	
21	Between-schools	1,650.72	218.47	<.001
	Within-schools	1,721.18	55.38	

Combined school-related variables model. Based on the results of Models 10-21, containing theory-driven combinations of school-related variables, four variables (emphasis on academic success - principal reports, resources for mathematics instruction, students economically disadvantaged, and home resources limiting teaching) were selected to enter into Model 9 as the school-related variables model to predict mathematics achievement in Model 22.

Pseudo R^2. To evaluate model fit, a pseudo R^2 was calculated for Model 22 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by the combined school-related variables compared to Model 9. Results of the pseudo R^2 calculation, shown in Table 125, indicate that the combination of the four school-related variables entered into Model 9 to predict mathematics achievement reduced the between-school variance by 26%.

Table 125

Comparison of Pseudo R^2 between U.S. Model 22 and Model 9

Model	Predictor	Between-School Variance	Within-School Variance
22	Combined school-related variables	.26	.00

Fixed and random effects. One fixed effect from each of three domains (school climate, school resources, and school socioeconomic status) in a combined school-related variables model showed statistically significant relationships with U.S. eighth-grade mathematics achievement. Results of Model 22 are shown in Table 126. Because the predictor variables were grand-mean centered, the fixed effect coefficient estimate for school emphasis on academic success - principal reports ($\gamma = 3.76$, $SE = 1.82$, $p = .03$) indicates that for each unit increase in that scale, students with mean values on all other predictors in the model would be expected to have 3.76 points increase in their mathematics scores. The fixed effect coefficient estimate for shortage of resources for mathematics instruction ($\gamma = -2.97$, $SE = 1.36$, $p = .03$) indicates that for each unit increase in that scale, students with mean values on all other predictors in the model would be expected to decrease 2.97 points in their TIMSS mathematics scores. The fixed effect coefficient estimate for home resources limiting teaching was found statistically significant ($\gamma = -8.75$, $SE = 1.81$, $p < .001$). This means that with every unit increase in the home resources limiting teaching scale, mathematics scores of students with mean values all other predictors in the model would be expected to decrease by 8.75 points.

Table 126

Parameter Estimates for U.S. Model 22 (Combined School Variables)

Effect	Parameter	Estimate	*SE*	*p*
Fixed	Intercept	510.70	3.45	<.001
	School emphasis on academic success-principals report	3.76	1.82	.03
	Shortage of resources for mathematics instruction	-2.97	1.36	.03
	Students economically disadvantaged	-7.95	4.22	.06
	Home resources limiting teaching	-8.75	2.15	<.001
Random	Between-schools	1,604.89	203.91	<.001
	Within-schools	1,719.65	55.37	

Teacher-Related Variables

Research Question 4 for each country in this study is the extent to which teacher- or classroom-related variables (access and equity, curriculum, tools and technology, classroom assessment, and teacher professionalism) predict eighth-grade mathematics achievement. The approach toward answering this question was to enter the teacher-related variables into the combined Level-1 model, Model 9. First, variables measuring access and equity were entered separately as Models 23 and 24, and then because only Model 24 of those two was a statistically significant predictor of eighth-grade mathematics achievement, Model 25, which was intended to combine both access and equity variables if they were statistically significant, was omitted. Next, variables measuring the construct of curriculum were entered separately into Model 9 as Models 26 and 27, and then because neither of those two was a statistically significant predictor of eighth-grade mathematics achievement, Model 28, which was intended to combine both curriculum variables if they were statistically significant, was omitted. Variables measuring classroom assessment were entered separately as predictors of eighth-grade mathematics achievement into Model 9 to create Models 29 and 30. Then, because only

Model 30 of those two was a statistically significant predictor of eighth-grade mathematics achievement, Model 31, which was intended to combine both assessment variables if they were statistically significant, was omitted. The six variables measuring teacher professionalism were entered separately in Model 9 as predictors of eighth-grade mathematics achievement. Those variables with significant fixed effects in Models 32-37 were included in the combined teacher professionalism model, Model 38. The teacher-level variables that were found to contribute significantly to mathematics achievement were selected to be entered into a combined model (Model 39) of teacher-related variables to predict mathematics achievement as a group.

Access and equity. To what extent are mathematics classroom access and equity variables (mathematics instructional hours per year and mathematics topics taught) associated with eighth-grade mathematics achievement in the U.S.? To address this question, each of the Level-2 access and equity variables was entered into Model 9 to create Models 23 and 24. Because only mathematics topics taught of the two fixed effects measuring access and equity had a statistically significant relationship with mathematics achievement, Model 24 was selected to measure overall access and equity, and Model 25, intended to be a combined access and equity model was omitted for the U.S.

Pseudo R^2. To evaluate model fit, a pseudo R^2 was calculated for Models 23 and 24 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by each of the access and equity variables compared to Model 9. Results of pseudo R^2 calculations, shown in Table 127, indicate that the entering of mathematics instructional hours per year into Model 9 to predict mathematics achievement did not change the between-school variance by any discernible amount. The entering of mathematics topics taught as a predictor by itself to the combined Level-1 model reduced the between-school variance by 13%.

Table 127

Comparison of Pseudo R^2 between U.S. Models 23-24 and Model 9

Model	Predictor	Between-School Variance	Within-School Variance
23	Mathematics instructional hours per year	.00	.00
24	Mathematics topics taught	.13	.00

Fixed and random effects. Model 24 with mathematics topics taught as a Level-2 predictor of mathematics achievement yielded a statistically significant fixed effect ($\gamma = 11.25$, $SE = 2.26$, $p < .001$). This means that with every unit increase in the access and equity scale, mathematics scores of students with mean Level-1 variable values would be expected to increase by 11.25 points. The results of Models 23 and 24 are shown in Tables 128 and 129.

Table 128

Estimation of Fixed Effects for U.S. Models 23-24

Model	Parameter	Coefficient	*SE*	*p*
23	Intercept	512.63	3.13	<.001
	Mathematics instructional hours per year	-0.10	0.05	.06
24	Intercept	513.99	2.94	<.001
	Mathematics topics taught	11.25	2.26	<.001

Table 129

Estimation of Random Effects for U.S. Models 23-24

Model	Parameter	Variance Components	*SE*	*p*
23	Between schools	2,158.04	211.25	<.001
	Within schools	1,705.35	63.02	
24	Between schools	1,885.15	175.96	<.001
	Within schools	1,705.15	62.49	

Curriculum. To what extent are classroom curriculum variables (instructional materials and instruction) associated with eighth-grade mathematics achievement in the U.S.? To address this question, each of the Level-2 classroom instruction variables was entered into Model 9 to create Models 26 and 27. Scores from the composite variables derived from teacher questionnaire items to measure teachers' instructional materials were not included in this analysis because they were found to be unreliable, as shown in Table 5. In addition, the Wright maps for the two variables derived to measure instructional materials showed mismatches of response thresholds and scale scores, as indicated in Appendix B. So, rather than create multilevel models with unreliable scales or completely disregard the variables, descriptive statistics of each of the instructional materials items were investigated. The descriptive statistics are shown in Table 130, as well as in Tables C85-C88 in Appendix C. Descriptive statistics indicate that eighth-grade students in the U.S. whose teachers use textbooks and computer software as bases for instruction had higher mathematics scores than students whose teachers used textbooks and computer software as supplements for instruction or not at all. Further, students whose teachers used concrete objects or materials to supplement instruction had higher mathematics scores than students whose teachers used them as either a basis for instruction or not at all. Finally, students whose teachers did not use workbooks or worksheets at all had higher mathematics scores than students whose teachers used them as either a basis for instruction to supplement instruction.

Table 130

Descriptive Statistics for U.S. Instructional Materials and Mathematics Achievement

Instructional materials	Basis for instruction %	Supplement %	Not used %	Basis for instruction mean	Supplement mean	Not used mean
Textbooks	48.0	42.6	9.4	521.6	504.7	498.9
Workbooks / worksheets	18.9	77.0	4.1	490.2	517.2	520.4
Concrete objects / materials	16.9	74.6	8.5	502.9	514.5	510.7
Computer software	14.0	62.2	23.8	514.0	512.7	509.8

Pseudo R^2. To evaluate model fit, a pseudo R^2 was calculated for Models 26 and 27 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by each of the classroom curriculum variables compared to the combined Level-1 model. Results of pseudo R^2 calculations, shown in Table 131, indicate that neither instruction to engage students nor research-based practices reduced the between-school variance by a statistically discernable amount.

Table 131

Comparison of Pseudo R^2 between U.S. Models 26-27 and Model 9

Model	Predictor	Between-School Variance	Within-School Variance
26	Instruction to engage students	.00	.00
27	Research-based practices	.00	.00

Fixed and random effects. The results of Models 26 and 27 are shown in Table 132 and 133. Fixed effects coefficient estimates for neither singular variables measuring classroom instruction had a statistically significant relationship with eighth-grade mathematics achievement; hence, the intended combined curriculum model, Model 28, was omitted in the U.S. analysis.

Table 132

Estimation of Fixed Effects for U.S. Model 26-27

Model	Parameter	Coefficient	*SE*	*p*
26	Intercept	512.70	3.12	<.001
	Instruction to engage students	0.41	1.98	.84
27	Intercept	512.70	3.12	<.001
	Research-based practices	-0.76	1.64	.44

Table 133

Estimation of Random Effects for U.S. Model 26-27

Model	Parameter	Variance Components	*SE*	*p*
26	Between schools	2,173.28	214.27	<.001
	Within schools	1,706.28	62.79	
27	Between schools	2,171.75	214.38	<.001
	Within schools	1,706.25	62.84	

Classroom assessment. To what extent are classroom assessment variables (assessment question types and class emphasis on assessment) associated with eighth-grade mathematics achievement in the U.S.? To address this question, each of the Level-2 classroom assessment variables was added to the combined Level-1 model (Model 9) to create Models 29 and 30. Only one fixed effect, classroom emphasis on assessment in Model 30, was found to have a statistically significant relationship with mathematics achievement. Therefore, Model 30 was selected to represent classroom assessment, and the intended combined classroom assessment model, Model 31, was omitted from analysis for the U.S.

Pseudo R^2. To evaluate model fit, a pseudo R^2 was calculated for Models 29 and 30 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by each of the classroom assessment variables compared to Model 9. Results of pseudo R^2 calculations, shown in Table 134, indicate that the entering of assessment question types into Model 9 to predict mathematics achievement did not reduce the between-school variance by any discernible amount. The entering of class emphasis on assessment as a predictor by itself into Model 9 reduced the between-school variance by 1%.

Table 134

Comparison of Pseudo R^2 between U.S. Models 29-30 and Model 9

Model	Predictor	Between-School Variance	Within-School Variance
29	Assessment question types	.00	.00
30	Class emphasis on assessment	.01	.00

Fixed and random effects. Fixed effects coefficient estimates for only one of the two variables measuring classroom assessment had a statistically significant relationship with eighth-grade mathematics achievement. Model 30 with class emphasis on assessment as a Level-2 predictor of mathematics achievement yielded a statistically significant fixed effect ($\gamma = -3.22$, $SE = 1.66$, $p = .05$). This means that with every unit increase in the class emphasis on assessment scale, mathematics scores of students with mean Level-1 variable values would be expected to decrease by 3.22 points. Because Model 29 did not yield a statistically significant fixed effect, Model 30 was selected to represent classroom assessment, and the intended combined model for classroom assessment, Model 31, was omitted from U.S. analysis. The results of Models 29 and 30 are shown in Tables 135 and 136.

Table 135

Estimation of Fixed Effects for U.S. Model 29-30

Model	Parameter	Coefficient	*SE*	*p*
29	Intercept	512.75	3.12	<.001
	Assessment question types	1.21	1.32	.36
30	Intercept	512.57	3.11	<.001
	Class emphasis on assessment	-3.22	1.66	.05

Table 136

Estimation of Random Effects for U.S. Model 29-30

Model	Parameter	Variance Components	*SE*	*p*
29	Between schools	2,165.79	213.21	
	Within schools	1,706.49	62.75	
30	Between schools	2,140.73	211.18	<.001
	Within schools	1,706.09	62.72	

Teacher professionalism. To what extent are teacher professionalism variables (professional development, professional collaboration, teacher experience, teacher knowledge, teacher preparation, and teacher efficacy) associated with eighth-grade mathematics achievement in the U.S.? To address this question, each of the Level-2 teacher professionalism variables was added to the combined Level-1 model (Model 9) to create Models 32-37. Then, the variables with significant fixed effects were included in the combined teacher professional model, Model 38.

Pseudo R^2. To evaluate model fit, a pseudo R^2 was calculated for Models 32-38 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by each of the teacher professionalism variables compared to Model 9. Results of pseudo R^2 calculations, shown in Table 137, indicate that the entering of teacher professional development and teacher experience into Model 9 to predict mathematics achievement each reduced the between-school variance by 1%. The entering of the remaining variables into Model 9 did not reduce between-school variance by any statistically discernible amount. Overall, Model 38 with the combined professional development and teacher experience variables was more efficient than any of Models 32-37 with singular teacher professionalism variables in predicting mathematics achievement for students in the U.S.

Table 137

Comparison of Pseudo R^2 between U.S. Models 32-38 and Model 9

Model	Predictor	Between-School Variance	Within-School Variance
32	Professional development	.01	.00
33	Professional collaboration	.00	.00
34	Teacher experience	.01	.00
35	Teacher knowledge	.00	.00
36	Teacher preparation	.00	.00
37	Teacher efficacy	.00	.00
38	Combined teacher professionalism	.03	.00

Fixed and random effects. Fixed effects coefficient estimates for two of the six variables measuring teacher professionalism had a statistically significant relationship with eighth-grade mathematics achievement. Model 32 with professional development as a Level-2 predictor of mathematics achievement yielded a statistically significant fixed effect ($\gamma = -4.32$, $SE = 1.51$, $p = .01$). This means that with every unit increase in the professional development scale, mathematics scores of students with mean Level 1 variable values would be expected to decrease by 4.32 points. This surprising negative relationship prompted further investigation. The teacher questionnaire items that comprised this composite variable were examined. Results of this examination are shown in Tables C111-C117 in Appendix C. TIMSS U.S. eighth-grade mathematics scores decreased with teachers' positive responses to attending professional development for every topic except for professional development related to mathematics, in which case mathematics scores increased with teachers' positive responses.

The fixed effect coefficient estimate for teacher experience was found statistically significant in Model 34 ($\gamma = 0.67$, $SE = 0.28$, $p = .02$). This means that with every unit increase in the level of teacher experience, mathematics scores of students with mean Level 1 variable values would be expected to increase by .67 points. The parameter estimates of Models 32-38 are shown in Tables 138 and 139.

Table 138

Estimation of Fixed Effects for U.S. Model 32-38

Model	Parameter	Coefficient	*SE*	*p*
32	Intercept	512.78	3.12	<.001
	Professional development	-4.32	1.51	.01
33	Intercept	512.63	3.13	<.001
	Professional collaboration	-1.34	1.15	.25
34	Intercept	512.53	3.11	<.001
	Teacher experience	0.67	0.28	.02
35	Intercept	512.74	3.12	<.001
	Teacher knowledge	-2.02	0.59	.44
36	Intercept	512.69	3.61	<.001
	Teacher preparation	-0.38	1.80	.83
37	Intercept	512.70	3.12	<.001
	Teacher self-efficacy	0.68	1.65	.68
38	Intercept	512.63	3.11	<.001
	Professional development	-4.17	1.50	.01
	Teacher experience	0.64	0.28	.02

Table 139

Estimation of Random Effects for U.S. Models 32-38

Model	Parameter	Variance Components	*SE*	*p*
32	Between schools	2,137.36	210.34	<.001
	Within schools	1,705.14	62.89	
33	Between schools	2,164.50	211.97	<.001
	Within schools	1,706.00	62.68	
34	Between schools	2,130.37	208.11	<.001
	Within schools	1,705.74	62.71	
35	Between schools	2,169.63	212.70	<.001
	Within schools	1,706.02	62.72	
36	Between schools	2,173.35	214.36	<.001
	Within schools	1,706.29	62.81	
37	Between schools	2,171.20	214.23	<.001
	Within schools	1,706.39	62.82	
38	Between schools	2,096.17	204.58	<.001
	Within schools	1,704.67	62.80	

Combined teacher-related variables. Based on the results of Models 23-38 the four variables teacher- and classroom-related variables (mathematics topics taught, class emphasis on assessment, teacher professional development, and teacher experience) that were found to have individually statistically significant relationships with mathematics achievement were entered into Model 9 to predict mathematics achievement as Model 39.

Pseudo R^2. To evaluate model fit, a pseudo R^2 was calculated for Model 39 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by the combined teacher-related variables compared to the combined Level-1 model. Results of pseudo R^2 calculations, shown in Table 140, indicate that the entering of the four teacher-related variables to the combined Level 1 model to predict mathematics achievement reduced the between-school variance by 18%.

Table 140

Comparison of Pseudo R^2 between U.S. Model 39 and Model 9

Model	Predictor	Between-School Variance	Within-School Variance
39	Combined teacher variables	.18	.00

Fixed and random effects. Three of the four predictors in Model 39, the combined teacher-related variables model, had statistically significant fixed effects, shown in Table 141. Because the predictor variables were grand-mean centered, the fixed effect coefficient estimate for mathematics topics taught ($\gamma = 11.44$, $SE = 2.26$, $p < .001$) indicates that for each unit increase in that scale, students with mean values on all other predictors in the model would be expected to have 11.44 points increase in their mathematics scores. The fixed effect coefficient estimate for class emphasis on assessment (γ = -3.39, *SE* = 1.59, *p* = .03) indicates that for each unit increase in that scale, students with mean values on all other predictors in the model would be expected to decrease 3.39 points in their TIMSS mathematics scores. The fixed effect coefficient estimate for professional development was found statistically significant (γ = -3.48, *SE* = 1.42, *p* = .02). This means that with every unit increase in the professional development scale, mathematics scores of students with mean values on all other predictors in the model would be expected to decrease by 3.48 points. It should be kept in mind that professional development related to mathematics curriculum had an opposite relationship from the other professional development topics addressed in the TIMSS teacher questionnaire.

Table 141

Parameter Estimates for U.S. Model 39 (Combined Teacher Variables)

Effect	Parameter	Estimate	*SE*	*p*
Fixed	Intercept	513.86	2.90	<.001
	Mathematics topics taught	11.44	2.26	<.001
	Class emphasis on assessment	-3.39	1.59	.03
	Professional development	-3.48	1.42	.02
	Teacher experience	0.45	0.26	.09
Random	Between-schools	1,773.58	166.87	<.001
	Within-schools	1,703.96	62.52	

U.S. Full Model

The eight Level 2 fixed effects that were found in Models 22 (combined school-related variables) and 39 (combined teacher-related variables) to have statistically significant relationships with mathematics achievement were entered into Model 9 to create an efficient model for predicting eighth-grade mathematics achievement in the

U.S. The four school-related variables were school emphasis on academic success - principal reports, school resources for mathematics instruction, school students economically disadvantaged, and home resources limiting teaching. The four classroom-related variables were mathematics topics taught, class emphasis on assessment, teacher professional development, and teacher experience.

Pseudo R^2. To evaluate model fit, a pseudo R^2 was calculated for Model 40 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by each of the Level 2 variables compared to the combined Level 1 model. Results of pseudo R^2 calculations, shown in Table 142, indicate that the entering of school emphasis on academic success - principal reports, resources for mathematics instruction, students economically disadvantaged, home resources limiting teaching, mathematics topics taught, class emphasis on assessment, teacher professional development, and teacher experience to the combined Level 1 model to predict mathematics achievement reduced the between-school variance by 31%. Overall, Model 40 with the combined school-related variables was more efficient than any of the previous models in predicting mathematics achievement for students in the U.S.

Table 142

Comparison of Pseudo R^2 between U.S. Model 40 and Model 9

Model	Predictor	Between-School Variance	Within-School Variance
40	Full model	.31	.00

Fixed and random effects. Four of the eight Level 2 predictors in Model 40 had statistically significant fixed effects, shown in Table 143. Because the predictor variables were grand-mean centered, the fixed effect coefficient estimate for students economically disadvantaged ($\gamma = -11.41$, $SE = 3.63$, $p = .002$) indicates that for each unit increase in that scale, students with mean values on all other predictors in the model would be expected to have 11.41 points decrease in their mathematics scores. The fixed effect coefficient estimate for home resources limiting teaching ($\gamma = -7.89$, $SE = 1.77$, $p < .001$) indicates that for each unit increase in that scale, students with mean values on all other predictors in the model would be expected to decrease 7.89 points in their TIMSS mathematics scores. The fixed effect coefficient estimate for mathematics topics taught was found to be statistically significant ($\gamma = 10.33$, $SE = 2.19$, $p <.001$). This means that with every unit increase in the mathematics topics taught scale, mathematics scores of students with mean on all other predictors in the model would be expected to increase by 10.33 points. Finally, the fixed effect coefficient estimate for class emphasis on assessment was found statistically significant ($\gamma = -4.40$, $SE = 1.50$, $p = .004$). This means that with every unit increase in the mathematics topics taught scale, mathematics scores of students with mean values on all other predictors in the model would be expected to decrease by 4.40 points. In addition, all five Level 1 fixed effects in Model 40 were found to have statistically significant relationships with mathematics achievement in combination with the Level 2 variables.

Table 143

Estimation of Fixed Effects for U.S. Model 40

Parameter	Coefficient	*SE*	*p*
Intercept	513.09	2.75	<.001
School emphasis on academic success-principal reports	0.47	1.40	.74
Resources for mathematics instruction	-0.97	1.33	.47
Students economically disadvantaged	-11.41	3.63	.002
Home resources limiting teaching	-7.89	1.77	<.001
Mathematics topics taught	10.33	2.19	<.001
Class emphasis on assessment	-4.40	1.50	.004
Professional development	-2.32	1.33	.08
Teacher experience	0.18	0.25	.47
Home possessions for learning	4.65	0.85	<.001
Parent education	1.81	0.88	.04
Parent expectations and involvement	-3.04	0.47	<.001
Self-confidence in mathematics	10.90	0.45	<.001
Value mathematics	-0.05	0.02	.01

Table 144

Estimation of Random Effects for U.S. Model 40

Model	Parameter	Variance Components	*SE*	*p*
39	Between-schools	1,499.98	139.50	<.001
	Within-schools	1,702.88	62.64	

Summary. The U.S. had the most statistically significant predictors of mathematics achievement in the final model of the three countries studied in this dissertation. The U.S. had statistically significant predictors in both domains of home resources and student beliefs in Level 1. It also had statistically significant variables in the Level-2 domains of school socioeconomic status, classroom-level access and equity, classroom assessment, and teacher professionalism. Domains for which the U.S. did not have variables with statistically significant relationships with mathematics achievement in the final model were school climate, school resources, administrator leadership, and classroom curriculum.

CHAPTER V

DISCUSSION

Study Overview

This study was developed with the theory that student mathematics achievement is shaped by four major sources: students' homes and families, their own beliefs about mathematics, their schools, and their teachers. A review of literature was conducted through that lens. As one might expect, many variables have been reported to be predictors of mathematics achievement in various contexts. The predictors of mathematics achievement that were selected for this study are those which were found in the literature to be consistently reported across cultures and decades of research.

The four major sources that shape student mathematics achievement were considered in this study at two levels: the student home and beliefs variables were investigated at the student level, and the school and classroom/teacher variables were investigated at the school level. Three variables related to students' homes were selected: home possessions for learning, parent education, and parent expectations and involvement in their children's education. Variables that were selected relating to student beliefs were self-confidence in mathematics and value of mathematics.

Because most countries that participated in the TIMSS 2011 sampled one intact class per school, school and teacher variables were treated as being in the same level. School-related predictors of mathematics achievement found in the literature were categorized into four domains: school climate, school resources, school administrator leadership, and school socioeconomic status. Teacher- and classroom-related predictors of mathematics achievement selected from the literature were categorized into five domains: access and equity, curriculum, tools and technology, classroom assessment, and teacher professionalism.

The TIMSS 2011 international database was selected for this study because, in addition to measuring mathematics achievement, the dependent variable in this study, it collected extensive background information from the students, school administrators, and teachers who participated in the TIMSS to provide measures of the independent variables identified for this study. Finally, three countries that participated in the TIMSS 2011 were selected for this study to represent a wide range of mathematics achievement and cultures: Chinese Taipei, Ghana, and the U.S.

To measure the independent variables, all items in the three background questionnaires (student, school administrator, and teacher) were examined for alignment with the variables that were identified from the review of literature. Some questionnaire items that were found to align with the predictors in the literature had already been organized by other TIMSS researchers into composite variables. Eleven of those previously derived variables were selected for use in this study. Principal components analysis was used to derive 17 new composite variables from the remaining questionnaire items for which no previously derived composite variables were found. These variables and the items that compose them are described in detail in Chapter 3 and Appendix A of this dissertation.

The 17 self-derived composite variables were scaled using Rasch's Item Response Theory partial credit model. Two of the scales, representing the variables textbooks and worksheets for instruction and tools and technology for instruction, under of the domain of instructional materials, were found to be not sufficiently reliable to be included in the multilevel modeling. In addition, the Wright maps for these two variables showed mismatches of response thresholds and scale scores; so, descriptive statistics of the two instructional materials variables were investigated, but they were not included in the multilevel modeling.

Scaled scores of most of the composite variables, unless they already had easily interpretable values, were transformed to have a mean of 10 and standard deviation of two to facilitate interpretation. The glaring exception to this transformation is the variable value mathematics, the scores of which were transformed to have a mean of 10 but ended up having a standard deviation of 65. The very large standard deviation for value mathematics resulted in relatively low coefficients for value mathematics in the regression equations compared to the other transformed scales.

HLM was selected to study the relationships between the dependent variable mathematics achievement and the 26 remaining predictors of mathematics achievement because of the nested nature of the student-level variables in the school- and teacher-level variables. Recommended (Foy et al., 2013) weightings, because of the sampling methods used in the TIMSS 2011, were used in the HLM.

Every independent variable in this study had some missing data because of questionnaire items that were not answered by students, school administrators, or teachers. Because HLM calculates parameter estimates based on complete cases, missing data in any variable results in that student’s case being not included in any HLM model. A lot of missing data in any one variable, then, will diminish the sample size by that number of cases for all HLM models built from the data set. This was the situation created by two of the variables in this study—calculator use for instruction and computer use for instruction in the domain of tools and technology in the teacher-related variables. Because of the high number of non-responses to the items composing these variables, the sample sizes for each country would be reduced by more than half if these two variables were included in the HLM analyses. Therefore, those two variables were examined in separate exploratory models rather than being included in the HLM models of this study.

The design of this study was to investigate four questions with multilevel modeling across the three selected countries:

1. To what extent do home-related variables (home possessions for learning, parent educational attainment, and parent expectations for and involvement in their children's education) predict eighth-grade mathematics achievement?
2. To what extent do student beliefs (self-confidence in mathematics and value of mathematics) predict eighth-grade mathematics achievement?
3. To what extent do school-related variables (school climate, school resources, administrator leadership, and school socioeconomic status) predict eighth-grade mathematics achievement?
4. To what extent do teaching-related variables (access and equity, curriculum, tools and technology, assessment, and teacher professionalism) predict eighth-grade mathematics achievement in each country?

The remainder of this section will be a discussion of the results found in the analyses investigating these four questions.

Unconditional Model

The multilevel modeling for each country began with Model 1, an unconditional model, containing only the dependent variable which was the five plausible values of student mathematics achievement, and the grouping variable of schools. HLM 7 software accommodates plausible values by running the requested analysis for each plausible value and then averaging the results.

Descriptive statistics of mathematics achievement in the three countries are provided in Table 145. The TIMSS mathematics achievement scale ranges from zero to 1,000 with student performance typically ranging between 300 and 700. The achievement scores are scaled so that the mean of the overall achievement distribution for each grade is 500, and the standard deviation is 100. Chinese Taipei had the third highest mean scale score (*M* = 615.17, *SD* = 101.34) in eighth-grade mathematics of the 42 countries that participated in the TIMSS 2011. The five highest-achieving countries in both the fourth- and eighth-grade mathematics assessments are in East Asia. Ghana achieved the lowest overall eighth-grade mathematics scores (*M* = 344.72, *SD* = 85.02) of the 42 countries. Ghana, along with Morocco, both in northwest Africa, had the highest percentages (exceeding 25%) of students with achievement too low for estimation. The U.S. had the ninth highest mean scale score of eighth-grade mathematics achievement (*M* = 509.92 *SD* = 76.11) of the 42 countries that participated in the TIMSS 2011. The U.S. was one of 10 countries with eighth-grade mathematics achievement higher than the scale centerpoint of 500 (Mullis, Martin, Foy, et al., 2012).

Table 145

Descriptive Statistics for Mathematics Achievement in Each Country

	Chinese Taipei		Ghana		U.S.	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*
Mathematics achievement	615.17	101.34	344.72	85.02	509.92	76.11

Intraclass Correlation Coefficients were calculated from the unconditional models in each country in this study to determine the ratios of between-school and within-school variance compared to the total variance in each country's unconditional model. The percentages of between- and within-school variance for each country are shown in Table 146. The low variation of mathematics achievement between schools and corresponding high variation of mathematics achievement within schools in Chinese Taipei indicate a high degree of homogeneity in student achievement across schools in Chinese Taipei. Some possible explanations for lower between-school variation in mathematics achievement may be a school system that is structured in a fairly equitable manner or a more nationalized curriculum (Organization for Economic Cooperation and Development, 2004).

The U.S had the highest variation between schools of the three countries in this study. Substantial variation in performance between schools and corresponding less variation within schools indicate that students are grouped in schools with other students who perform at levels similar to their own. Some possible explanations for greater between-school variation in mathematics achievement may be differences in access to schools based on location of family residences or the differences in curricula across schools (Organization for Economic Cooperation and Development, 2004). For example, in 2011, the Common Core State Standards (CCSS) were just beginning to be adopted by a number of states in the U.S. Even though the CCSS were and are not a national curriculum, prior to the introduction of the CCSS, every state in the U.S. had its own set of content standards and curricula for each subject area.

Table 146

Percentages of Total Variance in Each Country

	Chinese Taipei		Ghana		U.S.	
Variable	Between Schools	Within Schools	Between Schools	Within Schools	Between Schools	Within Schools
Percent Variance	22%	78%	43%	57%	55%	45%

The unconditional models in each country provide baseline information about the relative eighth-grade mathematics achievement and the percentages of total variance attributable to between-school and within-school differences. Models 2-8 in each country contained student-level variables entered into and compared to the unconditional model.

Home-Related Variables

The first research question for this dissertation is the extent to which home-related variables (home possessions for learning, parent educational attainment, and parent expectations for and involvement in their children's education) predict eighth-grade mathematics achievement in each country. To address this question, the three variables related to the student's home were entered separately into the unconditional model as Models 2-4 as predictors of eighth-grade mathematics achievement in each country. Descriptive statistics for the home-related variables in each country are provided in Table 147. As described in previous sections, variables such as home possessions for learning and parent expectations and involvement were scaled to have a mean of 10 and standard deviation of two. This scaling facilitates interpretation, for example, that students in Chinese Taipei and the U.S. reported typically more home possessions for learning than students in Ghana did. Likewise, and perhaps surprisingly given Ghana's relatively low average mathematics achievement, students in Ghana reported higher levels of parent expectations and involvement in their education than students in either Chinese Taipei or the U.S. did. Indeed, an examination of the responses to the items that comprise this composite variable confirms that a greater percentage of students in Ghana reported more frequent incidences of the indicators of parent expectations and involvement than students in either Chinese Taipei or the U.S.

The values for the variable parent education were not transformed because its original values had interpretable meaning. The values were based on the International Standard Classification of Education (UNESCO Institute for Statistics, 2012) in which the value 1 represents primary education; 2, lower secondary education; 3, upper secondary education; 4, post-secondary but not university education; and so on. Visual examination of the parent education values in each country shows that students in the U.S. reported their parents having a mean education level of post-secondary, but not university, education levels. Students in Chinese Taipei reported their parents typically having between upper secondary education and post-secondary education. Finally, students in Ghana reported their parents typically having secondary-level education.

Overall, the literature indicates that a higher level of parent education is a predictor of higher mathematics achievement. Visual examination of the items that composed the parent education scale shows that for Chinese Taipei, that positive relationship was seen for both mothers' and fathers' educations. However, in Ghana that positive relationship was observed to be stronger for the father's education more so than the mother's; and in the U.S., the positive relationship was observed to be stronger for the mother's education than the father's. One possible explanation for this difference in relationships between Ghana and the U.S. could be cultural differences in roles that fathers and mothers tend to have between these two countries.

Table 147

Descriptive Statistics for Home-Related Variables in Each Country

	Chinese Taipei		Ghana		U.S.	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*
Home possessions for learning	10.81	1.64	7.91	1.68	10.83	1.64
Parent education	3.56	1.05	2.68	1.24	4.05	1.16
Parent expectations and involvement	8.86	2.01	10.42	2.07	9.86	1.96

A pseudo R^2 was calculated for Models 2-4 to estimate the proportional reduction in unexplained variance in the random parameters accounted for by each of the home-related variables compared to the unconditional model. Results of the R^2 calculations for each country are shown in Table 148. The percentage of variation attributable to the home-related variables, both between and within schools, was much greater in Chinese Taipei than in either Ghana or the U.S. The stronger association between home-related variables and mathematics achievement in Chinese Taipei, as well as other East Asian countries, has been a stable relationship. Schneider and Lee (1990) proposed explanations for this phenomenon related to culture; socioeconomics; and expectations of parents, teachers, and peer groups. Results of their ethnography indicated that education in East Asian cultures is valued as the path to self-improvement and family honor, and socioeconomic benefits of education are regarded as less important. This regard and expectation for education corresponds with Asian parents' structuring their children's out-of-school time with continued academically-focused activities.

The percentage of variation explained by the home-related variables was least in Ghana. Moreover, none of the home-related variables in this study had statistically significant relationships with mathematics achievement in Ghana. These results are consistent with those from Ansong, Chowa, and Sherraden (2015) who found no direct relationship between home assets nor parent expectations with mathematics achievement among junior high students in Ghana. Ansong, Chowa, and Sherraden proposed that a possible explanation for the statistically insignificant relationships between home-related variables and mathematics achievement in Ghana is that, because of the poverty and low levels of parent education in Ghana, households may not meet critical thresholds of possessions and education sufficient to exert a direct effect on mathematics achievement. Other recent studies of home- and family-related predictors of school achievement in Ghana have found statistically significant positive relationships between home-related variables and school achievement (Arthur, Addo, & Annan, 2015; Azigwe, Adda, Awuni, & Ayamba, 2016).

Table 148

Comparison of Pseudo R^2 Between Models 2-4 and Model 1 in Each Country

		Chinese Taipei		Ghana		U.S.	
Model	Predictor	Between-School	Within-School	Between-School	Within-School	Between-School	Within-School
2	Home possessions for learning	.34	.08	-.004	.02	.13	.03
3	Parent education	.30	.06	.01	.01	.09	.01
4	Parent expectations and involvement	.09	.03	.01	.01	-.002	.02

Compared with Chinese Taipei, in which all three home-related variables had statistically significant relationships with mathematics achievement and explained a large percentage of variation, and Ghana, in which not any of the home-related variables had statistically significant relationships with mathematics achievement and explained almost none of the variation, the U.S. had mixed results with the home-related variables. Two of the three home-related variables showed significant relationships with mathematics achievement, and they had much smaller coefficients than Chinese Taipei's, even considering the difference in mathematics achievement scores. Estimated coefficients of fixed effects for the singular home-related variables in each country are shown in Table 149.

Table 149

Estimation of Fixed Effects for Models 2-4 in Each Country

		Chinese Taipei		Ghana		U.S.	
Model	Parameter	Coefficient	*SE*	Coefficient	*SE*	Coefficient	*SE*
2	Intercept	611.70***	3.77	332.52***	6.30	513.09***	3.25
	Home possessions for learning	17.16***	1.12	-1.75	1.47	5.92***	0.79
3	Intercept	611.81***	3.86	333.40***	7.17	510.24***	3.30
	Parent education	23.95***	1.72	0.44	1.52	5.87***	0.80
4	Intercept	610.72***	4.28	334.01***	6.24	510.06***	3.46
	Parent expectations and involvement	6.74***	0.86	1.62	0.84	-0.64	0.45

Note. $*p < .05$, $**p < .01$, $***p < .001$

Model 5 in each country contained the combined statistically significant home-related predictors from Models 2-4. Model 5 for Ghana was omitted because not any of its home-related predictors had a statistically significant relationship with mathematics achievement. A pseudo R^2 was calculated for Model 5 in Chinese Taipei and the U.S. to estimate the proportional reduction in unexplained variance in the random parameters accounted for by the combination of home-related variables compared to Model 1, the unconditional model. Results of pseudo R^2 calculations are shown in Table 150. In Chinese Taipei, the combined home-related variables explained almost half of the total between-school variance. The large ratio of between-school variance in mathematics achievement explained by home-related variables indicates a high degree of differences in socioeconomics and parent education across schools in Chinese Taipei. Recall, however, that at the same time, Chinese Taipei's low variation of mathematics achievement between schools indicated a high degree of homogeneity in mathematics achievement across schools. Using the same reasoning, the very low ratio of both between- and within-school variances explaining home-related predictors in Ghana indicate a high degree of homogeneity of socioeconomic status and parent education both between schools and within schools.

In comparison, home-related variables in the U.S. explained about one sixth of the between-school variance in mathematics achievement, indicating that schools in the U.S. tend to serve more equitably distributed populations of students than those in Chinese Taipei. Within-school variance of home-related variables in the U.S. was remarkably low, indicating that within schools, only 5% of the variation in mathematics achievement was attributable to differences in home possessions and parent education. This, while less than 20% of the between-school variation in mathematics achievement was attributable to differences in home possessions and parent education.

Table 150

Comparison of Pseudo R^2 Between Model 5 and Model 1 in Each Country

		Chinese Taipei		Ghana		U.S.	
Model	Predictor	Between-School	Within-School	Between-School	Within-School	Between-School	Within-School
5	Combined home-related variables	.46	.12	--	--	.17	.05

Estimated coefficients of fixed effects for Model 5 in each country are shown in Table 151. In both Chinese Taipei and the U.S., all three home-related variables had statistically significant relationships with mathematics achievement. In general, home-related variables had a stronger relationship with mathematics achievement in Chinese Taipei than they did in the U.S. A perhaps surprising result, explained in Chapter 4 of this dissertation, is that parent expectations and involvement in the U.S. had a negative relationship with mathematics achievement in the presence of home possessions for learning and parent educational attainment.

Table 151

Estimation of Fixed Effects for Model 5 in Each Country

	Chinese Taipei		Ghana		U.S.	
Country	Estimate	*SE*	Estimate	*SE*	Estimate	*SE*
Intercept	612.90***	3.56	--	--	512.96***	3.14
Home possessions for learning	13.03***	1.12	--	--	5.82***	0.83
Parent education	16.37***	1.71	--	--	3.88***	0.92
Parent expectations and involvement	2.66**	0.86	--	--	-2.13***	0.50

Note. *$p < .05$, **$p < .01$, ***$p < .001$

Student-Beliefs Variables

The second research question in this dissertation is the extent to which student beliefs (self-confidence in mathematics and value of mathematics) predict eighth-grade mathematics achievement. Descriptive statistics for the student beliefs variables for each country are shown in Table 152. By far, students in Chinese Taipei expressed the lowest self-confidence in mathematics and value for mathematics. Students in Ghana expressed the greatest value for mathematics, and students in Ghana and the U.S. expressed about equal self-confidence in mathematics.

As described in previous sections, variables such as self-confidence in mathematics were scaled to have a mean of 10 and standard deviation of two. The variable value mathematics was not scaled with the same parameters. While it was scaled to have a mean of 10, the standard deviation is approximately 65, so the values in the scale have a much wider range, and the results are not as easily interpreted as or compared to the other variables in this study.

Countries in East Asia, such as China, Japan, South Korea, Singapore, and Chinese Taipei, are frequently grouped together in international studies of student achievement because they are typically the top performing countries in such studies, and they also tend to be similar in predictors of achievement (Hirabayashi, 2006; Mullis, Martin, Foy, et al., 2012). For example, students in Chinese Taipei, while having among the highest achievement of all countries, expressed less self-confidence in mathematics and value for mathematics than students in either Ghana or the U.S. These results are consistent with other studies which have reported students from high-performing countries in East Asia expressing low self confidence in mathematics and value for mathematics and students in low-performing countries, including Ghana and South Africa, reporting greater self-confidence in mathematics and value for mathematics (Shen & Tam, 2008; Yoshino, 2012). Shen and Tam suggested these differences in relationships between student beliefs and mathematics achievement may result from differences in curricula in countries and cultural and social contexts. For example, high-achieving countries have rigorous curricula, so students tend to think it is challenging. In addition, Yoshino suggested that students in high achieving countries, comparing themselves to other high-achieving students in their country, may feel less confident in mathematics.

Regarding the construct of value of mathematics, Hirabayashi (2006) reported that students in Japan express hate for mathematics as difficult, boring, and irrelevant to their lives. Hirabayashi explained that secondary school in Japan is valued primarily as preparation for passing entrance exams for university, and for students entering the sciences, mathematics is learned only for the entrance exam for the university science department, not for its educational quality. If a student's university studies are not in the sciences, mathematics is not on the entrance exam, so mathematics is seen as completely worthless. This is a possible explanation for students' low value for mathematics in Chinese Taipei. An undesirable result of this perception, according to Hirabayashi, is that the mathematics that is learned in secondary school is quickly forgotten, even among high achievers.

In contrast to Chinese Taipei, students in Ghana expressed a relatively high value for mathematics. This result is consistent with other recent studies of Ghanaian student attitudes, as well. Students across Ghana tend to have positive attitudes towards mathematics and see mathematics as a very important subject which will help them in their daily lives (Ampadu, 2009). In addition, students in Ghana consider mathematics among the most useful subjects for preparing for future work (Anamuah-Mensah, Asabere-Ameyaw, & Dennis, 2007).

Table 152

Descriptive Statistics for Student-Beliefs Variables in Each Country

	Chinese Taipei		Ghana		U.S.	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*
Self-confidence in mathematics	8.62	2.38	10.59	1.85	10.67	2.3
Value mathematics	-36.87	59.47	63.36	57.48	-2.23	58.89

Like the home-related variables, the percentage of variation attributable to the student beliefs variables, both between and within schools was much greater in Chinese Taipei than in either Ghana or the U.S., as shown in Table 153, with the lowest being in

Ghana. This means that all the student level variables in this study explained much more of the total variance in Chinese Taipei than in either Ghana or the U.S. Also, all the student level variables accounted for relatively little variance in mathematics achievement in Ghana, compared to either the U.S. or Chinese Taipei.

Table 153

Comparison of Pseudo R^2 *Between Models 6-7 and Model 1 in Each Country*

		Chinese Taipei		Ghana		U.S.	
Model	Predictor	Between-School	Within-School	Between-School	Within-School	Between-School	Within-School
6	Self-confidence in mathematics	.28	.29	.06	.10	.13	.22
7	Value mathematics	.19	.20	.04	.07	.04	.05

Both student beliefs variables of self-confidence in mathematics and value mathematics had statistically significant positive relationships with mathematics achievement in all three countries as shown in Table 154. The coefficients for the two variables were greatest for Chinese Taipei, indicating a greater increase in mathematics achievement for each unit of increase in both student beliefs scales. Chinese Taipei's students' relatively low values for student beliefs in regard to mathematics despite their high achievement was previously discussed. A possible explanation for the higher coefficient for estimations of fixed effects in Chinese Taipei is that even though students in Chinese Taipei have higher achievement in mathematics, their self-confidence is skewed by the other high achievers to whom they compare themselves. Likewise, as was previously discussed, students in Chinese Taipei have reason, such as preparing for competitive university entrance, for their expressed low affective value of mathematics.

Because of their greater achievement in mathematics, the coefficient for student beliefs variables are higher than other countries that have lower achievement but higher levels of student beliefs. In Ghana, with the lowest mathematics achievement of all 42 countries who participated in the TIMSS 2011, the coefficients of both student belief variables were higher than those in the U.S. So, in the U.S., student beliefs had less effect on student achievement than in either Chinese Taipei or Ghana.

Table 154

Estimation of Fixed Effects for Models 6-7 in Each Country

		Chinese Taipei		Ghana		U.S.	
Model	Parameter	Coefficient	*SE*	Coefficient	*SE*	Coefficient	*SE*
6	Intercept	611.61***	3.80	334.91***	6.07	512.88***	3.31
	Self-confidence in mathematics	21.49***	0.65	11.82***	0.75	10.24***	0.41
7	Intercept	610.86***	4.05	334.76***	6.16	512.24***	3.47
	Value mathematics	0.71***	0.03	0.29***	0.02	0.19***	0.02

Note. $*p < .05$, $**p < .01$, $***p < .001$

Model 8 in each country contained the combined student belief variables. A pseudo R^2 was calculated for Model 8 in each country to estimate the proportional reduction in unexplained variance in the random parameters accounted for by the combination of student-beliefs variables compared to Model 1. Results of pseudo R^2 calculations are shown in Table 155. Student beliefs accounted for almost one third of Chinese Taipei's both between-school and within-school variation, by far the greatest ratios of all three countries. Possible explanations for this were discussed in the previous two sections. Very little of Ghana's variation in mathematics achievement, either between schools or within school is explained by student beliefs variables. Student beliefs about mathematics in the U.S. accounted for a little more variation, both between- and within-schools, than in Ghana.

Table 155

Comparison of Pseudo R^2 Between Model 8 and Model 1 in Each Country

		Chinese Taipei		Ghana		U.S.	
Model	Predictor	Between-School	Within-School	Between-School	Within-School	Between-School	Within-School
8	Combined student-beliefs variables	.30	.32	.07	.12	.14	.23

Considering the mathematics achievement in each country, the comparison of estimated coefficients of fixed effects for the combined student beliefs model, shown in Table 156, shows nothing unexpected except perhaps the negative coefficient in the U.S. for value mathematics in the presence of self-confidence in mathematics. Possible explanations for this negative coefficient were discussed in chapter 4 of this dissertation.

Table 156

Estimation of Fixed Effects for Model 8 in Each Country

	Chinese Taipei		Ghana		U.S.	
Country	Estimate	*SE*	Estimate	*SE*	Estimate	*SE*
Intercept	612.90***	3.56	335.27***	6.06	512.91***	3.31
Self-confidence in mathematics	17.96***	0.85	9.51***	0.85	11.28***	0.45
Value mathematics	0.22***	0.04	0.14***	0.03	-0.07***	0.02

Note. *$p < .05$, **$p < .01$, ***$p < .001$

Combined Level-1 Variables

Model 9 in each country was the combined statistically significant student-level variables from previous models. A comparison of pseudo R^2 between this model and

Model 1, shown in Table 157, shows that student-level variables in this study account for more than half of the between-school variance in mathematics achievement in Chinese Taipei, and more than one-third of the within-school variance. To keep these ratios of variance in perspective, it should be kept in mind that only 22% of total variance in Chinese Taipei was between schools, while the between-school variances for both Ghana and the U.S. were closer to 50%. In comparison to combined student-level variables accounting for more than half of the between-school variance in Chinese Taipei, they accounted for about one fourth of the between-school variance in the U.S., and less than one tenth of the between-school variance in Ghana. Interestingly, student beliefs variables explained a greater percentage of within-school variance than the between-school variance in the U.S., indicating more homogeneity within schools related to student-level predictors than between schools.

Table 157

Comparison of Pseudo R^2 between Model 9 and Model 1 in Each Country

		Chinese Taipei		Ghana		U.S.	
Model	Predictor	Between-School	Within-School	Between-School	Within-School	Between-School	Within-School
9	Combined Level 1 variables	.56	.38	.07	.12	.26	.28

Table 158 shows the estimated coefficients of fixed effects for the combined student-level model in each country. In Chinese Taipei, all the student-level variables remained statistically significant in the combined model except parent expectations and involvement. In Ghana, Model 9 was equivalent with Model 8 because it included only combined student beliefs and no home-related variables based on results of the previous models. In the U.S. all the combined student-level variables had statistically significant relationships with mathematics achievement; however, two of those variables, parent expectations and involvement and value mathematics, were negatively related to mathematics achievement in the presence of the other variables. This means that across the three countries, parent expectations and involvement either did not have a statistically significant relationship with mathematics achievement or it had a negative relationship with mathematics achievement in the presence of the other student-level variables in this study. Proportionally, the greatest differences in estimated coefficients between Chinese Taipei and the U.S. (with their Model 9s containing all five student-level variables) were in parent education and value mathematics; that is, those two variables had several times more predictive power for mathematics achievement in Chinese Taipei than they did in the U.S.

Table 158

Estimation of Fixed Effects for Model 9 in Each Country

	Chinese Taipei		Ghana		U.S.	
Country	Estimate	*SE*	Estimate	*SE*	Estimate	*SE*
Intercept	613.96***	3.17	335.27***	6.06	513.57***	2.98
Home possessions for learning	9.79***	1.05	--	--	4.97***	0.82
Parent education	12.11***	1.48	--	--	2.40**	0.86
Parent expectations and involvement	-0.62	0.68	--	--	-3.12***	0.47
Self-confidence in mathematics	16.62***	0.84	9.51***	0.85	10.98***	0.43
Value mathematics	0.19***	0.04	0.14***	0.03	-0.05**	0.02

Note. $^*p < .05$, $^{**}p < .01$, $^{***}p < .001$

Model 9 in each country is important because each country's models using the 21 school-level variables are entered into that country's Model 9, which accounts for the student-level variables in that country. The cross-country comparisons of the school-level models will be discussed in the next section.

School-Related Variables

The third research question for each country in this dissertation is the extent to which school-related variables in the domains of school climate, school resources, administrator leadership, and school socioeconomic status predict eighth-grade mathematics achievement. School, teacher, and classroom variables are all treated as Level 2 variables in this dissertation study. Although generally, classes and teachers are nested in schools, yielding two different levels in multilevel analyses, most countries in the TIMSS 2011 selected one intact class per school so that variables associated with schools and teachers can both be treated at level two in multilevel analyses.

Descriptive statistics for all the school-related variables in this study are shown in Table 159. All variables were scaled to have a mean of 10 and standard deviation of two except for computer availability for instruction and students economically disadvantaged, because the original scales for those two variables were easily interpretable.

The three school climate variables were school emphasis on academic success from both teacher and principal reports and school discipline and safety. Although the differences in the scale means across all three countries were not great, Chinese Taipei had the highest values for all three school climate variables.

The domain of school resources was represented by three variables. The computer availability for instruction scale was coded so that higher values indicate more students per computer at the school, which also equates to fewer computers per student. Comparing across countries, the U.S. had the greatest computer availability per student, followed by Ghana, and then Chinese Taipei. That means that Chinese Taipei, the country in this study with the highest mathematics achievement, has the smallest ratio of computers available per student of the three countries. The U.S. also had the highest mean on the resources for general instruction scale. Chinese Taipei had the highest value for the remaining variable, resources for mathematics instruction. Ghana had the lowest mean of resources for general instruction and resources for mathematics instruction, and it had the middle value for computer availability for instruction.

The two variables representing school socioeconomic status may hold the biggest surprises of the school-related descriptive statistics. While it is likely no surprise that Ghana had the highest value on the students economically disadvantaged scale, it may be surprising that Chinese Taipei has the lowest value on the students economically disadvantaged scale. This finding prompted an examination of the two questions making up the students economically disadvantaged scale in Tables C65 and C66 to help explain the results. The two questions asked of school administrators, “Approximately what percentage of students in your school come from economically disadvantaged homes,” and “Approximately what percentage of students in your school come from economically affluent homes,” might be biased across schools and cultures. At the same time, schools in Chinese Taipei reported the highest value for a shortage of home resources limiting teaching, and Ghana reported the lowest value. Like the questionnaire items comprising the school socioeconomic status scale, the questionnaire items comprising the home resources limiting teaching scale, shown in Tables C68-C71 in Appendix C, might be biased across schools and cultures.

Table 159

Descriptive Statistics for School-Related Variables in Each Country

	Chinese Taipei		Ghana		U.S.	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*
School emphasis on academic achievement-teachers	10.93	1.81	10.68	1.83	10.64	2.17
School emphasis on academic achievement-principals	11.41	1.51	10.17	1.77	10.94	1.99
School discipline and safety	11.46	1.7	10.15	1.39	10.06	1.41
Computer availability for instruction	2.7	0.59	2.03	1.11	1.47	0.63
Resources for general instruction	10.39	2.11	9.04	1.05	11.08	1.95
Resources for mathematics instruction	10.11	1.89	9.44	2.18	9.6	1.89
Administrator leadership	9.5	1.89	10.28	1.91	9.83	1.92
Students economically disadvantaged	1.97	0.57	2.74	0.58	2.43	0.78
Home resources limiting teaching	10.48	1.79	9.86	1.69	10.26	1.54

Models 10-13 were the school climate models, with each of the three variables entered into Model 9 which accounted for student-level variables for that country. A comparison of pseudo R^2 between these models and Model 9, shown in Table 160, shows that the percentage of variation between schools attributable to the school climate variables was much less in Chinese Taipei than in either Ghana or the U.S. In fact, Models 10-12, in which each school climate variable was entered separately into Model 9, actually increased the between-school variance in Chinese Taipei. In comparison, school climate variables reduced the between-school variance by the greatest percentage in the U.S. and slightly less in Ghana.

Table 160

Comparison of Pseudo R^2 Between Models 10-13 and Model 9 in Each Country

		Chinese Taipei		Ghana		U.S.	
Model	Predictor	Between-School	Within-School	Between-School	Within-School	Between-School	Within-School
10	Emphasis on academic success - teachers	-.06	.03	.09	.00	.15	.00
11	Emphasis on academic success - principals	-.04	.03	.07	.00	.16	.00
12	School discipline and safety	-.36	.03	.11	.00	.12	.00
13	Combined school climate	.10	.03	.17	.00	.18	.00

Estimated coefficients of fixed effects for Models 10-13 in each country are shown in Table 161. All three singular school climate variables had statistically significant positive relationships with mathematics achievement in all three countries in Models 10-12, except for school discipline and safety in Chinese Taipei. In Model, 13, the combined school climate model, a different set of school climate variables had statistically significant relationships with mathematics across the three countries—school emphasis on academic success from both teacher and principal reports in Chinese Taipei, school emphasis on academic success - teacher reports and school discipline and safety in Ghana, and only school emphasis on academic success - principal reports in the U.S. Because the school climate variables increased between-school variance in Chinese Taipei and decreased between-school variance in Ghana and the U.S., it might be surprising that the fixed effects coefficients of the combined school climate variables in Model 13 had stronger relationships with mathematics achievement in Chinese Taipei than they did in either Ghana or the U.S. A possible explanation for this is the smaller standard error of the estimates in Chinese Taipei.

Table 161

Estimation of Fixed Effects for Models 10-13 in Each Country

		Chinese Taipei		Ghana		U.S.	
Model	Parameter	Coefficient	*SE*	Coefficient	*SE*	Coefficient	*SE*
10	Intercept	607.61***	3.23	334.79***	5.89	509.42***	3.49
	Emphasis on academic success - teachers	8.99***	1.86	10.25***	3.03	4.37***	1.23
11	Intercept	609.67***	3.27	337.36***	5.95	509.99***	3.60
	Emphasis on academic success - principals	8.65***	1.54	9.18**	3.22	6.68***	1.65
12	Intercept	605.42***	3.52	335.35***	5.84	508.55***	3.76
	School discipline and safety	-2.55	2.01	13.72***	3.95	5.43**	1.99
13	Intercept	610.19***	3.09	334.87***	5.71	509.35***	5.38
	Emphasis on academic success - teachers	6.43***	1.93	7.28*	3.53	2.22	2.08
	Emphasis on academic success - principals	6.59***	1.65	1.27	4.12	5.46**	3.28
	School discipline and safety	--	--	10.55*	4.35	0.82	2.51

Note. $*p < .05$, $**p < .01$, $***p < .001$

Models 14-16 were the school resources models, with each of the three variables entered into Model 9 which accounted for student-level variables for that country. A comparison of pseudo R^2 between Models 14-16 and Model 9, shown in Table 162, shows that the school resources variables increased the between-school variance in Chinese Taipei even more than the school climate variables did, each between 35% and 39%. In Ghana, the school resource variables explained very little of the between-school variance, and they reduced the between-school variance in the U.S. by 11-13%.

Table 162

Comparison of Pseudo R^2 Between Models 14-16 and Model 9 in Each Country

		Chinese Taipei		Ghana		U.S.	
Model	Predictor	Between-School	Within-School	Between-School	Within-School	Between-School	Within-School
14	Computer availability for instruction	-.39	.03	-.02	.00	.11	.00
15	Resources for general instruction	-.35	.03	.03	.00	.11	.00
16	Resources for mathematics instruction	-.39	.03	-.03	.00	.13	.00

Estimated coefficients of fixed effects for Models 14-16 in each country are shown in Table 163. The domain of school resources was investigated with three variables in this study. Each country in this study had a different school resources variable that had a statistically significant relationship with its mathematics achievement. In Chinese Taipei, that variable was computer availability for instruction; however, it was fewer computers per student available for instruction that predicted increased mathematics in Chinese Taipei, not more computers. In Ghana, the school resources variable that had a statistically significant relationship with mathematics achievement was resources for general instruction, while in the U.S., the school resources variable that had a statistically significant relationship with mathematics achievement was resources for mathematics instruction. A possible explanation for the statistical significance of only resources for general instruction in Ghana is its relatively low national income per capita (Mullis, Martin, Minnich, et al., 2012).

Table 163

Estimation of Fixed Effects for Models 14-16 in Each Country

		Chinese Taipei		Ghana		U.S.	
Model	Parameter	Coefficient	*SE*	Coefficient	*SE*	Coefficient	*SE*
14	Intercept	610.76***	3.51	335.97***	6.17	510.88***	5.38
	Computer availability for instruction	11.13**	1.68	-3.60	5.34	3.41	2.08
15	Intercept	605.61***	3.66	336.10***	6.06	510.27***	3.66
	Resources for general instruction	2.15	1.38	0.18*	1.38	0.18	1.38
16	Intercept	605.55***	3.55	335.69***	6.23	511.02***	3.53
	Resources for mathematics instruction	-0.97	1.76	-1.73	2.55	-3.47*	1.41

Note. $*p < .05$, $**p < .01$, $***p < .001$

School administrator leadership was measured with a singular variable in Model 18. School administrator leadership did not have a statistically significant relationship with mathematics achievement in any of the three countries in this study.

One possible explanation for this variable not having a statistically significant relationship with mathematics achievement may be found in the wording of the questions and the answer options in the school administrator questionnaire. Five items from the school questionnaire were found through principal components analysis in this study to measure one construct categorized as administrator leadership. The five items asked school administrators approximately how much time during the past year they spent in their role as school principal keeping an orderly atmosphere in the school, ensuring that there are clear rules for student behavior, addressing disruptive student behavior, creating a climate of trust among teachers, and participating in professional development activities specifically for school principals. The three answer options for each of the five questions were no time, some time, and a lot of time. If an administrator spends a lot of time keeping an orderly atmosphere in the school or addressing disruptive student behavior, does that indicate that the school climate is poor because the administrator is spending time reacting to climate problems in the school, or does it indicate the school climate is good because the administrator spends a lot of time in those activities to prevent problems? Perhaps administrator leadership does in reality have a significant relationship with mathematics achievement in the countries in this study, and revision of the items and answer options in the school questionnaire might elicit more of that relationship.

Table 164

Comparison of Pseudo R^2 Between Model 18 and Model 9 in Each Country

		Chinese Taipei		Ghana		U.S.	
Model	Predictor	Between-School	Within-School	Between-School	Within-School	Between-School	Within-School
18	Administrator leadership	-.39	.03	-.02	.00	.11	.00

Models 19-20 were the school socioeconomic status models, with each of the two variables entered into Model 9 which accounted for student-level variables for that country. A comparison of pseudo R^2 between these models and Model 9, shown in Table 165, shows that the percentage of variation between schools attributable to school socioeconomic status was much less in Chinese Taipei than in either Ghana or the U.S. Possible explanations for these differences were discussed in Chapter 4 of this dissertation.

Table 165

Comparison of Pseudo R^2 Between Models 19-21 and Model 9 in Each Country

		Chinese Taipei		Ghana		U.S.	
Model	Predictor	Between-School	Within-School	Between-School	Within-School	Between-School	Within-School
19	Students economically disadvantaged	-.04	.03	.06	.00	.16	.00
20	Home resources limiting teaching	-.27	.03	.17	.00	.14	.00
21	Combined school socioeconomic status	.06	.03	.24	.00	.24	.00

Estimated coefficients of fixed effects for Models 19-21 in each country are shown in Table 166. Both variables measuring school socioeconomic status had statistically significant relationships with mathematics achievement in all three countries in this study. The domain of school socioeconomic status had the strongest overall relationship with mathematics achievement of all the variables in this study across all three countries, and school socioeconomic status was the only school-level domain in which all the variables contained in the domain were statistically significant across all three countries.

Table 166

Estimation of Fixed Effects for Models 19-21 in Each Country

		Chinese Taipei		Ghana		U.S.	
Model	Parameter	Coefficient	*SE*	Coefficient	*SE*	Coefficient	*SE*
19	Intercept	608.75***	3.20	336.98***	5.98	510.02***	3.62
	Students economically disadvantaged	-26.88***	4.64	-26.85**	5.47	-16.28**	5.47
20	Intercept	605.55***	3.42	335.67***	2.97	512.39***	2.97
	Home resources limiting teaching	-4.22*	1.98	-13.29***	3.10	-11.71***	1.81
21	Intercept	608.87***	3.08	336.60***	5.48	510.21***	3.40
	Students economically disadvantaged	-26.89***	4.58	-24.31**	9.52	-8.91***	1.99
	Home resources limiting teaching	-4.16*	1.73	-12.77***	3.01	-11.28*	3.70

Note. *$p < .05$, **$p < .01$, ***$p < .001$

Model 22 was the combined school-related variables model, with each of the statistically significant school-related variables from Models 10-20 entered into Model 9 which accounted for student-level variables for that country. A comparison of pseudo R^2 between these models and Model 9, shown in Table 167, shows that about one third of the variation between schools in Ghana was attributable to the combined school variables after accounting for student-level variables. About one fourth of the variation between schools in Chinese Taipei and the U.S. was attributable to the combined school variables after accounting for student-level variables.

Table 167

Comparison of Pseudo R^2 Between Model 22 and Model 9 in Each Country

		Chinese Taipei		Ghana		U.S.	
Model	Predictor	Between-School	Within-School	Between-School	Within-School	Between-School	Within-School
22	Combined school-related variables	.26	.03	.32	.00	.26	.00

Estimated coefficients of fixed effects for Model 22, the combined school-related variables in each country, are shown in Table 168. Two of the school climate variables, school emphasis on academic success from both teacher and principal reports, had statistically significant relationships with mathematics achievement in Chinese Taipei. The other of the three school climate variables, school discipline and safety, was the only one of three school climate variables with a statistically significant relationship with mathematics achievement in Ghana. In the U.S., the only school climate variable with a statistically significant relationship with mathematics achievement in the combined school-related variables model was school emphasis on academic success – principals report.

Shortage of resources in mathematics instruction was the only one of the three school resources variables in the combined school-related variables model to have a statistically significant relationship with mathematics achievement in the combined school-related variables model, and that was only in the U.S. Among the school socioeconomic status variables in the combined school-related variables model, each of the three countries had exactly one of the two variables to have a statistically significant relationship with mathematics achievement in the presence of the other school-related variables. Consistent with the relationships between other home-related variables and mathematics achievement in Chinese Taipei, the statistically significant school socioeconomic status variable was students economically disadvantaged rather than home resources limiting teaching in Chinese Taipei. In contrast, the statistically significant school socioeconomic status variable in Ghana and the U.S. was home resources limiting teaching rather than students economically disadvantaged.

Table 168

Estimation of Fixed Effects for Model 22 in Each Country

	Chinese Taipei		Ghana		U.S.	
Parameter	Coefficient	*SE*	Coefficient	*SE*	Coefficient	*SE*
Intercept	612.98***	3.24	335.56***	5.24	510.70***	3.45
Academic success-teachers	4.34*	1.92	3.97	3.02	--	--
Academic success-principals	4.57**	1.73	--	--	3.76*	1.82
Discipline and safety	--	--	8.80*	3.69	--	--
Computer availability for instruction	4.22	3.69	--	--	--	--
Shortage of resources for general instruction	--	--	-5.12	4.79	--	--
Shortage of resources for mathematics instruction	--	--	--	--	-2.97*	1.36
Students economically disadvantaged	-17.69***	4.63	-15.75	9.61	-7.95	4.22
Home resources limiting teaching	-2.65	1.63	-10.09***	2.96	-8.75***	2.15

Note. *$p < .05$, **$p < .01$, ***$p < .001$

Teacher-Related Variables

The fourth research question for each country in this dissertation is the extent to which teacher- or classroom-related variables in the domains of access and equity, curriculum, tools and technology, classroom assessment, and teacher professionalism predict eighth-grade mathematics achievement. Descriptive statistics for all the teacher-related variables in this study are shown in Table 169. All variables were scaled to have a mean of 10 and standard deviation of two except for hours per year of mathematics instruction and teacher education, because the original scales for those two variables were easily interpretable. The U.S. had the fewest mean hours of mathematics instruction per year of the three countries. Hours of mathematics instruction per year in Chinese Taipei and Ghana were within five hours of each other; however, Chinese Taipei's hours had a much smaller standard deviation than Ghana's. It should be kept in mind that Chinese Taipei had the third highest eighth-grade mathematics achievement of the 42 countries that participated in the TIMSS 2011, and Ghana had the lowest. Chinese Taipei, with a national curriculum that is arguably the most rigorous and strictly enforced of the curricula of the countries in this study, also had the highest value of the three countries in this study on the mathematics topics taught scale. Furthermore, Chinese Taipei had the lowest values on the instruction to engage students and research-based instruction scales. There was little difference in mean values across the three countries in the two variables measuring classroom assessment.

Among the six variables measuring teacher professionalism, the greatest differences across the three countries were in teacher collaboration, teacher experience, teacher preparation, and teacher self-efficacy. Perhaps surprisingly, Chinese Taipei had the lowest values on the teacher collaboration scale, and Ghana had the highest. Teachers in Ghana reported approximately half the years of teaching experience with seven years compared to teachers in Chinese Taipei and the U.S. who each reported having a mean of 14 years of experience. Finally, regarding the variable self-efficacy in teaching mathematics, teachers in Chinese Taipei had the lowest values on the scale, and teachers in Ghana had the highest values on the scale. These relationships are in the same order for each country as the students' self-confidence in mathematics scale.

Table 169

Descriptive Statistics for Teacher-Related Variables in Each Country

	Chinese Taipei		Ghana		U.S.	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*
Mathematics hours per year	167.86	30.79	164.57	79.84	155.81	59.5
Mathematics topics taught	12.78	1.29	9.48	1.41	9.79	1.44
Textbooks or workbooks for instruction	11.69	1.69	9.75	2.36	9.36	1.88
Tools or technology for instruction	9.4	1.61	9.58	1.66	10.59	2.26
Instruction to engage students	8.39	2.55	10.8	1.51	10.9	1.48
Research-based instruction	8.71	1.81	10.32	1.96	10.04	1.76
Classroom assessment question types	9.72	2.06	9.82	1.9	9.85	2.19
Classroom emphasis on assessment	9.11	2.14	10.5	2.01	9.69	1.77
Professional development	9.81	1.74	9.95	2.16	10.8	1.87
Professional collaboration	8.79	2.06	10.26	2.21	9.98	2.48
Teacher experience	13.87	8.22	7.13	6.27	13.9	9.56
Teacher education	1.96	1.09	2.69	1.41	2.47	1.18
Teacher preparation	8.28	1.56	10.33	1.82	10.84	1.76
Teacher self-efficacy	9.43	2.02	11.26	1.33	10.49	1.69

Models 23 and 24 were the classroom access and equity models, with each of the two variables entered into Model 9 which accounted for student-level variables for that country. A comparison of pseudo R^2 between these models and Model 9, shown in Table 170, shows that the percentage of variation between schools attributable to the access and equity variables was overall less in Ghana than in either Chinese Taipei or the U.S. Mathematics instructional hours per year decreased between-school variation in only Chinese Taipei, and mathematics topics taught reduced between-school variation by far the greatest percentage in the U.S. compared to Chinese Taipei and Ghana.

Table 170

Comparison of Pseudo R^2 Between Models 23-24 and Model 9 in Each Country

		Chinese Taipei		Ghana		U.S.	
Model	Predictor	Between-School	Within-School	Between-School	Within-School	Between-School	Within-School
23	Mathematics instructional hours per year	.06	.00	.00	.00	.00	.00
24	Mathematics topics taught	.03	.00	.04	.00	.13	.00

Estimated coefficients of fixed effects for Models 23 and 24 in each country are shown in Table 171. Mathematics instructional hours per year had a statistically significant relationship with mathematics achievement in only Chinese Taipei; however, the coefficient is so small that reasonable differences in the mathematics instructional hours per year would yield negligible changes in achievement scores. In the U.S., although mathematics instructional hours per year did not have a statistically significant relationship with mathematics, mathematics topics taught did and with a large coefficient. Both Chinese Taipei and Ghana have national standards for both instructional hours per year and mathematics curricula. The U.S. does not. This is a possible explanation for the respective similarities and differences in relationships between the access and equity variables and mathematics achievement across the three countries.

Table 171

Estimation of Fixed Effects for Models 23-24 in Each Country

		Chinese Taipei		Ghana		U.S.	
Model	Parameter	Coefficient	*SE*	Coefficient	*SE*	Coefficient	*SE*
23	Intercept	614.22***	3.10	334.59***	6.08	512.63***	3.13
	Mathematics Instructional Hours Per Year	0.23*	0.10	0.09	0.08	-0.10	0.05
24	Intercept	613.82***	3.14	335.28***	5.96	513.99***	2.94
	Mathematics Topics Taught	2.96	2.37	6.84	4.31	11.25***	2.26

Note. *$p < .05$, **$p < .01$, ***$p < .001$

Models 26 and 27 contained the curriculum variables, with each of the two variables entered singularly into Model 9 which accounted for student-level variables for that country. A comparison of pseudo R^2 between these models and Model 9, shown in Table 172, shows that the percentage of variation between schools attributable to the classroom curriculum variables, while still very little, was greater overall in Ghana than in either Chinese Taipei or the U.S.

Table 172

Comparison of Pseudo R^2 Between Models 26-27 and Model 9 in Each Country

		Chinese Taipei		Ghana		U.S.	
Model	Predictor	Between-School	Within-School	Between-School	Within-School	Between-School	Within-School
26	Instruction to engage students	.02	.00	.04	.00	.00	.00
27	Research-based practices	.00	.00	.01	.00	.00	.00

Estimated coefficients of fixed effects for Models 23 and 24 in each country are shown in Table 173. Neither of the two curriculum/instruction variables had a statistically significant relationship with mathematics in any of the three countries. Visual examination of the items comprising both of the scales reveals that the questions comprising both variables may elicit biased responses from teachers about their practices. In addition, the responses measure frequency of use of the teaching practices and not quality of the practices.

Table 173

Estimation of Fixed Effects for Models 26-27 in Each Country

		Chinese Taipei		Ghana		U.S.	
Model	Parameter	Coefficient	*SE*	Coefficient	*SE*	Coefficient	*SE*
26	Intercept	613.68***	3.14	334.89***	5.97	512.70***	3.12
	Instruction to engage students	1.89	1.10	-6.30	3.71	0.41	1.98
27	Intercept	613.80***	3.17	335.21***	6.05	512.70***	3.12
	Research-based practices	-0.07	1.62	-2.58	0.03	-0.76	1.64

Note. *$p < .05$, **$p < .01$, ***$p < .001$

Models 29 and 30 were the classroom assessment models, with each of the two variables entered into Model 9 which accounted for student-level variables for that country. A comparison of pseudo R^2 between these models and Model 9, shown in Table 174, shows that the percentage of variation between schools attributable to the classroom assessment variables was overall greater in Chinese Taipei than in either Ghana or the U.S.

Table 174

Comparison of Pseudo R^2 Between Models 29-30 and Model 9 in Each Country

		Chinese Taipei		Ghana		U.S.	
Model	Predictor	Between-School	Within-School	Between-School	Within-School	Between-School	Within-School
29	Assessment question types	.05	.00	.02	.00	.00	.00
30	Class emphasis on assessment	.01	.00	.00	.00	.01	.00

Estimated coefficients of fixed effects for Models 29 and 30 in each country are shown in Table 175. In Chinese Taipei, only assessment question types had a statistically significant relationship with mathematics achievement. A visual examination of the items that comprise the assessment question types scale indicates that teachers' increased use of explanations or justifications in their mathematics tests was associated with higher mathematics achievement. At the same time, teachers' decreased use of applications of mathematical procedures in their mathematics tests was associated with higher mathematics achievement.

In the U.S., only class emphasis on assessment had a statistically significant relationship with mathematics achievement, and that relationship was negative. A visual examination of the items that comprise the class emphasis on assessment scale indicates that some emphasis on assessment, rather than no emphasis or major emphasis, is associated with higher eighth-grade mathematics achievement in the U.S. Neither of the assessment variables in Ghana had a statistically significant relationship with mathematics achievement.

Table 175

Estimation of Fixed Effects for Models 29-30 in Each Country

		Chinese Taipei		Ghana		U.S.	
Model	Parameter	Coefficient	*SE*	Coefficient	*SE*	Coefficient	*SE*
29	Intercept	613.98***	3.11	334.47***	6.02	512.75***	3.12
	Assessment question types	3.11*	1.35	-3.24	2.92	1.21	1.32
30	Intercept	613.82***	3.16	335.11***	6.08	512.57***	3.11
	Class emphasis on assessment	0.79	1.36	-1.86	2.81	-3.22*	1.66

Note. **p* < .05, ***p* < .01, ****p* < .001

Models 32-38 were the teacher professionalism models, with each of the six variables entered singularly into Model 9 which accounted for student-level variables for that country. A comparison of pseudo R^2 between these models and Model 9, shown in Table 176, shows that the percentage of variation between schools attributable to the teacher professionalism variables was virtually negligible across all three countries.

Table 176

Comparison of Pseudo R^2 Between Models 32-38 and Model 9 in Each Country

		Chinese Taipei		Ghana		U.S.	
Model	Predictor	Between-School	Within-School	Between-School	Within-School	Between-School	Within-School
32	Professional development	.00	.00	.00	.00	.01	.00
33	Professional collaboration	.00	.00	.02	.00	.00	.00
34	Teacher experience	.03	.00	.02	.00	.01	.00
35	Teacher knowledge	.02	.00	.05	.00	.00	.00
36	Teacher preparation	.01	.00	.00	.00	.00	.00
37	Teacher efficacy	.03	.00	.02	.00	.00	.00
38	Combined teacher professionalism	--	--	--	--	.03	.00

Estimated coefficients of fixed effects for Models 32-38 in each country are shown in Table 177. In Models 32-37, the models in which each teacher professionalism variable was entered singularly, not any of the variables had a statistically significant relationship with mathematics achievement in either Chinese Taipei or Ghana. Therefore, Model 38, the combined teacher professionalism model, was created for only the U.S. with the two statistically significant variables from Models 32-37, professional development and teacher experience. The estimated coefficient for teacher experience in the U.S. was so small that a one-year increase in teacher experience would be predicted to yield less than one-point increase in mathematics achievement. The estimated coefficient for professional development in the U.S. indicated a negative relationship with mathematics achievement. This perhaps surprising relationship was discussed in Chapter 4, that U.S. mathematics scores decreased with teachers' positive responses to attending professional development for every topic except for professional development related to mathematics, in which case mathematics scores increased with teachers' positive responses.

Table 177

Estimation of Fixed Effects for Models 32-38 in Each Country

		Chinese Taipei		Ghana		U.S.	
Model	Parameter	Coefficient	*SE*	Coefficient	*SE*	Coefficient	*SE*
32	Intercept	613.77***	3.16	334.64***	6.06	512.78***	3.12
	Professional development	1.14	1.67	0.49	2.62	-4.32**	1.51
33	Intercept	613.70***	3.16	334.33***	6.06	512.63***	3.13
	Professional collaboration	1.09	1.40	-4.50	2.70	-1.34	1.15
34	Intercept	614.01***	3.15	335.31***	6.03	512.53***	3.11
	Teacher experience	0.56	0.35	1.26	1.08	0.67*	0.28
35	Intercept	613.64***	3.16	334.55***	5.94	512.74***	3.12
	Teacher knowledge	-4.39	2.66	6.48	4.11	-2.02	0.59
36	Intercept	613.80***	3.16	334.72***	6.06	512.69***	3.61
	Teacher preparation	0.98	1.84	0.74	3.05	-0.38	1.80
37	Intercept	613.77***	3.14	334.37***	7.08	512.70***	3.12
	Teacher self-efficacy	1.62	1.46	-3.87	0.94	0.68	1.65
38	Intercept	--	--	--	--	512.63***	3.11
	Professional development	--	--	--	--	-4.17**	1.50
	Teacher experience	--	--	--	--	0.64*	0.28

Note. $*p < .05$, $**p < .01$, $***p < .001$

Model 39 was the combined teacher-related variables model in each country, with the teacher-related variables that were found to have a statistically significant relationship with mathematics in Models 23-38 entered into Model 9 which accounted for student-level variables for that country. A comparison of pseudo R^2 between these models and Model 9, shown in Table 178, shows that the percentage of variation between schools attributable to the combined teacher-related variables in the U.S, about 18%, was greater than in Chinese Taipei, about 11%. Ghana did not have a Model 39 because not any of the teacher-related variables had a statistically significant relationship with mathematics achievement in Ghana.

Table 178

Comparison of Pseudo R^2 Between Model 39 and Model 9 in Each Country

		Chinese Taipei		Ghana		U.S.	
Model	Predictor	Between-School	Within-School	Between-School	Within-School	Between-School	Within-School
39	Combined teacher variables	.11	.00	--	--	.18	.00

Estimated coefficients of fixed effects for Model 39 in Chinese Taipei and the U.S. are shown in Table 179. The combined teacher-related variables models for Chinese Taipei and the U.S. had no variables common between them. Chinese Taipei's teacher-related variables model was composed of mathematical instructional hours per year and assessment question types, and both of those variables, in combination, had statistically significant relationships with eighth-grade mathematics achievement. The coefficient for mathematics instructional hours per year indicates that for students with mean values for all the other variables present in that model, an increase of approximately five additional hours per year of mathematics instruction is predicted to increase their mathematics scores by one point.

The combined teacher-related variables model in the U.S. was composed of mathematics topics taught, class emphasis on assessment, professional development, and teacher experience. Mathematics topics taught, class emphasis on assessment, and professional development had statistically significant relationships with eighth-grade mathematics achievement in that combination, but teacher experience did not.

Table 179

Estimation of Fixed Effects for Model 39 in Each Country

	Chinese Taipei		Ghana		U.S.	
Country	Estimate	*SE*	Estimate	*SE*	Estimate	*SE*
Intercept	614.40***	3.04	--	--	513.86***	2.90
Mathematics instructional hours per year	0.22*	0.09	--	--	--	--
Mathematics topics taught	--	--	--	--	11.44***	2.26
Assessment question types	2.94*	1.32	--	--	--	--
Class emphasis on assessment	--	--	--	--	-3.39*	1.59
Professional development	--	--	--	--	-3.48*	1.42
Teacher experience	--	--	--	--	0.45	0.26

Note. $*p < .05$, $**p < .01$, $***p < .001$

Final Models

Model 40 was the final model in each country, with the statistically significant school- and teacher-related variables entered into Model 9 which accounted for student-level variables for that country. A comparison of pseudo R^2 between Model 40 and Model 9, shown in Table 180, shows that the percentage of variation between schools attributable to the school- and teacher-related variables was about 25% in both Chinese Taipei and Ghana, and about 30% in the U.S. after accounting for the student-level variables.

Table 180

Comparison of Pseudo R^2 Between Model 40 and Model 9 in Each Country

		Chinese Taipei		Ghana		U.S.	
Model	Predictor	Between-School	Within-School	Between-School	Within-School	Between-School	Within-School
40	Full model	.24	.03	.25	.00	.31	.00

Estimated coefficients of fixed effects for Model 40 in each country are shown in Table 181. The only variables that were in Model 40 in all three countries were the two student beliefs variables, and they both remained strong predictors of eighth-grade mathematics achievement in combination with the other variables in each country. Value mathematics had a negative relationship with mathematics achievement in the U.S., however. Possible explanations for this were discussed in Chapter 4 of this dissertation.

Among the home-related variables, all three had statistically significant relationships with mathematics achievement in the U.S. final model. Home possessions for learning and parent education had statistically significant relationships with mathematics achievement in Chinese Taipei, while parent expectations and involvement did not. Ghana had no home-related variables in its final model.

Among the school-related variables, the three countries had few statistically significant variables in common in their final models except for the two school socioeconomic status variables. In Chinese Taipei, students economically disadvantaged had a statistically significant relationship with mathematics achievement; and in Ghana, home resources limiting teaching had a statistically significant relationship with mathematics achievement. In the U.S., both of the school socioeconomic status variables had a statistically significant relationship with mathematics achievement.

School climate variables had statistically significant relationships with mathematics achievement in Chinese Taipei and Ghana, but not in the U.S. The school climate variables that did have statistically significant relationships with mathematics achievement in Chinese Taipei and Ghana were different variables—school emphasis on academic success from both teacher and principal reports in Chinese Taipei, and school discipline and safety in Ghana. No school resources variables had statistically significant relationships with mathematics achievement in the final model of any of the three countries.

The most surprising result of the analyses in this dissertation may be the lack of predictive power that teacher-related variables have in eighth-grade mathematics achievement across the three countries. The U.S. was the only country with teacher-related variables having statistically significant relationships with mathematics achievement, and it had only two. Those variables were mathematics topics taught and class emphasis on assessment. Possible explanations for the predictive power of those two variables in the U.S. model were discussed in the previous section in this chapter.

Table 181

Estimation of Fixed Effects for Model 40 in Each Country

	Chinese Taipei		Ghana		U.S.	
Parameter	Estimate	*SE*	Estimate	*SE*	Estimate	*SE*
Intercept	610.76***	3.06	335.23***	5.42	513.09***	2.75
Home possessions for learning	8.08***	1.04	--	--	4.65***	0.85
Parent education	11.78***	1.66	--	--	1.81*	0.88
Parent expectations and involvement	0.31	0.80	--	--	-3.04***	0.47
Self-confidence in mathematics	15.40***	0.87	9.57***	0.84	10.90***	0.45
Value mathematics	0.22***	0.05	0.15***	0.03	-0.05**	0.02
Emphasis on academic success-teachers	4.45*	2.05	--	--	--	--
Emphasis on academic success-principals	5.55***	1.60	--	--	0.47	1.40
School discipline and safety	--	--	11.19**	3.74	--	--
Resources for mathematics instruction	--	--	--	--	-0.97	1.33
Students economically disadvantaged	-15.88**	5.18	--	--	-11.41**	3.63
Home resources limiting teaching	--	--	-11.54***	3.00	-7.89***	1.77
Mathematics instructional hours per year	0.07	0.09	--	--	--	--
Mathematics topics taught	--	--	--	--	10.33***	2.19
Assessment question types	0.31	1.48	--	--	--	--
Class emphasis on assessment	--	--	--	--	-4.40**	1.50
Professional development	--	--	--	--	-2.32	1.33
Teacher experience	--	--	--	--	0.18	0.25

Note. *$p < .05$, **$p < .01$, ***$p < .001$

Limitations of Study

This study was designed to evaluate relationships of home, student, school, and classroom-related variables with student achievement in mathematics across countries; however, the study has limitations. The data used for measuring and evaluating the contexts for learning mathematics were largely self-reported responses to questionnaires. Participants may have been biased toward desirable responses. In addition, questionnaire items focused on the frequency of the use of many educational practices and did not address the quality of the practices. Observations of educational environments and practices, interviews with stakeholders, and analyses of educational materials would yield more direct measurement of contexts for learning. Correlational studies of questionnaire data have been shown to yield lower effects of teaching than experimental or quasi-experimental designs using direct observation or video because of the more distal nature of questionnaire data (Seidel & Shavelson, 2007). In addition, the models in this study did not account for all the variance in eighth-grade mathematics achievement in any country, although some of the models did account for a large percentage of between-school variance in mathematics achievement.

Recommendations for Research

This study extends previous research in several ways. This dissertation includes a comprehensive review of classic and recent literature regarding predictors of mathematics achievement organized by four major sources—students' homes and families, students themselves, students' schools, and students' teachers and classroom environments. Seventeen scales using the Rasch partial credit model were developed to measure contextual variables in this study. These scales may be used to study predictors of student achievement in other countries that participated in the TIMSS 2011. The results of this study may be used by stakeholders in the countries of this study, or in other countries with similar cultures and contextual variables, to examine the relationships between the independent variables of this study and middle-grades mathematics achievement in these countries. These relationships may be used to reinforce and support variables that contribute to student achievement.

Three pathways of future research are recommended to extend the findings of this study. The TIMSS can be used to conduct research of trends of variables of interest across several occasions of the TIMSS within countries. The TIMSS 2011 was the fifth cycle of the study, having begun in 1995, so the time is right to investigate student achievement trends and the contexts for teaching and learning mathematics to inform stakeholders in education around the world.

The independent variables of this study were derived from self-reported questionnaire items. Responses to many items may be biased. Studies such as this dissertation are useful to inform stakeholders in education, but the variables should also be further investigated with more direct research methods such as observations, interviews, and analyses of educational materials.

Finally, this study can be replicated for countries other than the three in this study. Although the three countries in this study were purposively selected to represent a wide range of mathematics achievement and cultures, they did not cover the full range. The methods of analysis and variables of interest in this study would provide valuable information to other countries that participated in the TIMSS 2011, as well.

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APPENDIX A

DERIVED VARIABLES AND CORRESPONDING QUESTIONNAIRE ITEMS

Table A1

Derived Variables and Corresponding Questionnaire Items

Domain	Related variables	Variable derived by	Questionnaire	Item	Response options
Home resources	Home possessions	Author	Student	About how many books are there in your home?	None or very few (0–10), Enough to fill one shelf (11-25) Enough to fill one bookcase (26-100) Enough to fill two bookcases (101-200) Enough to fill three or more bookcases (more than 200)
				Computer Study desk/table for your use Books of your very own Internet connection	Yes No

Table A1 (Continued)

Home resources	Parent educational attainment	TIMSS	Student	What is the highest level of education completed by your mother? What is the highest level of education completed by your father?	Six years or less Lower secondary Upper secondary Post-secondary Associate's degree Bachelor's degree Beyond bachelor's degree I don't know
Home resources	Parent expectations and involvement	Author	Student	My parents ask me what I am learning in school I talk about my schoolwork with my parents My parents make sure that I set aside time for my homework My parents check if I do my homework	Every day or almost every day Once or twice a week Once or twice a month Never or almost never
Student beliefs	Self-confidence in mathematics	TIMSS	Student	I usually do well in mathematics I learn things quickly in mathematics I am good at working out difficult mathematics problems	Agree a lot Agree a little Disagree a little Disagree a lot
Student beliefs	Value mathematics	Author	Student	I enjoy learning mathematics I learn many interesting things in mathematics I like mathematics It is important to do well in mathematics I am interested in what my teacher says I would like a job that involves using mathematics I think learning mathematics will help me in my daily life	Agree a lot Agree a little Disagree a little Disagree a lot

Table A1 (Continued)

School climate	School emphasis on academic success - teachers	TIMSS	Teacher	Teachers’ understanding of the school’s curricular goals Teachers’ degree of success in implementing the school’s curriculum Teachers’ expectations for student achievement Parental support for student achievement Students’ desire to do well in school	Very high High Medium Low Very low
School climate	School emphasis on academic success - principals	TIMSS	School	Teachers’ understanding of the school’s curricular goals Teachers’ degree of success in implementing the school’s curriculum Teachers’ expectations for student achievement Parental support for student achievement Students’ desire to do well in school	Very high High Medium Low Very low
School climate	School discipline and safety	TIMSS	School	To what degree is each of the following a problem among students in your school? Arriving late at school Absenteeism (i.e., unjustified absences) Classroom disturbance Cheating Profanity Vandalism Theft Intimidation or verbal abuse among students (including texting, emailing, etc.) Physical injury to other students Intimidation or verbal abuse of teachers or staff Physical injury to teachers or staff	Not a problem Minor problem Moderate problem Serious problem

Table A1 (Continued)

School resources	Computers available for instruction	TIMSS		Students per computer	One computer for 1-2 students One computer for 3-5 students Once computer for six or more students No computers available
School resources	Resources for general instruction	Author	School	How much is your school's capacity to provide instruction affected by a shortage or inadequacy of the following? Instructional materials (e.g., textbooks) Supplies (e.g., papers, pencils) School buildings and grounds Heating/cooling and lighting systems Instructional space (e.g., classrooms) Technologically competent staff	Not at all A little Some A lot

Table A1 (Continued)

School resources	Resources for mathematics instruction	Author	School	Teachers with a specialization in mathematics Computers for mathematics instruction Computer software for mathematics instruction Library materials relevant to mathematics instruction Audio-visual resources for mathematics instruction Calculators for mathematics instruction	Not at all A little Some A lot
Administrator leadership		Author	School	During the past year, approximately how much time have you spent on the following school leadership activities in your role as a school principal? Keeping an orderly atmosphere in the school Ensuring that there are clear rules for student behavior Addressing disruptive student behavior Creating a climate of trust among teachers Participating in professional development activities specifically for school principals	No time Some time A lot of time
School socioeconomic status	Percent economically disadvantaged	TIMSS	School	Approximately what percentage of students in your school have the following backgrounds? Come from economically disadvantaged homes Come from economically affluent homes	0 to 10% 11 to 25% 26 to 50% More than 50%
School socioeconomic status	Home resources limiting teaching	Author	Teacher	To what extent do the following limit how you teach? Students lacking prerequisite knowledge or skills Students suffering from lack of basic nutrition Students suffering from not enough sleep Disruptive students Uninterested students	Not applicable Not at all Some A lot

Table A1 (Continued)

Access equity	Mathematics instructional hours per year	Author	Teacher	Instructional time mathematics hours per week	_____ hours _____ minutes
			School	Total instructional days per week	6 days 5 ½ days 5 days 4 ½ days 4 days
			School	Total instructional days per year	_____ days
Access equity	Topics taught	Author	Teacher	Representing, comparing, ordering, and computing with integers Problem Solving involving percents and proportions Numeric, algebraic, and geometric patterns or sequences Simplifying and evaluating algebraic expressions Simple linear equations and inequalities Simultaneous equations Representation of functions as ordered pairs, tables, graphs, words, or equations Points on the Cartesian Plane	Mostly taught before this year Mostly taught this year Not yet taught or just introduced
Instructional materials	Textbooks workbooks for instruction	Author	Teacher	When you teach mathematics to this class, how do you use the following resources? Textbooks Workbooks or worksheets	Basis for instruction Supplement Not used

Table A1 (Continued)

Instructional materials	Tools tech for instruction	Author	Teacher	When you teach mathematics to this class, how do you use the following resources? Concrete objects or materials that help students understand quantities or procedures Computer software	Basis for instruction Supplement Not used
Instruction	Instruction to engage students	TIMSS	Teacher	How often do you do the following in teaching this class? Summarize what students should have learned from the lesson Use questioning to elicit reasons and explanations Encourage all students to improve their performance Praise students for good effort	Every or almost every lesson About half the lessons Some lessons Never
Instruction	Research-based practices	Author	Teacher	In teaching mathematics to this class, how often do you usually ask students to do the following? Work problems (individually or with peers) with my guidance Explain their answers Relate what they are learning in mathematics to their daily lives Decide on their own procedures for solving complex problems Work on problems for which there is no immediately obvious method of solution	Every or almost every lesson About half the lessons Some lessons Never

Table A1 (Continued)

Tools tech	Calculator use	Author	Teacher	How often do students in this class use calculators in their mathematics lessons for the following activities? Check answers Do routine computations Solve complex problem Explore number concepts	Every or almost every lesson About half the lessons Some lessons Never
Tools tech	Computer use	Author	Teacher	How often do you have the students do the following computer activities during mathematics lessons? Explore mathematics principles and concepts Practice skills and procedures Look up ideas and information Process and analyze data	Every or almost every lesson About half the lessons Some lessons Never
Assessment	Assessment question types	Author	Teacher	How often do you include the following types of questions in your mathematics tests or examinations? Questions involving application of mathematical procedures Questions involving searching for patterns and relationships Questions requiring explanations or justifications	Always or almost always Sometimes Never or almost never
Assessment	Assessment emphasis	Author	Teacher	How much emphasis do you place on the following sources to monitor students' progress in mathematics? Evaluation of students' ongoing work Classroom tests (for example, teacher-made or textbook tests) National or regional achievement tests	Major emphasis Some emphasis Little or no emphasis

Table A1 (Continued)

Teacher professionalism	Professional development	Author	Teacher	In the past two years, have you participated in professional development in any of the following? Mathematics content Mathematics pedagogy/instruction Mathematics curriculum Integrating information technology into mathematics Improving students' critical thinking or problem solving skills Mathematics assessment Addressing individual students' needs	Yes No
Teacher professionalism	Collaboration	TIMSS	Teacher	How often do you have the following types of interactions with other teachers? Discuss how to teach a particular topic Collaborate in planning and preparing instructional materials Share what I have learned about my teaching experiences Visit another classroom to learn more about teaching Work together to try out new ideas	Never or almost never 2 or 3 times per month 1–3 times per week Daily or almost daily
Teacher professionalism	Teacher experience	TIMSS	Teacher	By the end of this school year, how many years will you have been teaching altogether?	Open-ended
Teacher professionalism	Teacher knowledge	TIMSS	Teacher	What is the highest level of formal education you have completed?	Did not complete upper secondary Finished upper secondary Finished post-secondary Finished associate's degree Finished bachelor's degree Finished master's degree or higher

Table A1 (Continued)

Teacher professionalism	Teacher preparation	Author	Teacher	How well prepared do you feel to teach computing, estimating, or approximating with whole numbers How well prepared do you feel to teach concepts of fractions and computing with fractions How well prepared do you feel to teach concepts of decimals and computing with decimals How well prepared do you feel to teach representing, comparing ordering, and computing with integers How well prepared do you feel to teach problem solving involving percents and proportions How well prepared do you feel to teach simplifying and evaluating algebraic expressions How well prepared do you feel to teach simple linear equations and inequalities How well prepared do you feel to teach points on the Cartesian plane How well prepared do you feel to teach reading and displaying data using tables, pictographs, bar graphs, pie charts, and line graphs	Not applicable Very well prepared Somewhat prepared Not well prepared
Teacher professionalism	Teacher self-efficacy	TIMSS	Teacher	In teaching mathematics to this class, how confident do you feel to do the following? Answer students’ questions about mathematics Show students a variety of problem solving strategies Provide challenging tasks for capable students Adapt my teaching to engage students’ interest Help students appreciate the value of learning mathematics	Very confident Somewhat confident Not confident

APPENDIX B

PARTIAL CREDIT STATISTICS AND WRIGHT MAPS

Table B1

Home Possessions for Learning Partial Credit Statistics

Item Number	Item Description	Infit Statistic	Item Threshold 1	Item Threshold 2	Item Threshold 3	Item Threshold 4
1	Number of books	1.10	-.39	1.23	2.55	3.45
2	Computer	.88	-.47			
3	Study desk	1.00	-.56			
4	Books	1.09	-.78			
5	Internet connections	.91	.11			

```
             X|                                  |
             X|                                  |
            XX|                                  |
             X|                                  |
 4          XX|                                  |
           XXX|                                  |
           XXX|                                  |
         XXXXX|                                  |
 3       XXXXX|                                  |
        XXXXXX|                                  |
        XXXXXX|                                  |
       XXXXXXX|                                  |
    XXXXXXXXXX|                                  |
 2   XXXXXXXXX|                                  |
     XXXXXXXXX|                                  |
     XXXXXXXXX|1                                 |
     XXXXXXXXX|                                  |
     XXXXXXXXX|                                  |
 1   XXXXXXXXX|                                  |
      XXXXXXXX|                                  |
     XXXXXXXXX|                                  |
       XXXXXXX|                                  |
        XXXXXX|5                                 |
 0     XXXXXXX|                                  |
         XXXXX|                                  |
         XXXXX|2 3                               |
         XXXXX|                                  |
          XXXX|4                                 |
-1         XXX|                                  |
            XX|                                  |
             X|                                  |
            XX|                                  |
-2           X|                                  |
              |                                  |
             X|                                  |
             X|                                  |
             X|                                  |
-3            |                                  |
```

Figure B1. Home possessions for learning Wright map of latent distributions and thresholds

Table B2

Parent Expectations and Involvement Partial Credit Statistics

Item Number	Item Description	Infit Statistic	Item Threshold 1	Item Threshold 2	Item Threshold 3
1	Ask what learning	.99	-.82	-.29	.62
2	Talk about schoolwork	1.05	-.55	-.02	.88
3	Time for homework	.96	-1.06	-.53	.37
4	Check homework	1.06	-.25	.28	1.18

```
              X|                                  |
              X|                                  |
              X|                                  |
  3           X|                                  |
             XX|                                  |
            XXX|                                  |
            XXX|                                  |
            XXX|                                  |
           XXXX|                                  |
  2       XXXXX|                                  |
          XXXXX|                                  |
        XXXXXXX|                                  |
       XXXXXXXX|                                  |
       XXXXXXXX|                                  |
       XXXXXXXX|                                  |
      XXXXXXXXX|                                  |
  1   XXXXXXXXX|                                  |
     XXXXXXXXXX|                                  |
     XXXXXXXXXX|                                  |
      XXXXXXXXX|4                                 |
      XXXXXXXXX|                                  |
       XXXXXXXX|                                  |
  0    XXXXXXXX|2                                 |
         XXXXXX|                                  |
         XXXXXX|1  3                              |
        XXXXXXX|                                  |
           XXXX|                                  |
           XXXX|                                  |
           XXXX|                                  |
 -1          XX|                                  |
             XX|                                  |
            XXX|                                  |
              X|                                  |
              X|                                  |
              X|                                  |
 -2           X|                                  |
```

Figure B2. Parent expectations and involvement Wright map of latent distributions and thresholds

Table B3

Value Mathematics Partial Credit Statistics

Item Number	Item Description	Infit Statistic	Item Threshold 1	Item Threshold 2	Item Threshold 3
1	Enjoy learning mathematics	.81	-0.93	0.30	1.91
2	Learn interesting things	.92	-1.17	0.06	1.67
3	Like mathematics	.83	-0.79	0.44	2.06
4	Important to do well in mathematics	1.25	-2.86	-1.63	-0.02
5	Interested in what teacher says	1.06	-1.29	-0.06	1.55
6	Mathematics will help me	1.16	-2.39	-1.16	0.45
7	Job involving mathematics	1.19	-0.08	1.15	2.76

```
              X|                                   |
              X|                                   |
  5           X|                                   |
              X|                                   |
              X|                                   |
             XX|                                   |
             XX|                                   |
  4          XX|                                   |
            XXX|                                   |
            XXX|                                   |
           XXXX|                                   |
  3       XXXXX|                                   |
          XXXXX|                                   |
          XXXXX|                                   |
         XXXXXX|                                   |
       XXXXXXXX|                                   |
  2     XXXXXXX|                                   |
       XXXXXXXX|                                   |
       XXXXXXXX|                                   |
       XXXXXXXX|                                   |
      XXXXXXXXX|7                                  |
  1  XXXXXXXXXX|                                   |
      XXXXXXXXX|                                   |
     XXXXXXXXXX|3                                  |
       XXXXXXXX|1                                  |
  0      XXXXXX|2  5                               |
        XXXXXXX|                                   |
          XXXXX|                                   |
          XXXXX|                                   |
           XXXX|                                   |
 -1        XXXX|6                                  |
            XXX|4                                  |
             XX|                                   |
              X|                                   |
              X|                                   |
 -2           X|                                   |
```

Figure B3. Value mathematics Wright map of latent distributions and thresholds

Table B4

School Resources General Instruction Partial Credit Analysis

Item Number	Item Description	Infit Statistic	Item Threshold 1	Item Threshold 2	Item Threshold 3
1	Instructional materials	1.01	-1.18	-.17	1.39
2	Supplies	1.04	-.58	.43	1.99
3	School buildings	.90	-1.45	-.43	1.13
4	Heating systems	1.11	-.94	.08	1.64
5	Instructional space	.87	-1.49	-.47	1.09
6	Technological staff	1.13	-1.57	-.55	1.00

```
              |                                  |
             X|                                  |
              |                                  |
 4           X|                                  |
             X|                                  |
             X|                                  |
            XX|                                  |
            XX|                                  |
 3          XX|                                  |
            XX|                                  |
          XXXX|                                  |
          XXXX|                                  |
          XXXX|                                  |
         XXXXX|                                  |
 2      XXXXXX|                                  |
        XXXXXX|                                  |
        XXXXXX|                                  |
       XXXXXXX|                                  |
     XXXXXXXXX|                                  |
 1    XXXXXXXX|                                  |
      XXXXXXXX|                                  |
    XXXXXXXXXX|                                  |
       XXXXXXX|                                  |
       XXXXXXX|3 5 6                             |
 0     XXXXXXX|                                  |
       XXXXXXX|1 4                               |
        XXXXXX|                                  |
         XXXXX|2                                 |
          XXXX|                                  |
           XXX|                                  |
-1         XXX|                                  |
            XX|                                  |
            XX|                                  |
             X|                                  |
             X|                                  |
-2           X|                                  |
              |                                  |
             X|                                  |
```

Figure B4. School resources for general instruction Wright map of latent distributions and thresholds

Table B5

Resources for Mathematics Instruction Partial Credit Statistics

Item Number	Item Description	Infit Statistic	Item Threshold 1	Item Threshold 2	Item Threshold 3
1	Teach spec math	1.83	-1.13	.10	1.60
2	Computers for instruction	.84	-1.30	-.06	1.43
3	Computer software	.75	-1.58	.34	1.15
4	Library materials	.83	-1.66	-.42	1.07
5	Audio-visual resources	.75	-1.43	-.19	1.31
6	Calculators	1.04	-.85	.39	1.88

```
                |                                  |
               X|                                  |
               X|                                  |
  4           XX|                                  |
               X|                                  |
              XX|                                  |
             XXX|                                  |
             XXX|                                  |
  3        XXXXX|                                  |
           XXXXX|                                  |
          XXXXXX|                                  |
           XXXXX|                                  |
  2      XXXXXXX|                                  |
       XXXXXXXXX|                                  |
        XXXXXXXX|                                  |
       XXXXXXXXX|                                  |
       XXXXXXXXX|                                  |
  1    XXXXXXXXX|                                  |
       XXXXXXXXX|                                  |
      XXXXXXXXXX|                                  |
       XXXXXXXXX|                                  |
      XXXXXXXXXX|3 4                               |
  0      XXXXXXX|2 5                               |
          XXXXXX|1                                 |
         XXXXXXX|6                                 |
           XXXXX|                                  |
           XXXXX|                                  |
 -1         XXXX|                                  |
             XXX|                                  |
             XXX|                                  |
              XX|                                  |
               X|                                  |
 -2            X|                                  |
               X|                                  |
                |                                  |
               X|                                  |
               X|                                  |
 -3            X|                                  |
                |                                  |
                |                                  |
```

Figure B5. Resources for mathematics instruction Wright map of latent distributions and thresholds

Table B6

Administrator Leadership Partial Credit Statistics

Item Number	Item Description	Infit Statistic	Item Threshold 1	Item Threshold 2
1	Orderly atmosphere	.85	-3.09	.97
2	Clear rules	.83	-2.69	1.38
3	Address behavior	.96	-1.33	2.73
4	Climate of trust	1.03	-2.16	1.90
5	Professional development for principals	1.26	-.88	3.18

```
  6            |                                  |
              X|                                  |
              X|                                  |
             XX|                                  |
             XX|                                  |
  5          XX|                                  |
            XXX|                                  |
           XXXX|                                  |
          XXXXX|                                  |
         XXXXXX|                                  |
  4      XXXXXX|                                  |
         XXXXXX|                                  |
       XXXXXXXX|                                  |
     XXXXXXXXXX|                                  |
      XXXXXXXXX|                                  |
  3  XXXXXXXXXX|                                  |
     XXXXXXXXXX|                                  |
      XXXXXXXXX|                                  |
      XXXXXXXXX|                                  |
     XXXXXXXXXX|                                  |
  2   XXXXXXXXX|                                  |
     XXXXXXXXXX|                                  |
        XXXXXXX|                                  |
         XXXXXX|                                  |
        XXXXXXX|                                  |
          XXXXX|5                                 |
  1      XXXXXX|                                  |
          XXXXX|                                  |
           XXXX|3                                 |
           XXXX|                                  |
            XXX|                                  |
  0           X|                                  |
             XX|4                                 |
              X|                                  |
               |2                                 |
              X|1                                 |
 -1           X|                                  |
              X|                                  |
               |                                  |
```

Figure B6. Administrator leadership Wright map of latent distributions and thresholds

Table B7

Home Resources Limiting Teaching Partial Credit Statistics

Item Number	Item Description	Infit Statistic	Item Threshold 1	Item Threshold 2
1	Lacking knowledge	.98	-2.76	1.04
2	Lack of nutrition	1.18	-.85	2.95
3	Lack of sleep	.97	-1.88	1.92
4	Disruptive students	.96	-1.74	2.06
5	Uninterested students	.94	-2.27	1.55

```
             X|                                   |
              |                                   |
              |                                   |
 3           X|                                   |
             X|                                   |
            XX|                                   |
            XX|                                   |
            XX|                                   |
           XXX|                                   |
 2         XXX|                                   |
         XXXXX|                                   |
         XXXXX|                                   |
        XXXXXX|                                   |
        XXXXXX|                                   |
       XXXXXXX|                                   |
     XXXXXXXXX|2                                  |
 1   XXXXXXXXX|                                   |
    XXXXXXXXXX|                                   |
     XXXXXXXXX|                                   |
     XXXXXXXXX|                                   |
     XXXXXXXXX|3                                  |
    XXXXXXXXXX|                                   |
 0   XXXXXXXXX|                                   |
    XXXXXXXXXX|4                                  |
       XXXXXXX|                                   |
        XXXXXX|                                   |
       XXXXXXX|1 5                                |
         XXXXX|                                   |
-1       XXXXX|                                   |
         XXXXX|                                   |
          XXXX|                                   |
           XXX|                                   |
            XX|                                   |
             X|                                   |
             X|                                   |
-2           X|                                   |
              |                                   |
             X|                                   |
             X|                                   |
             X|                                   |
```

Figure B7. Home resources limiting teaching Wright map of latent distributions and thresholds

Table B8

Mathematics Topics Taught Partial Credit Statistics

Item Number	Item Description	Infit Statistic	Item Threshold 1	Item Threshold 2
1	Representing, comparing, ordering, and computing with integers	.92	-3.30	-0.42
2	Problem Solving involving percents and proportions	1.05	-2.33	0.56
3	Numeric, algebraic, and geometric patterns or sequences	1.17	-1.42	1.47
4	Simplifying and evaluating algebraic expressions	.87	-1.62	1.27
5	Simple linear equations and inequalities	.91	-1.46	1.43
6	Simultaneous equations	.92	0.33	3.21
7	Representation of functions as ordered pairs, tables, graphs, words, or equations	1.00	-0.39	2.49
8	Points on the Cartesian Plane	1.21	-1.36	1.53

```
                    |                                  |
                   X|                                  |
                   X|                                  |
       5           X|                                  |
                   X|                                  |
                   X|                                  |
                  XX|                                  |
       4          XX|                                  |
                  XX|                                  |
                 XXX|                                  |
                 XXX|                                  |
                XXXX|                                  |
       3        XXXX|                                  |
               XXXXX|                                  |
                XXXX|                                  |
               XXXXX|                                  |
       2     XXXXXXX|                                  |
             XXXXXXX|                                  |
            XXXXXXXX|6                                 |
            XXXXXXXX|                                  |
            XXXXXXXX|7                                 |
       1    XXXXXXXX|                                  |
           XXXXXXXXX|                                  |
           XXXXXXXXX|                                  |
          XXXXXXXXXX|8                                 |
            XXXXXXXX|3                                 |
       0      XXXXXX|5                                 |
             XXXXXXX|4                                 |
               XXXXX|                                  |
               XXXXX|2                                 |
      -1        XXXX|                                  |
                 XXX|                                  |
                 XXX|                                  |
                  XX|                                  |
                   X|                                  |
      -2           X|                                  |
                   X|                                  |
                    |1                                 |
```

Figure B8. Mathematics topics taught Wright map of latent distributions and thresholds

Table B9

Textbooks and Workbooks for Instruction Partial Credit Analysis

Item Number	Item Description	Infit Statistic	Item Threshold 1	Item Threshold 2
1	How do you use textbooks?	1.00	-1.96	.82
2	How do you use workbooks or worksheets?	1.00	-.82	1.96

```
             |                                  |
            X|                                  |
            X|                                  |
           XX|                                  |
           XX|                                  |
           XX|                                  |
          XXX|                                  |
         XXXX|                                  |
        XXXXX|                                  |
       XXXXXX|                                  |
       XXXXXX|                                  |
       XXXXXX|                                  |
      XXXXXXX|                                  |
   XXXXXXXXXX|                                  |
    XXXXXXXXX|                                  |
   XXXXXXXXXX|                                  |
   XXXXXXXXXX|                                  |
1   XXXXXXXXX|                                  |
    XXXXXXXXX|                                  |
   XXXXXXXXXX|                                  |
    XXXXXXXXX|                                  |
   XXXXXXXXXX|                                  |
      XXXXXXX|                                  |
       XXXXXX|                                  |
      XXXXXXX|                                  |
        XXXXX|                                  |
       XXXXXX|                                  |
        XXXXX|                                  |
         XXXX|                                  |
         XXXX|2                                 |
           XX|                                  |
            X|                                  |
           XX|                                  |
           XX|                                  |
             |                                  |
            X|                                  |
            X|                                  |
            X|                                  |
0            |                                  |
             |                                  |
             |                                  |
             |                                  |
             |                                  |
             |                                  |
             |                                  |
             |                                  |
             |                                  |
             |1                                 |
```

Figure B9. Textbooks and workbooks for instruction Wright map of latent distributions and thresholds

Table B10

Tools and Technology for Instruction Partial Credit Analysis

Item Number	Item Description	Infit Statistic	Item Threshold 1	Item Threshold 2
1	How do you use concrete objects or materials that help students understand quantities or procedures?	1.00	-1.19	1.98
2	How do you use computer software?	1.00	-1.98	1.19

```
               |                                  |
              X|                                  |
              X|                                  |
             XX|                                  |
             XX|                                  |
             XX|                                  |
            XXX|                                  |
           XXXX|                                  |
          XXXXX|                                  |
         XXXXXX|                                  |
         XXXXXX|                                  |
         XXXXXX|                                  |
        XXXXXXX|                                  |
     XXXXXXXXXX|                                  |
      XXXXXXXXX|                                  |
     XXXXXXXXXX|                                  |
     XXXXXXXXXX|                                  |
  1   XXXXXXXXX|                                  |
      XXXXXXXXX|                                  |
     XXXXXXXXXX|                                  |
      XXXXXXXXX|                                  |
     XXXXXXXXXX|                                  |
       XXXXXXXX|                                  |
         XXXXXX|                                  |
        XXXXXXX|                                  |
          XXXXX|                                  |
          XXXXX|                                  |
          XXXXX|                                  |
           XXXX|                                  |
           XXXX|                                  |
             XX|                                  |
              X|1                                 |
             XX|                                  |
             XX|                                  |
               |                                  |
              X|                                  |
  0           X|                                  |
              X|                                  |
               |                                  |
               |                                  |
               |2                                 |
```

Figure B10. Tools and technology for instruction Wright map of latent distributions and thresholds

Table B11

Research-Based Instruction Partial Credit Analysis

Item Number	Item Description	Infit Statistic	Item Threshold 1	Item Threshold 2	Item Threshold 3
1	Work with guidance	1.14	-3.19	-.32	.74
2	Explain their answers	1.02	-3.13	-.26	.81
3	Relate to daily life	.98	-2.34	0.53	1.59
4	Own procedures	.91	-1.68	1.18	2.25
5	No obvious solution	.94	-.98	1.89	2.95

```
               |                                   |
              X|                                   |
  4           X|                                   |
               |                                   |
              X|                                   |
              X|                                   |
             XX|                                   |
             XX|                                   |
             XX|                                   |
  3         XXX|                                   |
            XXX|                                   |
          XXXXX|                                   |
          XXXXX|                                   |
          XXXXX|                                   |
          XXXXX|                                   |
        XXXXXXX|                                   |
      XXXXXXXXX|                                   |
  2    XXXXXXXX|                                   |
      XXXXXXXXX|                                   |
      XXXXXXXXX|                                   |
      XXXXXXXXX|5                                  |
      XXXXXXXXX|                                   |
     XXXXXXXXXX|                                   |
      XXXXXXXXX|                                   |
  1  XXXXXXXXXX|                                   |
        XXXXXXX|4                                  |
         XXXXXX|                                   |
        XXXXXXX|                                   |
          XXXXX|                                   |
          XXXXX|                                   |
          XXXXX|                                   |
  0        XXXX|                                   |
            XXX|3                                  |
             XX|                                   |
              X|                                   |
              X|                                   |
              X|                                   |
               |                                   |
              X|                                   |
 -1           X|                                   |
              X|1 2                                |
```

Figure B11. Research-based instruction Wright map of latent distributions and thresholds

Table B12

Calculator Use Partial Credit Statistics

Item Number	Item Description	Infit Statistic	Item Threshold 1	Item Threshold 2	Item Threshold 3
1	Check answers	.89	-2.99	.61	1.66
2	Computations	.95	-2.47	1.13	2.18
3	Complex problems	.94	-3.23	.36	1.41
4	Explore	1.07	-2.29	1.30	2.35

```
 6            |                                  |
             X|                                  |
             X|                                  |
             X|                                  |
 5           X|                                  |
            XX|                                  |
           XXX|                                  |
 4          XX|                                  |
            XX|                                  |
           XXX|                                  |
 3        XXXX|                                  |
          XXXX|                                  |
          XXXX|                                  |
        XXXXXX|                                  |
 2      XXXXXX|                                  |
        XXXXXX|                                  |
       XXXXXXX|                                  |
 1   XXXXXXXXX|                                  |
      XXXXXXXX|                                  |
      XXXXXXXX|2 4                               |
 0    XXXXXXXX|                                  |
     XXXXXXXXX|1                                 |
    XXXXXXXXXX|3                                 |
     XXXXXXXXX|                                  |
-1    XXXXXXXX|                                  |
       XXXXXXX|                                  |
         XXXXX|                                  |
-2      XXXXXX|                                  |
        XXXXXX|                                  |
           XXX|                                  |
-3         XXX|                                  |
            XX|                                  |
            XX|                                  |
-4          XX|                                  |
             X|                                  |
             X|                                  |
              |                                  |
-5            |                                  |
              |                                  |
             X|                                  |
-6            |                                  |
```

Figure B12. Calculator use Wright map of latent distributions and thresholds

Table B13

Computer Use Partial Credit Statistics

Item Number	Item Description	Infit Statistic	Item Threshold 1	Item Threshold 2	Item Threshold 3
1	Explore concept	.93	-3.04	.36	2.90
2	Do procedures	.96	-3.52	-.11	2.42
3	Look up ideas	1.24	-3.31	.10	2.63
4	Process data	.94	-2.59	.81	3.30

```
 5           X|                                  |
             X|                                  |
             X|                                  |
 4           X|                                  |
             X|                                  |
 3          XX|                                  |
            XX|                                  |
 2        XXXX|                                  |
          XXXX|                                  |
         XXXXX|                                  |
 1       XXXXX|                                  |
        XXXXXX|4                                 |
 0       XXXXX|1                                 |
       XXXXXXX|2 3                               |
       XXXXXXX|                                  |
-1   XXXXXXXXX|                                  |
     XXXXXXXXX|                                  |
-2   XXXXXXXXX|                                  |
    XXXXXXXXXX|                                  |
-3  XXXXXXXXXX|                                  |
     XXXXXXXXX|                                  |
     XXXXXXXXX|                                  |
-4    XXXXXXXX|                                  |
       XXXXXXX|                                  |
-5   XXXXXXXXX|                                  |
       XXXXXXX|                                  |
         XXXXX|                                  |
-6       XXXXX|                                  |
          XXXX|                                  |
-7        XXXX|                                  |
           XXX|                                  |
-8         XXX|                                  |
            XX|                                  |
             X|                                  |
-9           X|                                  |
             X|                                  |
-10           |                                  |
             X|                                  |
```

Figure B13. Computer use Wright map of latent distributions and thresholds

Table B14

Assessment Emphasis Partial Credit Statistics

Item Number	Item Description	Infit Statistic	Item Threshold 1	Item Threshold 2
1	Evaluation of work	1.01	-.1.42	.53
2	Classroom tests	.99	-1.85	.09
3	National or regional tests	1.00	.35	2.30

```
              |                                  |
 4           X|                                  |
             X|                                  |
            XX|                                  |
            XX|                                  |
            XX|                                  |
           XXX|                                  |
          XXXX|                                  |
         XXXXX|                                  |
        XXXXXX|                                  |
 3      XXXXXX|                                  |
        XXXXXX|                                  |
       XXXXXXX|                                  |
    XXXXXXXXXX|                                  |
     XXXXXXXXX|                                  |
    XXXXXXXXXX|                                  |
     XXXXXXXXX|                                  |
     XXXXXXXXX|                                  |
     XXXXXXXXX|                                  |
 2  XXXXXXXXXX|                                  |
     XXXXXXXXX|                                  |
    XXXXXXXXXX|                                  |
       XXXXXXX|3                                 |
        XXXXXX|                                  |
       XXXXXXX|                                  |
         XXXXX|                                  |
        XXXXXX|                                  |
         XXXXX|                                  |
 1        XXXX|                                  |
          XXXX|                                  |
            XX|                                  |
             X|                                  |
            XX|                                  |
             X|                                  |
              |                                  |
             X|                                  |
             X|                                  |
 0           X|                                  |
              |                                  |
              |                                  |
              |1                                 |
              |                                  |
              |                                  |
              |                                  |
              |                                  |
              |                                  |
-1            |                                  |
              |2                                 |
```

Figure B14. Assessment emphasis Wright map of latent distributions and thresholds

Table B15

Assessment Question Types Partial Credit Statistics

Item Number	Item Description	Infit Statistic	Item Threshold 1	Item Threshold 2
1	Application of procedures	1.04	-3.74	.56
2	Search for pattern	.99	-1.32	2.98
3	Justification	1.01	-1.39	2.92

```
             X|                                  |
 5           X|                                  |
            XX|                                  |
            XX|                                  |
            XX|                                  |
           XXX|                                  |
 4        XXXX|                                  |
         XXXXX|                                  |
        XXXXXX|                                  |
        XXXXXX|                                  |
        XXXXXX|                                  |
      XXXXXXXX|                                  |
 3  XXXXXXXXXX|                                  |
     XXXXXXXXX|                                  |
    XXXXXXXXXX|                                  |
     XXXXXXXXX|                                  |
     XXXXXXXXX|                                  |
 2   XXXXXXXXX|                                  |
    XXXXXXXXXX|                                  |
     XXXXXXXXX|                                  |
    XXXXXXXXXX|                                  |
      XXXXXXXX|                                  |
        XXXXXX|                                  |
 1     XXXXXXX|                                  |
         XXXXX|3                                 |
        XXXXXX|2                                 |
         XXXXX|                                  |
          XXXX|                                  |
          XXXX|                                  |
 0          XX|                                  |
             X|                                  |
            XX|                                  |
             X|                                  |
              |                                  |
-1           X|                                  |
             X|                                  |
             X|                                  |
              |1                                 |
```

Figure B15. Assessment question types Wright map of latent distributions and thresholds

Table B16

Professional Development Partial Credit Analysis

Item Number	Item Description	Infit Statistic	Item Threshold 1
1	Mathematics content	.92	-.87
2	Mathematics pedagogy	1.00	.21
3	Mathematics curriculum	.91	-.33
4	Informational technology	1.27	.19
5	Critical thinking	.93	.46
6	Mathematics assessment	.94	.37
7	Student Needs	1.03	.40

```
 6                                          |                                       |
                                           X|                                       |
                                           X|                                       |
                                            |                                       |
 5                                         X|                                       |
                                          XX|                                       |
                                           X|                                       |
                                        XXXX|                                       |
                                       XXXXX|                                       |
 4                                     XXXXX|                                       |
                                     XXXXXXX|                                       |
                                   XXXXXXXXX|                                       |
                                  XXXXXXXXXX|                                       |
 3                                 XXXXXXXXX|                                       |
                           XXXXXXXXXXXXXXXXX|                                       |
                           XXXXXXXXXXXXXXXXX|                                       |
                          XXXXXXXXXXXXXXXXXX|                                       |
 2                    XXXXXXXXXXXXXXXXXXXXXX|                                       |
                  XXXXXXXXXXXXXXXXXXXXXXXXXX|                                       |
                 XXXXXXXXXXXXXXXXXXXXXXXXXXX|                                       |
                   XXXXXXXXXXXXXXXXXXXXXXXXX|                                       |
 1           XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX|                                       |
   XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX|                                       |
      XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX|5                                      |
         XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX|6 7                                    |
 0  XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX|4                                      |
                XXXXXXXXXXXXXXXXXXXXXXXXXXXX|2                                      |
                  XXXXXXXXXXXXXXXXXXXXXXXXXX|3                                      |
                   XXXXXXXXXXXXXXXXXXXXXXXXX|                                       |
                   XXXXXXXXXXXXXXXXXXXXXXXXX|1                                      |
-1                     XXXXXXXXXXXXXXXXXXXXX|                                       |
                       XXXXXXXXXXXXXXXXXXXXX|                                       |
                            XXXXXXXXXXXXXXXX|                                       |
                             XXXXXXXXXXXXXXX|                                       |
-2                              XXXXXXXXXXXX|                                       |
                                  XXXXXXXXXX|                                       |
                                 XXXXXXXXXXX|                                       |
                                      XXXXXX|                                       |
-3                                      XXXX|                                       |
                                      XXXXXX|                                       |
                                          XX|                                       |
                                          XX|                                       |
-4                                         X|                                       |
                                           X|                                       |
                                            |                                       |
```

Figure B16. Professional development Wright map of latent distributions and thresholds

Table B17

Prepared to Teach Mathematics Partial Credit Statistics

Item Number	Item Description	Infit Statistic	Item Threshold 1	Item Threshold 2
1	Computing with whole numbers	.92	-3.35	3.68
2	Computing with fractions	.63	-4.11	3.46
3	Computing with decimals	.63	-4.12	3.62
4	Representing, comparing, ordering, and computing with integers	.68	-4.09	2.87
5	Problem solving involving percents and proportions	.78	-2.89	3.10
6	Simplifying and evaluating algebraic expressions	1.27	-3.70	1.75
7	Simple linear equations and inequalities	1.00	-2.76	2.64
8	Points on the Cartesian plane	1.62	-1.22	3.80
9	Reading and displaying data using tables and graphs	1.20	-2.71	4.04

```
  14            |                                 |
               X|                                 |
  13           X|                                 |
              XX|                                 |
  12          XX|                                 |
              XX|                                 |
             XXX|                                 |
  11         XXX|                                 |
           XXXXX|                                 |
  10       XXXXX|                                 |
          XXXXXX|                                 |
   9       XXXXX|                                 |
         XXXXXXX|                                 |
   8   XXXXXXXXX|                                 |
        XXXXXXXX|                                 |
       XXXXXXXXX|                                 |
   7   XXXXXXXXX|                                 |
       XXXXXXXXX|                                 |
   6   XXXXXXXXX|                                 |
      XXXXXXXXXX|                                 |
   5   XXXXXXXXX|                                 |
      XXXXXXXXXX|                                 |
   4     XXXXXXX|                                 |
           XXXXX|                                 |
          XXXXXX|                                 |
   3        XXXX|                                 |
           XXXXX|                                 |
   2       XXXXX|                                 |
            XXXX|8                                |
   1        XXXX|                                 |
             XXX|9                                |
   0           X|1 5 7                            |
               X|2 3                              |
  -1           X|4 6                              |
```

Figure B17. Prepared to teach mathematics Wright map of latent distributions and thresholds

APPENDIX C

TIMSS ALMANAC ITEM TABLES

Home Possessions

Table C1

Question: About how many books are there in your home?

Country	Sample	Valid N	0-10 Books %	11-25 Books %	26-100 Books %	101-200 Books %	More than 200 Books %	0-10 Books mean	11-25 Books mean	26-100 Books mean	101-200 Books mean	More than 200 Books mean
Chinese Taipei	5,042	5,039	16.5	20.3	29.5	14.5	19.2	523.3	591.2	623.0	645.3	654.2
Ghana	7,323	7,085	42.6	35.9	13.0	3.9	4.6	332.1	325.5	345.7	353.4	327.8
United States	10,477	10,379	15.9	22.6	28.2	17.5	15.8	464.9	485.1	515.5	542.0	547.7

Table C2

Question: Do you have a computer at your home?

Country	Sample	Valid N	Yes %	No %	Yes mean	No mean
Chinese Taipei	5,042	5,041	97.1	2.9	611.5	535.1.
Ghana	7,323	7,206	23.0	77.0	339.0	329.3
United States	10,477	10,370	95.8	4.2	512.3	463.8

Table C3

Question: Do you have a study desk/table for your use at your home?

Country	Sample	Valid N	Yes %	No %	Yes Mean	No Mean
Chinese Taipei	5,042	5,034	87.1	12.9	615.6	567.3
Ghana	7,323	7,020	51.3	48.7	339.2	327.1
United States	10,477	10,363	86.5	13.5	514.6	483.1

Table C4

Question: Do you have books of your very own at your home?

Country	Sample	Valid N	Yes %	No %	Yes Mean	No Mean
Chinese Taipei	5,042	5,036	80.3	19.7	617.9	574.5.
Ghana	7,323	7,031	68.0	32.0	340.9	316.9
United States	10,477	10,362	86.7	13.3	516.8	468.7

Table C5

Question: Do you have an Internet connection at your home?

Country	Sample	Valid N	Yes %	No %	Yes Mean	No Mean
Chinese Taipei	5,042	5,018	93.0	7.0	612.9	569.7
Ghana	7,323	7,050	11.0	89.0	334.5	333.5
United States	10,477	10,358	92.4	7.6	513.5	471.6

Parent Education

Table C6

Question: What is the highest level of education completed by your mother?

Country	Sample	Valid N	ISC ed 1 or 2 or No school %	ISC ed 2 %	ISC ed 3 %	ISC ed 4 %	ISC ed 5A, 1st degree %	ISC ed 5A 1st degree %	Beyond ISC ed 5A 1st degree %	Don't Know %	ISC ed 1 or 2 or No school mean	ISC ed 2 mean	ISC ed 3 mean	ISC ed 4 mean	ISC ed 5A, 1st degree mean	ISC ed 5A 1st degree mean	Beyond ISC ed 5A 1st degree mean	Don't Know mean
Chinese Taipei	5,042	4,998	4.2	12.2	44.5	10.0	1.2	12.0	3.4	12.5	551.9	565.9	606.9	656.1	628.0	657.1	679.7	584.0
Ghana	7,323	6,643	30.7	34.3	11.9	5.9	1.6	1.9	1.8	11.9	322.3	335.0	351.4	338.1	353.0	343.7	346.6	333.8
United States	10,477	10,323	2.7	7.5	19.7	3.6	3.1	23.4	12.1	28.0	467.9	478.6	501.5	508.5	495.4	535.9	544.8	495.9

Table C7

Question: What is the highest level of education completed by your father?

Country	Sample	Valid N	ISC ed 1 or 2 or No school %	ISC ed 2 %	ISC ed 3 %	ISC ed 4 %	ISC ed 5A, 1st degree %	ISC ed 5A 1st degree %	Beyond ISC ed 5A 1st degree %	Don't Know %	ISC ed 1 or 2 or No school mean	ISC ed 2 mean	ISC ed 3 mean	ISC ed 4 mean	ISC ed 5A, 1st degree mean	ISC ed 5A 1st degree mean	Beyond ISC ed 5A 1st degree mean	Don't Know mean
Chinese Taipei	5,042	5,004	3.9	14.9	35.8	9.3	1.3	13.0	6.6	15.2	545.8	571.0	602.9	653.3	623.1	657.3	678.4	585.1
Ghana	7,323	6,584	19.8	26.8	18.5	9.3	3.2	4.6	3.2	14.7	314.3	332.1	341.7	339.0	338.2	356.2	371.6	335.6
United States	10,477	10,312	2.4	7.4	18.9	4.4	3.1	17.4	11.8	34.5	469.9	480.5	503.1	510.9	502.1	539.2	495.4	554.9

Parent Expectations and Involvement

Table C8

Question: How often do your parents ask what you learned in school?

Country	Sample	Valid N	Every Day or Almost Every Day %	Once or Twice a Week %	Once Twice a Month %	Never Or Almost Never %	Every Day or Almost Every Day Mean	Once or Twice a Week Mean	Once Twice a Month Mean	Never Or Almost Never Mean
Chinese Taipei	5,042	5,036	27.1	31.5	20.5	20.9	632.3	610.4	604.2	582.7
Ghana	7,323	7,038	61.6	19.6	8.1	10.7	331.3	342.0	340.1	317.8
United States	10,477	10,344	41.1	33.4	12.5	13.1	510.2	517.0	515.6	491.1

Table C9

Question: How often do you talk about schoolwork with your parents at home?

Country	Sample	Valid N	Every Day or Almost Every Day %	Once or Twice a Week %	Once Twice a Month %	Never Or Almost Never %	Every Day or Almost Every Day Mean	Once or Twice a Week Mean	Once Twice a Month Mean	Never Or Almost Never Mean
Chinese Taipei	5,042	5,031	19.5	28.0	24.3	28.2	641.4	621.6	612.2	572.9
Ghana	7,323	6,883	39.6	35.3	12.4	12.6	333.0	338.8	330.2	327.6
United States	10,477	10,343	31.6	35.1	16.8	16.5	515.7	515.5	510.7	490.4

Table C10

Question: How often do your parents make sure that you set aside time for your homework?

Country	Sample	Valid N	Every Day or Almost Every Day %	Once or Twice a Week %	Once Twice a Month %	Never Or Almost Never %	Every Day or Almost Every Day Mean	Once or Twice a Week Mean	Once Twice a Month Mean	Never Or Almost Never Mean
Chinese Taipei	5,042	5,028	36.1	21.2	14.8	27.9	627.2	619.0	606.4	580.9
Ghana	7,323	6,857	64.0	14.2	7.5	14.3	342.1	317.5	304.1	330.7
United States	10,477	10,334	61.4	17.0	8.2	13.4	511.8	508.0	512.1	509.0

Table C11

Question: How often do your parents check if you do your homework?

Country	Sample	Valid N	Every Day or Almost Every Day %	Once or Twice a Week %	Once Twice a Month %	Never Or Almost Never %	Every Day or Almost Every Day Mean	Once or Twice a Week Mean	Once Twice a Month Mean	Never Or Almost Never Mean
Chinese Taipei	5,042	5,026	25.9	16.8	14.4	43.0	618.1	606.4	606.6	606.4
Ghana	7,323	6,876	55.5	16.7	7.2	20.6	340.9	325.5	319.9	328.4
United States	10,477	10,337	36.8	21.3	11.5	30.4	506.3	506.5	515.6	517.5

Self-Efficacy in Mathematics

Table C12

Question: How much do you agree that you usually do well in mathematics?

Country	Sample	Valid N	Agree a lot %	Agree a little %	Disagree a little %	Disagree a lot %	Agree a lot Mean	Agree a little Mean	Disagree a little Mean	Disagree a lot Mean
Chinese Taipei	5,042	5,033	13.4	31.8	34.3	20.5	685.8	658.3	592.7	510.9
Ghana	7,323	7,022	45.5	42.1	7.5	4.8	337.7	335.4	316.9	296.2
United States	10,477	10,326	44.9	38.8	11.5	4.8	540.3	497.3	469.6	440.7

Table C13

Question: How much do you agree that you learn things quickly in mathematics?

Country	Sample	Valid N	Agree a lot %	Agree a little %	Disagree a little %	Disagree a lot %	Agree a lot Mean	Agree a little Mean	Disagree a little Mean	Disagree a lot Mean
Chinese Taipei	5,042	5,024	11.0	25.0	40.7	23.3	682.9	661.9	606.4	523.5
Ghana	7,323	6,876	44.8	34.1	13.1	8.0	343.4	331.5	326.6	304.5
United States	10,477	10,231	30.2	36.3	23.6	9.8	540.7	514.9	489.1	456.8

Table C14

Question: How much do you agree that you are good at working out difficult mathematics problems?

Country	Sample	Valid N	Agree a lot %	Agree a little %	Disagree a little %	Disagree a lot %	Agree a lot mean	Agree a little mean	Disagree a little mean	Disagree a lot mean
Chinese Taipei	5,042	5,002	6.3	21.1	41.8	30.8	673.2	671.7	621.1	538.9
Ghana	7,323	6,875	32.6	38.7	15.5	13.2	334.8	341.8	328.1	318.5
United States	10,477	10,280	22.0	36.6	26.6	14.9	541.5	523.2	494.6	464.7

Value Mathematics

Table C15

Question: How much do you agree that you enjoy learning mathematics?

Country	Sample	Valid N	Agree a lot %	Agree a little %	Disagree a little %	Disagree a lot %	Agree a lot Mean	Agree a little Mean	Disagree a little Mean	Disagree a lot Meant
Chinese Taipei	5,042	5,027	15.1	31.5	30.0	23.5	677.9	646.2	600.5	527.9
Ghana	7,323	7,035	68.2	24.7	4.0	3.1	338.6	327.7	303.0	294.7
United States	10,477	10,338	27.3	37.3	18.7	16.6	529.6	514.1	503.0	480.0

Table C16

Question: How much do you agree that you learn many interesting things in mathematics?

Country	Sample	Valid N	Agree a lot %	Agree a little %	Disagree a little %	Disagree a lot %	Agree a lot Mean	Agree a little Mean	Disagree a little Mean	Disagree a lot Meant
Chinese Taipei	5,042	5,004	16.0	37.6	29.6	16.8	659.3	632.9	593.4	539.2.
Ghana	7,323	6,852	66.4	22.2	6.9	4.4	339.7	335.8	296.3	304.5
United States	10,477	10,271	29.7	38.0	20.7	11.6	513.1	513.2	517.5	483.8

Table C17

Question: How much do you agree that you like mathematics?

Country	Sample	Valid N	Agree a lot %	Agree a little %	Disagree a little %	Disagree a lot %	Omitted %	Agree a lot Mean	Agree a little Mean	Disagree a little Mean	Disagree a lot Meant
Chinese Taipei	5,042	5,020	15.5	28.9	30.7	24.9	0.4	677.6	647.8	601.0	533.2
Ghana	7,323	6,839	65.9	23.8	5.6	4.7	5.2	342.3	329.0	300.1	291.4
United States	10,477	10,268	26.9	34.9	19.1	19.2	1.4	532.9	515.7	502.8	478.7

Table C18

Question: How much do you agree that it is important to do well in mathematics?

Country	Sample	Valid N	Agree a lot %	Agree a little %	Disagree a little %	Disagree a lot %	Agree a lot Mean	Agree a little Mean	Disagree a little Mean	Disagree a lot Meant
Chinese Taipei	5,042	5,030	36.4	39.8	14.6	9.2	649.7	609.5	573.5	507.8
Ghana	7,323	6,961	84.5	9.1	3.0	3.4	342.7	298.2	267.5	270.4
United States	10,477	10,323	77.4	17.8	2.6	2.2	516.2	498.8	477.0	452.6

Table C19

Question: How much do you agree that you are interested in what your teacher is saying in your mathematics lessons?

Country	Sample	Valid N	Agree a lot %	Agree a little %	Disagree a little %	Disagree a lot %	Agree a lot Mean	Agree a little Mean	Disagree a little Mean	Disagree a lot Mean
Chinese Taipei	5,042	5,025	14.3	30.3	36.2	19.2	644.1	631.4	607.9	552.3
Ghana	7,323	6,949	74.7	19.0	3.8	2.5	337.1	334.8	300.7	279.2
United States	10,477	10,299	28.2	39.6	21.9	10.2	516.8	514.0	506.6	489.8

Table C20

Question: How much do you agree that learning mathematics will help you in your daily life?

Country	Sample	Valid N	Agree a lot %	Agree a little %	Disagree a little %	Disagree a lot %	Agree a lot mean	Agree a little mean	Disagree a little mean	Disagree a lot mean
Chinese Taipei	5,042	5,035	30.9	46.9	15.1	7.1	637.9	607.7	597.5	521.5
Ghana	7,323	7,022	84.9	11.2	2.0	2.0	338.1	312.4	287.4	282.0
United States	10,477	10,320	61.7	27.3	7.3	3.7	512.1	511.7	507.8	484.6

Table C21

Question: How much do you agree that you would like a job that involves using mathematics?

Country	Sample	Valid N	Agree a lot %	Agree a little %	Disagree a little %	Disagree a lot %	Agree a lot mean	Agree a little mean	Disagree a little mean	Disagree a lot mean
Chinese Taipei	5,042	5,034	7.4	17.9	41.1	33.6	645.4	645.4	620.4	568.7
Ghana	7,323	6,891	55.5	28.9	7.3	8.3	335.4	340.3	327.7	313.2
United States	10,477	10,300	16.3	28.5	28.1	27.1	526.2	523.9	511.5	487.0

School Climate

Table C22

Question: How would you characterize teachers' understanding of the school's curricular goals within your school?

Country	Sample	Valid N	Very High %	High %	Medium %	Low %	Very Low %	Very High Mean	High Mean	Medium Mean	Low Mean
Chinese Taipei	150	150	16.2	74.1	9.7	0.0	0.0	626.4	605.7	608.4	
Ghana	161	161	15.5	69.4	14.3	0.9	0.0	335.8	331.6	323.2	302.2
United States	501	444	28.4	57.3	13.9	0.4	0.0	519.7	511.1	488.6	472.0

Table C23

Question: How would you characterize teachers' degree of success in implementing the school's curriculum within your school?

Country	Sample	Valid N	Very High %	High %	Medium %	Low %	Very Low %	Very High Mean	High Mean	Medium Mean	Low Mean
Chinese Taipei	150	150	37.6	58.6	3.8	0.0	0.0	613.5	608.4	580.5	
Ghana	161	160	10.7	58.7	28.8	1.7	0.0	344.5	333.5	322.5	322.6
United States	501	444	22.3	52.7	23.8	1.1	0.1	522.9	515.4	488.3	479.3

Table C24

Question: How would you characterize teachers' expectations for student achievement within your school?

Country	Sample	Valid N	Very High %	High %	Medium %	Low %	Very Low %	Very High Mean	High Mean	Medium Mean	Low Mean
Chinese Taipei	150	150	24.0	61.0	13.8	1.3	0.0	624.5	608.5	592.8	541.3
Ghana	161	161	26.0	58.9	13.6	1.5	0.0	350.0	328.3	305.3	328.6
United States	501	443	33.3	48.0	17.2	1.5	0.0	526.4	503.4	500.3	485.4

Table C25

Question: How would you characterize parental support for student achievement within your school?

Country	Sample	Valid N	Very High %	High %	Medium %	Low %	Very Low %	Very High Mean	High Mean	Medium Mean	Low Mean	Very Low Mean
Chinese Taipei	150	150	15.6	53.5	29.1	1.1	0.6	650.4	609.1	591.5	521.3	587.0
Ghana	161	161	3.0	11.6	42.4	32.7	10.2	355.0	346.4	344.1	310.5	316.1
United States	501	443	14.6	33.8	36.6	11.9	3.0	536.1	522.9	499.8	488.5	455.4

Table C26

Question: How would you characterize students' desire to do well in school within your school?

Country	Sample	Valid N	Very High %	High %	Medium %	Low %	Very Low %	Very High Mean	High Mean	Medium Mean	Low Mean	Very Low Mean
Chinese Taipei	150	150	8.7	63.1	27.6	0.6	0.0	661.7	611.7	589.9	483.4	
Ghana	161	161	11.4	36.2	43.6	7.8	1.1	361.8	345.6	315.1	310.2	293.2
United States	501	443	12.7	50.8	32.4	3.7	0.4	529.9	513.4	504.2	465.5	374.0

Table C27

Question: School Emphasis on Academic Success - Principal Reports (Scale)

Country	Sample	Valid N	Mean	Mode	Min	P5	P10	Q1	Median	Q3	P90	P95	Max
Chinese Taipei	150	150	11.4	11.4	4.9	9.1	9.9	10.6	11.4	12.0	13.4	14.2	15.6
Ghana	161	161	10.0	10.6	4.9	7.6	7.6	8.4	9.9	10.6	12.0	13.4	15.6
United States	501	444	10.9	10.6	4.9	7.6	8.4	9.9	10.6	12.0	13.4	15.6	15.6

Table C28

Question: School Emphasis on Academic Success - Principal Reports (Index)

Country	Sample	Valid N	Very High %	High %	Medium %	Low %	Very Low %	Very High Mean	High Mean	Medium Mean	Low Mean	Very Low Mean
Chinese Taipei	150	150	12.3	80.7	7.0	0.0	0.0	657.1	604.6	578.7		
Ghana	161	161	6.4	52.8	40.9	0.0	0.0	374.3	337.5	315.5		
United States	501	444	14.8	60.9	24.4	1.9	9.3	531.6	514.5	486.5	484.8	507.5

Table C29

Question: How would you characterize teachers' understanding of the school's curricular goals within your school?

Country	Sample	Valid N	Very High %	High %	Medium %	Low %	Very Low %	Very High Mean	High Mean	Medium Mean	Low Mean	Very Low Mean
Chinese Taipei	162	162	25.0	58.6	14.9	1.5	0.0	635.2	603.7	592.4	561.2	
Ghana	170	166	34.8	51.0	12.2	2.0	0.0	325.4	336.3	321.1	326.1	
United States	559	439	40.6	45.0	11.5	1.2	1.7	518.4	506.4	505.4	491.5	556.1

Table C30

Question: How would you characterize teachers' degree of success in implementing the school's curriculum within your school?

Country	Sample	Valid N	Very High %	High %	Medium %	Low %	Very Low %	Very High Mean	High Mean	Medium Mean	Low Mean	Very Low Mean
Chinese Taipei	162	161	41.4	50.8	7.4	0.4	0.0	625.2	600.2	592.1	483.8	
Ghana	170	166	27.2	50.9	20.9	1.1	0.0	334.9	332.9	318.5	331.6	
United States	559	440	28.1	50.1	18.7	1.8	1.2	521.8	513.2	494.9	523.7	510.0

Table C31

Question: How would you characterize teachers' expectations for student achievement within your school?

Country	Sample	Valid N	Very High %	High %	Medium %	Low %	Very Low %	Very High Mean	High Mean	Medium Mean	Low Mean	Very Low Mean
Chinese Taipei	162	162	25.0	58.6	14.9	1.5	0.0	635.2	603.7	592.4	561.2	
Ghana	170	166	34.8	51.0	12.2	2.0	0.0	325.4	336.3	321.1	326.1	
United States	559	439	40.6	45.0	11.5	1.2	1.7	518.4	506.4	505.4	491.5	556.1

Table C32

Question: How would you characterize parental support for student achievement within your school?

Country	Sample	Valid N	Very High %	High %	Medium %	Low %	Very Low %	Very High Mean	High Mean	Medium Mean	Low Mean	Very Low Mean
Chinese Taipei	162	162	8.8	41.3	39.2	9.1	1.5	632.3	627.3	595.5	574.1	551.8
Ghana	170	165	2.7	15.4	28.2	31.4	22.3	359.0	375.0	331.3	319.7	309.1
United States	559	436	9.0	25.5	39.0	20.5	6.0	543.2	532.7	511.9	481.6	483.1

Table C33

Question: How would you characterize students' desire to do well in school within your school?

Country	Sample	Valid N	Very High %	High %	Medium %	Low %	Very Low %	Very High Mean	High Mean	Medium Mean	Low Mean	Very Low Mean
Chile	194	183	2.4	21.0	46.4	23.9	6.3	511.4	449.3	414.7	396.1	369.9
Ghana	170	166	16.7	39.7	31.3	10.5	1.8	354.6	345.5	307.9	305.8	312.0
United States	559	441	4.9	26.0	51.0	15.0	3.0	534.5	530.8	508.6	490.7	482.2

Table C34

Scale: School Emphasis on Academic Success - Teacher Reports

Country	Sample	Valid N	Mean	Mode	Min	P5	P10	Q1	Median	Q3	P90	P95	Max
Chinese Taipei	162	162	11.0	10.9	5.0	7.8	8.6	9.4	10.9	12.3	13.7	13.7	16.2
Ghana	170	166	10.7	10.9	5.0	6.7	7.8	9.4	10.9	12.3	12.9	12.9	14.6
United States	559	441	10.8	10.2	5.0	6.7	7.8	9.4	10.9	12.3	13.7	13.7	16.2

Table C35

Question: To what degree is arriving late at school a problem among <eighth-grade> students in your school?

Country	Sample	Valid N	Not a problem %	Minor problem %	Moderate problem %	Serious problem %	Not a problem Mean	Minor problem Mean	Moderate problem Mean	Serious problem Mean
Chinese Taipei	150	150	60.5	36.7	2.7	0.0	613.8	606.4	545.8	
Ghana	161	160	8.8	58.4	23.1	9.8	376.7	334.7	313.6	307.5
United States	501	444	24.5	61.1	13.2	1.2	514.0	516.5	476.6	484.6

Table C36

Question: To what degree is absenteeism a problem among <eighth-grade> students in your school?

Country	Sample	Valid N	Not a problem %	Minor problem %	Moderate problem %	Serious problem %	Not a problem Mean	Minor problem Mean	Moderate problem Mean	Serious problem Mean
Chinese Taipei	150	150	72.3	26.6	1.1	0.0	611.0	604.8	601.7	
Ghana	161	160	8.9	44.8	28.4	17.9	381.6	344.3	307.8	308.6
United States	501	443	26.6	60.8	11.1	1.5	527.3	507.2	488.8	497.3

Table C37

Question: To what degree is classroom disturbance a problem among <eighth-grade> students in your school?

Country	Sample	Valid N	Not a problem %	Minor problem %	Moderate problem %	Serious problem %	Not a problem Mean	Minor problem Mean	Moderate problem Mean	Serious problem Mean
Chinese Taipei	150	150	45.4	50.7	3.9	0.0	611.3	610.1	574.7	
Ghana	161	159	24.1	52.9	20.5	2.5	343.6	320.6	343.3	323.3
United States	501	444	19.0	61.0	17.6	2.4	524.3	509.4	504.5	460.7

Table C38

Question: To what degree is cheating a problem among <eighth-grade> students in your school?

Country	Sample	Valid N	Not a problem %	Minor problem %	Moderate problem %	Serious problem %	Not a problem Mean	Minor problem Mean	Moderate problem Mean	Serious problem Mean
Chinese Taipei	150	150	57.6	40.5	1.9	0.0	608.6	612.2	570.0	
Ghana	161	159	34.4	52.2	10.5	2.9	349.1	326.0	304.8	315.8
United States	501	444	42.2	54.7	3.0	0.1	506.4	514.1	493.8	508.9

Table C39

Question: To what degree is profanity a problem among <eighth-grade> students in your school?

Country	Sample	Valid N	Not a problem %	Minor problem %	Moderate problem %	Serious problem %	Not a problem Mean	Minor problem Mean	Moderate problem Mean	Serious problem Mean
Chinese Taipei	150	150	37.2	52.0	10.8	0.0	605.3	616.8	586.8	
Ghana	161	156	45.1	38.1	13.3	3.4	345.5	316.4	328.8	312.3
United States	501	442	21.5	53.5	20.6	4.4	519.3	512.1	506.1	468.1

Table C40

Question: To what degree is vandalism a problem among <eighth-grade> students in your school?

Country	Sample	Valid N	Not a problem %	Minor problem %	Moderate problem %	Serious problem %	Not a problem Mean	Minor problem Mean	Moderate problem Mean	Serious problem Mean
Chinese Taipei	150	149	48.2	45.3	6.5	0.0	614.4	605.3	599.5	
Ghana	161	159	70.7	17.8	8.4	3.0	337.8	316.6	307.7	314.4
United States	501	443	49.0	46.1	4.6	0.3	513.3	509.7	485.2	423.3

Table C41

Question: To what degree is theft a problem among <eighth-grade> students in your school?

Country	Sample	Valid N	Not a problem %	Minor problem %	Moderate problem %	Serious problem %	Not a problem Mean	Minor problem Mean	Moderate problem Mean	Serious problem Mean
Chinese Taipei	150	150	71.4	27.3	1.2	0.0	609.9	608.0	602.4	
Ghana	161	160	36.2	45.1	14.1	4.6	340.7	330.7	304.1	336.1
United States	501	438	47.4	47.8	4.3	0.5	516.2	505.3	511.4	404.6

Table C42

Question: To what degree is intimidation or verbal abuse among students a problem among <eighth-grade> students in your school?

Country	Sample	Valid N	Not a problem %	Minor problem %	Moderate problem %	Serious problem %	Not a problem Mean	Minor problem Mean	Moderate problem Mean	Serious problem Mean
Chinese Taipei	150	150	50.8	47.3	1.9	0.0	599.4	620.9	584.8	
Ghana	161	160	54.1	34.6	9.2	2.0	336.0	326.2	315.8	339.7
United States	501	442	7.7	60.4	28.2	3.7	508.5	516.4	499.2	501.9

Table C43

Question: To what degree is physical injury to other students a problem among <eighth-grade> students in your school?

Country	Sample	Valid N	Not a problem %	Minor problem %	Moderate problem %	Serious problem %	Not a problem Mean	Minor problem Mean	Moderate problem Mean	Serious problem Mean
Chinese Taipei	150	149	70.0	28.9	1.2	0.0	608.4	612.3	593.0	
Ghana	161	160	63.4	31.0	3.5	2.0	330.7	334.0	307.5	327.8
United States	501	441	49.9	46.8	3.2	0.2	519.3	503.1	481.2	416.1

Table C44

Question: To what degree is intimidation or verbal abuse of teachers or staff a problem among <eighth-grade> students in your school?

Country	Sample	Valid N	Not a problem %	Minor problem %	Moderate problem %	Serious problem %	Not a problem Mean	Minor problem Mean	Moderate problem Mean	Serious problem Mean
Chinese Taipei	150	150	79.8	19.6	0.6	0.0	609.6	609.5	560.2	
Ghana	161	160	75.4	17.4	4.7	2.5	336.1	314.7	289.1	365.8
United States	501	440	64.0	30.7	4.1	1.2	513.8	503.6	511.0	462.9

Table C45

Question: To what degree is physical injury to teachers or staff a problem among <eighth-grade> students in your school?

Country	Sample	Valid N	Not a problem %	Minor problem %	Moderate problem %	Serious problem %	Not a problem Mean	Minor problem Mean	Moderate problem Mean	Serious problem Mean
Chinese Taipei	150	148	95.1	4.9	0.0	0.0	609.0	613.2		
Ghana	161	160	92.0	4.3	1.0	2.7	333.2	294.5	247.2	340.3
United States	501	439	93.6	5.9	0.3	0.2	511.4	491.6	513.7	416.1

Table C46

TIMMS-Derived Scale: School Discipline and Safety

Country	Sample	Valid N	Mean	Mode	Min	P5	P10	Q1	Median	Q3	P90	P95	Max
Chinese Taipei	150	150	11.4	14.0	7.7	9.0	9.2	10.1	11.2	12.7	14.0	14.0	14.0
Ghana	161	160	10.0	9.8	4.0	8.0	8.5	9.0	9.8	11.2	11.6	12.1	14.0
United States	501	444	10.1	9.5	6.3	8.0	8.5	9.2	9.8	10.8	12.1	12.7	14.0

School Resources

Table C47

Question: Computers Available for Instruction

Country	Sample	Valid N	1 for 1-2 students %	1 for 3-5 students %	1 for 6 or more students %	No computers %	1 for 1-2 students mean	1 for 3-5 students mean	1 for 6 or more students mean	No computers mean
Chinese Taipei	150	147	5.7	17.5	76.0	0.7	619.5	591.1	613.8	507.3
Ghana	161	147	41.5	12.9	30.8	14.9	325.8	359.2	342.1	301.9
United States	501	436	58.4	32.3	9.3	0.0	512.1	506.6	511.5	

Table C48

Question: How much is your school's capacity to provide instruction affected by a shortage or inadequacy of instructional materials?

Country	Sample	Valid N	Not at all %	A little %	Some %	A lot %	Not at all Mean	A little Mean	Some Mean	A lot Mean
Chinese Taipei	150	150	86.8	6.1	1.3	5.8	608.6	623.3	524.4	624.5
Ghana	161	161	3.8	26.7	54.6	14.9	322.3	333.3	325.0	350.0
United States	501	444	54.7	26.7	12.3	6.2	510.7	512.4	493.8	529.0

Table C49

Question: How much is your school's capacity to provide instruction affected by a shortage or inadequacy of supplies?

Country	Sample	Valid N	Not at all %	A little %	Some %	A lot %	Not at all Mean	A little Mean	Some Mean	A lot Mean
Chinese Taipei	150	150	75.3	15.5	4.4	4.8	614.1	586.3	598.2	618.4
Ghana	161	158	36.9	27.2	27.8	8.1	332.8	307.5	338.5	369.0
United States	501	443	61.4	24.3	9.6	4.8	512.2	507.1	504.3	512.1

Table C50

Question: How much is your school's capacity to provide instruction affected by a shortage or inadequacy of school buildings and grounds?

Country	Sample	Valid N	Not at all %	A little %	Some %	A lot %	Not at all Mean	A little Mean	Some Mean	A lot Mean
Chinese Taipei	150	149	28.6	32.5	25.2	13.7	613.4	605.4	603.9	618.2
Ghana	161	160	14.7	18.4	47.1	19.8	326.8	322.4	326.6	351.5
United States	501	439	64.6	18.0	10.8	6.6	510.8	512.1	501.2	525.1

Table C51

Question: How much is your school's capacity to provide instruction affected by a shortage or inadequacy of heating/cooling and lighting systems?

Country	Sample	Valid N	Not at all %	A little %	Some %	A lot %	Not at all Mean	A little Mean	Some Mean	A lot Mean
Chinese Taipei	150	150	42.9	33.2	17.2	6.6	619.8	602.0	599.7	603.0
Ghana	161	160	44.4	20.4	23.0	12.2	321.6	346.7	334.9	333.4
United States	501	442	69.4	14.3	9.2	7.2	508.8	509.0	506.5	531.9

Table C52

Question: How much is your school's capacity to provide instruction affected by a shortage or inadequacy of instructional space?

Country	Sample	Valid N	Not at all %	A little %	Some %	A lot %	Not at all Mean	A little Mean	Some Mean	A lot Mean
Chinese Taipei	150	149	35.5	30.2	21.4	12.9	610.0	611.9	612.4	598.4
Ghana	161	160	11.9	23.6	48.7	15.8	320.3	312.6	332.3	355.6
United States	501	444	50.6	27.9	13.1	8.3	508.9	510.4	514.0	511.5

Table C53

Question: How much is your school's capacity to provide instruction affected by a shortage or inadequacy of technologically competent staff?

Country	Sample	Valid N	Not at all %	A little %	Some %	A lot %	Not at all Mean	A little Mean	Some Mean	A lot Mean
Chinese Taipei	150	147	29.9	35.1	27.7	7.2	616.9	609.5	603.5	601.8
Ghana	161	160	14.7	34.0	40.3	11.0	324.2	332.8	330.1	338.1
United States	501	436	38.3	34.9	21.6	5.2	510.0	512.2	509.6	502.6

Table C54

Question: How much is your school's capacity to provide instruction affected by a shortage or inadequacy of teachers with a specialization in mathematics?

Country	Sample	Valid N	Not at all %	A little %	Some %	A lot %	Not at all Mean	A little Mean	Some Mean	A lot Mean
Chinese Taipei	150	150	72.0	17.0	2.6	8.4	609.4	609.0	589.2	614.7
Ghana	161	159	20.7	32.2	37.1	10.1	311.8	337.8	333.2	344.5
United States	501	443	66.7	17.8	8.7	6.8	509.5	517.9	500.6	506.5

Table C55

Question: How much is your school's capacity to provide instruction affected by a shortage or inadequacy of computers for mathematics instruction?

Country	Sample	Valid N	Not at all %	A little %	Some %	A lot %	Not at all Mean	A little Mean	Some Mean	A lot Mean
Chinese Taipei	150	150	39.5	33.6	21.6	5.3	610.9	612.6	595.6	631.6
Ghana	161	160	75.5	5.1	8.3	11.1	328.4	336.9	362.5	320.5
United States	501	441	38.6	31.1	22.8	7.5	514.7	512.2	503.8	496.7

Table C56

Question: How much is your school's capacity to provide instruction affected by a shortage or inadequacy of computer software for mathematics instruction?

Country	Sample	Valid N	Not at all %	A little %	Some %	A lot %	Not at all Mean	A little Mean	Some Mean	A lot Mean
Chinese Taipei	150	150	23.8	31.4	38.9	5.8	611.2	616.5	601.1	617.4
Ghana	161	161	76.2	6.6	3.9	13.4	327.9	338.2	381.4	329.5
United States	501	443	30.9	35.9	26.1	7.1	519.9	508.7	502.3	501.9

Table C57

Question: How much is your school's capacity to provide instruction affected by a shortage or inadequacy of library materials relevant to mathematics instruction?

Country	Sample	Valid N	Not at all %	A little %	Some %	A lot %	Not at all Mean	A little Mean	Some Mean	A lot Mean
Chinese Taipei	150	149	21.6	36.1	32.7	9.6	599.4	625.5	607.3	584.1
Ghana	161	161	54.5	23.0	9.9	12.5	322.5	338.9	361.1	328.2
United States	501	442	28.7	39.8	24.7	6.8	516.7	508.2	510.9	499.7

Table C58

Question: How much is your school's capacity to provide instruction affected by a shortage or inadequacy of audio-visual resources for mathematics instruction?

Country	Sample	Valid N	Not at all %	A little %	Some %	A lot %	Not at all Mean	A little Mean	Some Mean	A lot Mean
Chile	193	172	15.7	36.2	29.9	18.2	435.0	427.4	408.7	396.5
Ghana	161	161	74.8	6.9	4.3	14.1	328.6	344.2	347.7	331.0
United States	501	443	37.3	38.9	18.0	5.8	513.2	513.7	498.6	500.9

Table C59

Question: How much is your school's capacity to provide instruction affected by a shortage or inadequacy of calculators for mathematics instruction?

Country	Sample	Valid N	Not at all %	A little %	Some %	A lot %	Not at all Mean	A little Mean	Some Mean	A lot Mean
Chinese Taipei	150	150	34.0	35.6	23.2	7.3	602.3	620.0	601.0	615.8
Ghana	161	161	64.4	15.5	7.8	12.4	333.8	314.7	338.5	330.9
United States	501	441	59.6	24.1	9.6	6.7	512.8	512.5	490.1	509.2

Administrator Leadership

Table C60

Question: During the past year, approximately how much time have you spent keeping an orderly atmosphere in the school in your role as school principal?

Country	Sample	Valid N	No time %	Some time %	A lot of time %	No time Mean	Some time Mean	A lot of time Mean
Chinese Taipei	150	150	0.0	25.1	74.9		617.1	606.6
Ghana	161	161	1.1	10.4	88.6	285.7	332.0	331.2
United States	501	439	0.4	24.4	75.2	493.6	517.1	508.1

Table C61

Question: During the past year, approximately how much time have you spent ensuring that there are clear rules for student behavior in your role as school principal?

Country	Sample	Valid N	No time %	Some time %	A lot of time %	No time Mean	Some time Mean	A lot of time Mean
Chinese Taipei	150	150	0.8	36.5	62.8	583.1	612.7	607.6
Ghana	161	160	0.5	17.2	82.3	275.3	324.2	331.4
United States	501	437	0.7	31.8	67.5	514.9	513.8	508.2

Table C62

Question: During the past year, approximately how much time have you spent addressing disruptive student behavior in your role as school principal?

Country	Sample	Valid N	No time %	Some time %	A lot of time %	No time Mean	Some time Mean	A lot of time Mean
Chinese Taipei	150	150	7.0	71.3	21.6	582.4	612.0	609.0
Ghana	161	160	0.7	42.3	57.0	311.6	330.9	330.7
United States	501	438	1.9	52.1	46.0	533.2	515.7	503.0

Table C63

Question: During the past year, approximately how much time have you spent creating a climate of trust among teachers in your role as school principal?

Country	Sample	Valid N	No time %	Some time %	A lot of time %	No time Mean	Some time Mean	A lot of time Mean
Chinese Taipei	150	150	0.7	31.2	68.1	596.7	604.0	611.8
Ghana	161	161	1.8	22.7	75.5	296.0	340.6	328.7
United States	501	439	2.7	39.4	57.9	505.4	506.9	512.8

Table C64

Question: During the past year, approximately how much time have you spent participating in professional development activities specifically for school principals in your role as school principal?

Country	Sample	Valid N	No time %	Some time %	A lot of time %	No time Mean	Some time Mean	A lot of time Mean
Chinese Taipei	150	149	1.4	67.5	31.1	597.2	606.4	615.8
Ghana	161	160	7.3	56.9	35.7	351.6	321.6	338.7
United States	501	438	5.6	58.4	36.0	511.5	510.2	509.4

School Socioeconomic Status

Table C65

Question: Approximately what percentage of students in your school come from economically disadvantaged homes?

Country	Sample	Valid N	0 to 10% %	11 to 25% %	26 to 50% %	More than 50% %	0 to 10% Mean	10 to 25% Mean	26 to 50% Mean	More than 50% Mean
Chinese Taipei	150	147	47.0	39.4	10.2	3.4	620.5	603.2	595.7	522.8
Ghana	161	159	6.7	8.6	12.0	72.6	367.1	355.8	353.7	319.7
United States	501	449	17.6	17.9	23.6	40.9	540.9	541.4	508.1	483.8

Table C66

Question: Approximately what percentage of students in your school come from economically affluent homes?

Country	Sample	Valid N	0 to 10% %	11 to 25% %	26 to 50% %	More than 50% %	0 to 10% Mean	10 to 25% Mean	26 to 50% Mean	More than 50% Mean
Chinese Taipei	150	146	62.1	19.7	14.0	4.2	593.0	620.9	655.1	653.6
Ghana	161	148	64.9	19.4	12.0	3.7	316.6	348.2	347.5	363.1
United States	501	440	46.5	21.5	17.5	14.4	492.2	518.0	530.3	533.9

Table C67

Question: To what extent does students' lacking prerequisite knowledge or skills limit how you teach this class?

Country	Sample	Valid N	Not applicable %	Not at all %	Some %	A lot %	Not applicable mean	Not at all mean	Some mean	A lot mean
Chinese Taipei	162	161	0.7	11.0	45.6	42.6	739.0	640.9	616.5	590.7
Ghana	170	164	3.9	11.4	70.0	14.7	338.0	342.7	332.4	310.9
United States	559	415	1.7	10.4	58.7	29.3	551.5	568.3	516.4	480.4

Table C68

Question: To what extent does students' suffering from lack of basic nutrition limit how you teach this class?

Country	Sample	Valid N	Not applicable %	Not at all %	Some %	A lot %	Not applicable mean	Not at all mean	Some mean	A lot mean
Chinese Taipei	162	162	33.5	45.0	19.8	1.8	613.7	601.9	620.2	591.2
Ghana	170	164	18.0	20.8	47.5	13.6	359.0	334.3	324.4	302.3
United States	559	416	10.2	57.9	30.6	1.3	521.0	523.7	489.1	448.3

Table C69

Question: To what extent does students' suffering from not enough sleep limit how you teach this class?

Country	Sample	Valid N	Not applicable %	Not at all %	Some %	A lot %	Not applicable mean	Not at all mean	Some mean	A lot mean
Chinese Taipei	162	161	6.6	17.8	51.6	24.0	612.9	608.9	606.1	615.3
Ghana	170	164	15.2	17.6	53.0	14.1	348.0	338.4	326.8	309.7
United States	559	416	3.1	18.8	67.2	10.9	530.9	544.8	506.0	485.3

Table C70

Question: To what extent does having disruptive students limit how you teach this class?

Country	Sample	Valid N	Not applicable %	Not at all %	Some %	A lot %	Not applicable mean	Not at all mean	Some mean	A lot mean
Chinese Taipei	162	162	8.2	27.2	38.7	25.9	637.3	612.3	604.9	603.9
Ghana	170	164	9.0	26.7	59.3	5.1	322.0	337.2	330.2	314.5
United States	559	416	0.8	24.6	60.6	14.0	554.8	548.6	505.6	472.0

Table C71

Question: To what extent does having uninterested students limit how you teach this class?

Country	Sample	Valid N	Not applicable %	Not at all %	Some %	A lot %	Not applicable mean	Not at all mean	Some mean	A lot mean
Chinese Taipei	162	162	1.9	5.2	45.0	47.9	635.3	647.1	618.0	596.0
Ghana	170	165	8.5	27.2	57.5	6.7	349.7	351.8	322.5	288.3
United States	559	414	0.8	13.2	67.5	18.6	554.8	568.7	507.9	485.4

Access and Equity

Table C72

Question: How many days per year is your school open for instruction?

Country	Sample	Valid N	Mean	Mode	Min	P5	P10	Q1	Median	Q3	P90	P95	Max
Chinese Taipei	150	147	200.8	200.0	171.0	192.0	200.0	200.0	200.0	200.0	206.0	210.0	240.0
Ghana	161	138	193.3	200.0	164.0	179.0	180.0	182.0	189.0	200.0	210.0	220.0	275.0
United States	501	443	179.4	180.0	160.0	173.0	175.0	178.0	180.0	180.0	185.0	187.0	200.0

Table C73

Question: In one calendar week, how many days is the school open for instruction?

Country	Sample	Valid N	6 days %	5 ½ days %	5 days %	4 ½ days %	6 days mean	5 ½ days mean	5 days mean	4 ½ days mean
Chinese Taipei	150	149	0.6	2.9	96.5	0.0	674.0	692.1	606.3	
Ghana	161	159	1.3	0.0	98.7	0.0	364.9		329.2	
United States	501	447	0.6	1.3	97.0	0.7	467.2	464.2	511.4	477.6

Table C74

Question: Days per Week for Instruction

Country	Sample	Valid N	Mean	Mode	Min	P5	P10	Q1	Median	Q3	P90	P95	Max
Chinese Taipei	150	149	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	6.0
Ghana	210	209	5.8	6.0	5.0	5.0	5.0	6.0	6.0	6.0	6.0	6.0	6.0
United States	193	170	5.0	5.0	4.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	6.0

Table C75

Question: In a typical week, how much time (hours) do you spend teaching mathematics to the students in this class?

Country	Sample	Valid N	Mean	Mode	Min	P5	P10	Q1	Median	Q3	P90	P95	Max
Chinese Taipei	162	161	3.7	3.0	2.0	3.0	3.0	3.0	4.0	4.0	5.0	5.0	7.0
Ghana	170	152	3.8	3.0	0.0	0.0	2.0	3.0	3.0	4.0	6.0	7.0	10.0
United States	559	412	4.0	4.0	0.0	1.0	3.0	3.0	4.0	5.0	6.0	7.0	9.0

Table C76

Question: Hours per Week for Mathematics Instruction

Country	Sample	Valid N	Mean	Mode	Min	P5	P10	Q1	Median	Q3	P90	P95	Max
Chinese Taipei	162	161	4.2	3.8	2.7	3.0	3.0	3.8	4.1	4.5	5.0	5.3	7.0
Ghana	170	152	4.2	3.5	0.0	0.9	2.8	3.5	3.8	4.7	6.8	7.0	10.0
United States	559	412	4.4	3.8	0.0	1.7	3.2	3.8	4.2	5.0	6.7	7.5	9.4

Table C77

Question: When have the students in the TIMSS class been taught the topic of representing, comparing, ordering, and computing with integers?

Country	Sample	Valid N	Mostly taught before this year %	Mostly taught this year %	Not yet taught or just introduced %	Not administered %	Mostly taught before this year mean	Mostly taught this year mean	Not yet taught or just introduced mean	Not administered mean
Chinese Taipei	162	162	98.2	1.8	0.0	0.0	610.0	568.4		
Ghana	170	166	77.8	21.1	1.0	1.0	333.2	325.7	280.4	347.7
United States	559	406	67.5	31.5	1.0	23.7	521.8	494.2	399.6	498.0

Table C78

Question: When have the students in the TIMSS class been taught the topic of problem solving involving percents and proportions?

Country	Sample	Valid N	Mostly taught before this year %	Mostly taught this year %	Not yet taught or just introduced %	Not administered %	Mostly taught before this year mean	Mostly taught this year mean	Not yet taught or just introduced mean	Not administered mean
Chinese Taipei	162	162	95.4	1.8	2.8	0.0	609.5	561.8	633.3	
Ghana	170	163	43.8	41.5	14.6	1.0	333.1	335.8	310.2	347.7
United States	559	412	59.7	39.0	1.3	23.7	527.0	490.0	484.9	498.0

Table C79

Question: When have the students in the TIMSS class been taught the topic of numeric, algebraic, and geometric patterns or sequences?

Country	Sample	Valid N	Mostly taught before this year %	Mostly taught this year %	Not yet taught or just introduced %	Not administered %	Mostly taught before this year mean	Mostly taught this year mean	Not yet taught or just introduced mean	Not administered mean
Chinese Taipei	162	162	58.0	42.0	0.0	0.0	606.3	613.4		
Ghana	170	164	42.0	45.8	12.2	1.0	338.9	326.9	322.0	347.7
United States	559	414	36.1	54.3	9.6	23.7	528.3	508.6	475.4	498.0

Table C80 *Question: When have the students in the TIMSS class been taught the topic of simplifying and evaluating algebraic expressions?*

Country	Sample	Valid N	Mostly taught before this year %	Mostly taught this year %	Not yet taught or just introduced %	Not administered %	Mostly taught before this year mean	Mostly taught this year mean	Not yet taught or just introduced mean	Not administered mean
Chinese Taipei	162	162	91.7	8.3	0.0	0.0	610.8	592.3		
Ghana	170	165	44.9	52.1	3.0	1.0	339.0	326.1	317.4	347.7
United States	559	413	18.7	76.9	4.3	23.7	541.5	507.9	466.7	498.0

Table C81

Question: When have the students in the TIMSS class been taught the topic of simple linear equations and inequalities?

Country	Sample	Valid N	Mostly taught before this year %	Mostly taught this year %	Not yet taught or just introduced %	Not administered %	Mostly taught before this year mean	Mostly taught this year mean	Not yet taught or just introduced mean	Not administered mean
Chinese Taipei	162	161	95.7	4.3	0.0	0.0	610.5	576.2		
Ghana	170	165	43.6	54.6	1.7	1.0	335.0	327.6	321.3	347.7
United States	559	413	13.8	75.9	10.3	23.7	555.2	510.1	474.6	498.0

Table C82

Question: When have the students in the TIMSS class been taught the topic of simultaneous (two variables) equations?

Country	Sample	Valid N	Mostly taught before this year %	Mostly taught this year %	Not yet taught or just introduced %	Not administered %	Mostly taught before this year mean	Mostly taught this year mean	Not yet taught or just introduced mean	Not administered mean
Chinese Taipei	162	162	95.6	4.4	0.0	0.0	609.6	601.8		
Ghana	170	165	8.6	23.2	68.2	1.0	330.6	336.2	329.1	347.7
United States	559	412	4.6	58.4	37.0	23.7	562.2	523.1	489.6	498.0

Table C83

Question: When have the students in the TIMSS class been taught the topic of representation of functions as ordered pairs, tables, graphs, words, or equations?

Country	Sample	Valid N	Mostly taught before this year %	Mostly taught this year %	Not yet taught or just introduced %	Not administered %	Mostly taught before this year mean	Mostly taught this year mean	Not yet taught or just introduced mean	Not administered mean
Chinese Taipei	162	162	61.7	25.1	13.2	0.0	616.9	599.2	592.9	
Ghana	170	164	17.4	52.2	30.5	1.0	334.9	333.4	326.1	347.7
United States	559	410	8.2	80.7	11.1	23.7	543.4	511.9	491.6	498.0

Table C84

Question: When have the students in the TIMSS class been taught the topic of points on the Cartesian plane?

Country	Sample	Valid N	Mostly taught before this year %	Mostly taught this year %	Not yet taught or just introduced %	Not administered %	Mostly taught before this year mean	Mostly taught this year mean	Not yet taught or just introduced mean	Not administered mean
Chinese Taipei	162	161	92.2	7.8	0.0	0.0	610.0	601.0		
Ghana	170	163	17.4	45.1	37.5	1.0	326.7	341.5	322.5	347.7
United States	559	412	60.2	29.4	10.4	23.7	525.9	496.0	480.4	498.0

Instructional Materials

Table C85

Question: When you teach mathematics to this class, how do you use textbooks?

Country	Sample	Valid N	Basis for instruction %	Supplement %	Not used %	Basis for instruction mean	Supplement mean	Not used mean
Chinese Taipei	162	162	91.9	6.6	1.6	607.0	640.0	611.5
Ghana	170	165	56.3	41.6	2.1	328.5	334.7	319.4
United States	559	414	48.0	42.6	9.4	521.6	504.7	498.9

Table C86

Question: When you teach mathematics to this class, how do you use workbooks or worksheets?

Country	Sample	Valid N	Basis for instruction %	Supplement %	Not used %	Basis for instruction mean	Supplement mean	Not used mean
Chinese Taipei	162	162	48.5	50.3	1.2	602.6	613.1	714.9
Ghana	170	165	26.6	50.6	22.8	330.9	327.4	338.6
United States	559	414	18.9	77.0	4.1	490.2	517.2	520.4

Table C87

Question: When you teach mathematics to this class, how do you use concrete objects or materials that help students understand quantities or procedures?

Country	Sample	Valid N	Basis for instruction %	Supplement %	Not used %	Basis for instruction mean	Supplement mean	Not used mean
Chinese Taipei	162	162	5.5	90.3	4.2	628.1	609.3	584.6
Ghana	170	165	50.2	42.1	7.7	331.5	332.1	320.2
United States	559	415	16.9	74.6	8.5	502.9	514.5	510.7

Table C88

Question: When you teach mathematics to this class, how do you use computer software for mathematics instruction?

Country	Sample	Valid N	Basis for instruction %	Supplement %	Not used %	Basis for instruction mean	Supplement mean	Not used mean
Chinese Taipei	162	162	0.7	52.2	47.1	507.3	608.3	611.9
Ghana	170	165	0.9	7.4	91.7	300.8	352.6	329.4
United States	559	415	14.0	62.2	23.8	514.0	512.7	509.8

Instruction

Table C89

Question: How often do you summarize what students should have learned from the lesson in teaching this class?

Country	Sample	Valid N	Every or almost every lesson %	About half the lessons %	Some lessons %	Never %	Every or almost every lesson mean	About half the lessons mean	Some lessons mean	Never mean
Chinese Taipei	162	162	57.7	26.8	15.5	0.0	613.2	601.8	607.7	
Ghana	170	166	87.3	7.8	4.9	0.0	329.9	337.1	342.9	
United States	559	414	79.2	14.8	6.0	0.1	512.3	506.6	520.1	482.3

Table C90

Question: How often do you use questioning to elicit reasons and explanations in teaching this class?

Country	Sample	Valid N	Every or almost every lesson %	About half the lessons %	Some lessons %	Never %	Every or almost every lesson mean	About half the lessons mean	Some lessons mean	Never mean
Chinese Taipei	162	161	51.5	31.6	17.0	0.0	613.6	605.0	605.3	
Ghana	170	166	73.4	15.7	9.5	1.4	328.6	328.0	352.0	355.0
United States	559	412	82.1	15.0	2.8	0.1	512.6	506.6	513.7	421.9

Table C91

Question: How often do you encourage all students to improve their performance in teaching this class?

Country	Sample	Valid N	Every or almost every lesson %	About half the lessons %	Some lessons %	Never %	Every or almost every lesson mean	About half the lessons mean	Some lessons mean	Never mean
Chinese Taipei	162	162	42.9	28.9	28.3	0.0	618.0	610.7	594.6	
Ghana	170	166	93.8	4.1	1.3	0.8	333.3	295.6	291.0	324.1
United States	559	414	91.6	7.1	1.3	0.0	511.1	525.6	503.2	

Table C92

Question: How often do you praise students for good effort in teaching this class?

Country	Sample	Valid N	Every or almost every lesson %	About half the lessons %	Some lessons %	Never %	Every or almost every lesson mean	About half the lessons mean	Some lessons mean	Never mean
Chinese Taipei	162	162	43.3	28.3	28.4	0.0	616.9	597.9	609.0	
Ghana	170	166	89.0	7.1	3.0	0.8	330.9	333.4	332.3	324.1
United States	559	413	90.8	8.7	0.2	0.4	508.9	538.6	524.0	554.0

Table C93

Question: In teaching mathematics to this class, how often do you usually ask students to work problems with your guidance?

Country	Sample	Valid N	Every or almost every lesson %	About half the lessons %	Some lessons %	Never %	Every or almost every lesson mean	About half the lessons mean	Some lessons mean	Never mean
Chinese Taipei	162	162	36.3	29.4	33.4	0.9	605.4	608.9	614.1	600.9
Ghana	170	166	68.8	20.7	10.5	0.0	328.7	329.0	348.8	
United States	559	414	75.4	16.8	7.8	0.0	510.7	517.7	514.8	

Table C94

Question: In teaching mathematics to this class, how often do you usually ask students to explain their answers?

Country	Sample	Valid N	Every or almost every lesson %	About half the lessons %	Some lessons %	Never %	Every or almost every lesson mean	About half the lessons mean	Some lessons mean	Never mean
Chinese Taipei	162	161	19.6	27.7	52.0	0.7	619.9	617.3	603.2	493.5
Ghana	170	164	67.5	16.2	16.3	0.0	334.4	321.5	325.8	
United States	559	414	63.8	24.1	11.9	0.2	515.8	502.2	513.6	521.1

Table C95

Question: In teaching mathematics to this class, how often do you usually ask students to relate what they are learning in mathematics to their daily lives?

Country	Sample	Valid N	Every or almost every lesson %	About half the lessons %	Some lessons %	Never %	Every or almost every lesson mean	About half the lessons mean	Some lessons mean	Never mean
Chinese Taipei	162	162	12.4	26.3	61.4	0.0	615.5	602.8	610.8	
Ghana	170	166	61.4	23.1	15.6	0.0	329.1	325.1	346.6	
United States	559	413	26.3	37.5	33.7	2.5	509.3	511.2	516.5	500.9

Table C96

Question: In teaching mathematics to this class, how often do you usually ask students to decide on their own procedures for solving complex problems?

Country	Sample	Valid N	Every or almost every lesson %	About half the lessons %	Some lessons %	Never %	Every or almost every lesson mean	About half the lessons mean	Some lessons mean	Never mean
Chinese Taipei	162	162	14.0	26.8	56.4	2.8	606.2	620.7	608.7	526.9
Ghana	170	165	26.0	23.1	41.8	9.1	338.6	320.8	333.7	325.4
United States	559	411	26.3	34.6	36.1	3.0	517.9	513.4	508.6	505.8

Table C97

Question: In teaching mathematics to this class, how often do you usually ask students to work on problems for which there is no immediately obvious method of solution?

Country	Sample	Valid N	Every or almost every lesson %	About half the lessons %	Some lessons %	Never %	Every or almost every lesson mean	About half the lessons mean	Some lessons mean	Never mean
Chinese Taipei	162	162	8.0	24.7	62.5	4.8	625.4	614.9	609.4	552.2
Ghana	170	162	14.8	19.9	50.0	15.3	333.5	322.4	333.1	331.7
United States	559	414	10.9	25.7	50.4	13.0	522.7	513.4	510.5	505.9

Tools and Technology

Table C98

Question: How often do students in this class use calculators in their mathematics lessons for checking answers?

Country	Sample	Valid N	Every or almost every lesson %	About half the lessons %	Some lessons %	Never %	Every or almost every lesson mean	About half the lessons mean	Some lessons mean	Never mean
Chinese Taipei	162	156	0.5	2.2	24.3	19.1	640.1	593.5	586.4	621.1
Ghana	170	146	1.4	1.1	18.1	0.9	344.6	369.4	300.1	254.1
United States	559	410	45.2	15.3	24.8	3.2	520.9	502.7	509.4	516.1

Table C99

Question: How often do students in this class use calculators in their mathematics lessons for doing routine computations?

Country	Sample	Valid N	Every or almost every lesson %	About half the lessons %	Some lessons %	Never %	Every or almost every lesson mean	About half the lessons mean	Some lessons mean	Never mean
Chinese Taipei	162	157	0.0	2.0	31.0	13.5	2.3		605.5	593.4
Ghana	170	147	0.5	4.7	12.9	4.0	12.7	411.0	332.4	292.8
United States	559	408	38.0	19.1	21.3	10.0	2.6	518.7	506.2	512.7

Table C100

Question: How often do students in this class use calculators in their mathematics lessons for exploring number concepts?

Country	Sample	Valid N	Every or almost every lesson %	About half the lessons %	Some lessons %	Never %	Every or almost every lesson mean	About half the lessons mean	Some lessons mean	Never mean
Chinese Taipei	162	156	0.0	1.0	26.8	18.3		595.6	596.4	609.8
Ghana	170	147	3.3	3.7	11.4	3.8	306.4	343.1	307.0	289.3
United States	559	409	33.5	17.1	32.5	5.3	521.0	507.3	510.1	523.2

Table C101

Question: How often do you have the students explore mathematics principles and concepts on the computer?

Country	Sample	Valid N	Every or almost every lesson %	About half the lessons %	Some lessons %	Never %	Every or almost every lesson mean	About half the lessons mean	Some lessons mean	Never mean
Chinese Taipei	162	161	0.0	1.1	6.4	15.9		533.8	595.3	622.9
Ghana	170	164	1.3	3.4	1.6	8.7	344.6	340.4	399.1	312.5
United States	559	412	3.6	5.4	15.6	19.1	503.2	471.6	513.7	505.3

Table C102

Question: How often do you have the students practice skills and procedures on the computer?

Country	Sample	Valid N	Every or Almost Every Day %	Once or Twice a Week %	Once Twice a Month %	Never Or Almost Never %	Not applicable %	Every or Almost Every Day Mean	Once or Twice a Week Mean	Once Twice a Month Mean	Never Or Almost Never Mean	Not applicable mean
Chinese Taipei	162	160	0.6	0.0	3.0	19.3	77.1	560.2		600.5	614.4	609.1
Ghana	170	164	1.6	3.1	1.6	8.7	85.0	335.8	344.5	399.1	312.5	331.2
United States	559	412	4.8	7.8	14.7	16.3	56.4	495.3	490.4	506.3	510.9	518.4

Table C103

Question: How often do you have the students look up ideas and information on the computer?

Country	Sample	Valid N	Every or Almost Every Day %	Once or Twice a Week %	Once Twice a Month %	Never Or Almost Never %	Not applicable %	Every or Almost Every Day Mean	Once or Twice a Week Mean	Once Twice a Month Mean	Never Or Almost Never Mean	Not applicable mean
Chinese Taipei	162	160	0.6	1.2	4.0	17.0	77.1	581.9	579.9	608.7	615.3	609.1
Ghana	170	164	0.9	4.5	1.0	8.7	85.0	302.9	371.1	338.3	312.5	331.2
United States	559	412	1.1	5.8	13.2	23.5	56.4	496.0	485.6	505.7	507.9	518.4

Table C104

Question: How often do you have the students process and analyze data on the computer?

Country	Sample	Valid N	Every or Almost Every Day %	Once or Twice a Week %	Once Twice a Month %	Never Or Almost Never %	Not applicable %	Every or Almost Every Day Mean	Once or Twice a Week Mean	Once Twice a Month Mean	Never Or Almost Never Mean	Not applicable mean
Chinese Taipei	162	160	0.0	0.6	4.3	18.1	77.1		560.2	597.7	616.1	609.1
Ghana	170	164	1.3	3.6	1.1	9.1	85.0	344.6	346.8	372.9	317.7	331.2
United States	559	411	1.9	4.3	14.8	22.5	56.5	493.4	476.5	509.5	506.1	518.4

Assessment

Table C105

Question: How much emphasis do you place on the evaluation of students' ongoing work to monitor students' progress in mathematics?

Country	Sample	Valid N	Major emphasis %	Some emphasis %	Little or no emphasis %	Major emphasis mean	Some emphasis mean	Little or no emphasis mean
Chinese Taipei	162	161	61.4	35.5	3.2	612.9	605.0	592.1
Ghana	170	164	90.3	8.9	0.8	331.1	337.3	254.1
United States	559	410	72.9	25.5	1.6	507.1	526.3	525.0

Table C106

Question: How much emphasis do you place on classroom tests to monitor students' progress in mathematics?

Country	Sample	Valid N	Major emphasis %	Some emphasis %	Little or no emphasis %	Major emphasis mean	Some emphasis mean	Little or no emphasis mean
Chinese Taipei	162	161	72.4	27.6	0.0	614.7	595.6	
Ghana	170	164	86.6	12.7	0.8	332.9	323.3	254.1
United States	559	409	81.9	18.1	0.0	515.2	499.3	

Table C107

Question: How much emphasis do you place on national or regional achievement tests to monitor students' progress in mathematics?

Country	Sample	Valid N	Major emphasis %	Some emphasis %	Little or no emphasis %	Major emphasis mean	Some emphasis mean	Little or no emphasis mean
Chinese Taipei	162	160	22.6	53.9	23.4	613.2	613.1	596.1
Ghana	170	164	40.7	39.1	20.2	326.5	326.2	349.9
United States	559	410	28.8	49.0	22.2	499.1	520.8	509.4

Table C108

Question: How often do you include questions involving application of mathematical procedures in your mathematics tests or examinations?

Country	Sample	Valid N	Always or almost always %	Sometimes %	Never or almost never %	Always or almost always mean	Sometimes mean	Never or almost never mean
Chinese Taipei	162	162	57.2	42.1	0.7	617.5	597.8	626.6
Ghana	170	163	72.8	27.2	0.0	334.2	322.5	
United States	559	410	83.0	16.6	0.4	512.1	514.1	508.2

Table C109

Question: How often do you include questions involving searching for patterns and relationships in your mathematics tests or examinations?

Country	Sample	Valid N	Always or almost always %	Sometimes %	Never or almost never %	Always or almost always mean	Sometimes mean	Never or almost never mean
Chinese Taipei	162	162	46.3	53.0	0.7	624.0	596.1	631.8
Ghana	170	164	25.5	72.8	1.8	338.2	328.1	353.5
United States	559	411	31.5	61.6	6.9	518.4	510.3	502.0

Table C110

Question: How often do you include questions requiring explanations or justifications in your mathematics tests or examinations?

Country	Sample	Valid N	Always or almost always %	Sometimes %	Never or almost never %	Always or almost always mean	Sometimes mean	Never or almost never mean
Chinese Taipei	162	162	20.2	73.6	6.2	615.2	610.4	576.6
Ghana	170	163	32.1	65.9	2.0	319.9	336.9	334.8
United States	559	409	34.8	53.4	11.8	515.7	511.7	504.3

Professional Development

Table C111

Question: In the past two years, have you participated in professional development in mathematics content?

Country	Sample	Valid N	Yes %	No %	Yes mean	No mean
Chinese Taipei	162	162	73.1	26.9	613.4	597.9
Ghana	170	165	67.5	32.5	333.0	327.4
United States	559	431	73.4	26.6	508.7	519.6

Table C112

Question: In the past two years, have you participated in professional development in mathematics pedagogy/instruction?

Country	Sample	Valid N	Yes %	No %	Yes mean	No mean
Chinese Taipei	162	162	61.2	38.8	612.5	604.3
Ghana	170	164	51.5	48.5	333.0	329.0
United States	559	432	73.2	26.8	509.7	516.6

Table C113

Question: In the past two years, have you participated in professional development in mathematics curriculum?

Country	Sample	Valid N	Yes %	No %	Yes mean	No mean
Chinese Taipei	162	162	66.8	33.2	612.7	602.3
Ghana	170	161	59.3	40.7	331.7	331.3
United States	559	433	78.2	21.8	512.9	506.6

Table C114

Question: In the past two years, have you participated in professional development in integrating information technology into mathematics?

Country	Sample	Valid N	Yes %	No %	Yes mean	No mean
Chinese Taipei	162	161	70.5	29.5	609.3	608.4
Ghana	170	165	24.9	75.1	324.7	333.3
United States	559	433	67.8	32.2	507.5	520.0

Table C115

Question: In the past two years, have you participated in professional development in improving students' critical thinking or problem solving skills?

Country	Sample	Valid N	Yes %	No %	Yes mean	No mean
Chinese Taipei	162	162	33.0	67.0	618.1	604.9
Ghana	170	164	65.7	34.3	334.6	324.9
United States	559	433	61.3	38.7	510.1	513.9

Table C116

Question: In the past two years, have you participated in professional development in mathematics assessment?

Country	Sample	Valid N	Yes %	No %	Yes mean	No mean
Chinese Taipei	162	162	42.3	57.7	613.6	606.1
Ghana	170	164	67.6	32.4	331.8	330.1
United States	559	433	61.0	39.0	508.5	516.4

Table C117

Question: In the past two years, have you participated in professional development in addressing individual students' needs?

Country	Sample	Valid N	Yes %	No %	Yes mean	No mean
Chinese Taipei	162	162	39.8	60.2	606.4	611.2
Ghana	170	165	58.4	41.6	334.7	326.2
United States	559	433	70.5	29.5	508.4	519.0

Teacher Collaboration

Table C118

Question: How often do you discuss how to teach a particular topic with other teachers?

Country	Sample	Valid N	Never or almost never %	2 or 3 times per month %	1-3 times per week %	Daily or almost daily %	Never or almost never mean	2 or 3 times per month mean	1-3 times per week mean	Daily or almost daily mean
Chinese Taipei	162	162	19.8	54.8	22.0	3.5	592.6	612.7	612.1	632.5
Ghana	170	166	24.7	46.5	20.2	8.6	337.3	328.2	330.3	326.6
United States	559	437	17.2	29.5	31.0	22.3	525.0	508.4	506.0	514.5

Table C119

Question: How often do you collaborate in planning and preparing instructional materials with other teachers?

Country	Sample	Valid N	Never or almost never %	2 or 3 times per month %	1-3 times per week %	Daily or almost daily %	Never or almost never mean	2 or 3 times per month mean	1-3 times per week mean	Daily or almost daily mean
Chinese Taipei	162	161	47.8	40.5	9.1	2.6	602.2	615.2	622.5	598.9
Ghana	170	166	29.3	45.5	17.6	7.6	330.1	327.3	337.2	338.8
United States	559	438	21.1	26.8	30.5	21.6	514.0	509.8	503.3	524.0

Table C120

Question: How often do you share what you have learned about your teaching experiences with other teachers?

Country	Sample	Valid N	Never or almost never %	2 or 3 times per month %	1-3 times per week %	Daily or almost daily %	Never or almost never mean	2 or 3 times per month mean	1-3 times per week mean	Daily or almost daily mean
Chinese Taipei	162	162	11.0	55.8	21.7	11.6	589.6	613.3	609.8	607.8
Ghana	170	166	13.1	43.0	23.3	20.6	340.5	326.5	328.4	336.3
United States	559	434	17.4	31.6	31.0	20.0	522.6	513.4	506.7	508.7

Table C121

Question: How often do you visit another classroom to learn more about teaching?

Country	Sample	Valid N	Never or almost never %	2 or 3 times per month %	1-3 times per week %	Daily or almost daily %	Never or almost never mean	2 or 3 times per month mean	1-3 times per week mean	Daily or almost daily mean
Chinese Taipei	162	161	56.6	40.3	2.4	0.7	606.4	612.8	621.3	592.0
Ghana	170	166	16.1	46.6	22.9	14.5	353.5	331.7	315.9	326.0
United States	559	436	76.0	17.9	3.9	2.2	515.0	496.3	496.1	559.5

Table C122

Question: How often do you work together with other teachers to try out new ideas?

Country	Sample	Valid N	Never or almost never %	2 or 3 times per month %	1-3 times per week %	Daily or almost daily %	Never or almost never mean	2 or 3 times per month mean	1-3 times per week mean	Daily or almost daily mean
Chinese Taipei	162	161	43.0	47.1	7.2	2.7	606.2	606.8	642.4	613.2
Ghana	170	166	12.8	46.8	23.3	17.1	349.2	329.5	323.0	330.9
United States	559	437	30.6	35.8	21.7	11.9	518.3	506.5	509.3	517.3

Teacher Experience

Table C123

Question: By the end of this school year, how many years will you have been teaching altogether?

Country	Sample	Valid N	Mean	Mode	Min	P5	P10	Q1	Median	Q3	P90	P95	Max
Chinese Taipei	162	160	14.1	8.0	0.0	3.0	5.0	8.0	12.0	19.0	27.0	30.0	46.0
Ghana	170	159	7.6	2.0	1.0	2.0	2.0	3.0	6.0	10.0	17.0	20.0	32.0
United States	559	442	13.9	7.0	0.0	2.0	3.0	6.0	11.0	20.0	30.0	36.0	43.0

Table C124

Question: Teachers' Years of Experience

Country	20 years or more %	10-19 years %	5-9 years %	Less than 5 years %	20 years or more mean	10-19 years mean	5-9 years mean	Less than 5 years mean
Chinese Taipei	23.9	40.9	26.0	9.1	621.1	607.5	608.4	593.1
Ghana	6.1	23.2	28.1	42.6	359.6	340.3	333.9	321.5
United States	26.1	28.4	28.2	17.3	518.8	517.4	506.1	504.6

Teacher Knowledge

Table C125

Question: During your post-secondary education, was mathematics your major or main area of study?

Country	Sample	Valid N	Yes %	No %	Yes mean	No mean
Chinese Taipei	162	162	57.6	42.4	615.0	601.5
Ghana	170	155	51.2	48.8	326.8	329.0
United States	559	441	53.8	46.2	517.1	506.5

Table C126

Question: During your post-secondary education, was mathematics your major or main area of study?

Country	Sample	Valid N	Yes %	No %	Yes mean	No mean
Chinese Taipei	162	162	89.1	10.9	612.3	584.8
Ghana	170	157	60.4	39.6	322.0	337.6
United States	559	441	43.6	56.4	515.0	510.3

Teacher Preparation

Table C127

Question: How well prepared do you feel you are to teach computing, estimating, or approximating with whole numbers?

Country	Sample	Valid N	Not applicable %	Very well prepared %	Somewhat prepared %	Not well prepared %	Not administered %	Not applicable mean	Very well prepared mean	Somewhat prepared mean	Not well prepared mean	Not administered mean
Chinese Taipei	162	162	50.8	38.6	10.7	0.0	0.0	611.3	609.8	597.7		
Ghana	170	165	14.0	80.0	4.2	1.8	1.0	325.5	332.2	333.2	300.0	347.7
United States	559	430	13.7	84.3	1.6	0.4	20.6	513.7	512.0	506.6	456.9	499.4

Table C128

Question: How well prepared do you feel you are to teach concepts of fractions and computing with fractions?

Country	Sample	Valid N	Not applicable %	Very well prepared %	Somewhat prepared %	Not well prepared %	Not administered %	Not applicable mean	Very well prepared mean	Somewhat prepared mean	Not well prepared mean	Not administered mean
Chinese Taipei	162	162	59.4	31.2	9.3	0.0	0.0	609.9	610.9	600.1		
Ghana	170	165	12.1	85.4	1.7	0.8	1.0	326.6	331.5	348.2	272.2	347.7
United States	559	430	8.9	87.5	3.3	0.3	20.6	509.0	513.1	495.4	439.9	499.4

Table C129

Question: How well prepared do you feel you are to teach concepts of decimals and computing with decimals?

Country	Sample	Valid N	Not applicable %	Very well prepared %	Somewhat prepared %	Not well prepared %	Not administered %	Not applicable mean	Very well prepared mean	Somewhat prepared mean	Not well prepared mean	Not administered mean
Chinese Taipei	162	162	59.4	31.2	9.3	0.0	0.0	609.9	610.9	600.1		
Ghana	170	165	11.3	82.4	5.5	0.8	1.0	328.0	331.3	335.9	272.2	347.7
United States	559	430	10.8	86.6	2.2	0.3	20.6	504.4	513.3	505.5	439.9	499.4

Table C130

Question: How well prepared do you feel you are to teach representing, comparing, ordering, and computing with integers?

Country	Sample	Valid N	Not applicable %	Very well prepared %	Somewhat prepared %	Not well prepared %	Not administered %	Not applicable mean	Very well prepared mean	Somewhat prepared mean	Not well prepared mean	Not administered mean
Chinese Taipei	162	161	55.0	35.0	10.0	0.0	0.0	612.5	608.0	597.3	593.2	
Ghana	170	164	12.3	85.4	1.5	0.8	1.0	326.2	331.3	344.3	272.2	347.7
United States	559	429	6.2	92.7	0.7	0.5	20.6	502.9	512.6	544.5	427.0	499.4

Table C131

Question: How well prepared do you feel you are to teach problem solving involving percents and proportions?

Country	Sample	Valid N	Not applicable %	Very well prepared %	Somewhat prepared %	Not well prepared %	Not administered %	Not applicable mean	Very well prepared mean	Somewhat prepared mean	Not well prepared mean	Not administered mean
Chinese Taipei	162	162	58.3	31.5	10.3	0.0	0.0	610.0	613.4	592.4		
Ghana	170	165	6.9	85.0	6.6	1.6	1.0	309.2	334.6	314.4	284.6	347.7
United States	559	428	5.6	91.5	2.2	0.7	20.6	497.4	514.2	471.4	491.6	499.4

Table C132

Question: How well prepared do you feel you are to teach simplifying and evaluating algebraic expressions?

Country	Sample	Valid N	Not applicable %	Very well prepared %	Somewhat prepared %	Not well prepared %	Not administered %	Not applicable mean	Very well prepared mean	Somewhat prepared mean	Not well prepared mean	Not administered mean
Chinese Taipei	162	162	23.5	67.4	9.2	0.0	0.0	615.0	607.7	606.5		
Ghana	170	165	3.5	93.5	2.2	0.8	1.0	306.7	332.7	308.0	272.2	347.7
United States	559	428	0.7	97.0	1.7	0.5	20.6	490.3	513.1	475.9	482.2	499.4

Table C133

Question: How well prepared do you feel you are to teach simple linear equations and inequalities?

Country	Sample	Valid N	Not applicable %	Very well prepared %	Somewhat prepared %	Not well prepared %	Not administered %	Not applicable mean	Very well prepared mean	Somewhat prepared mean	Not well prepared mean	Not administered mean
Chinese Taipei	162	162	49.4	41.4	9.3	0.0	0.0	610.2	611.4	594.9		
Ghana	170	165	2.9	93.5	2.5	1.0	1.0	322.6	331.4	330.2	291.6	347.7
United States	559	430	1.3	95.3	2.9	0.5	20.6	479.4	514.0	462.9	482.2	499.4

Table C134

Question: How well prepared do you feel you are to teach points on the Cartesian plane?

Country	Sample	Valid N	Not applicable %	Very well prepared %	Somewhat prepared %	Not well prepared %	Not administered %	Not applicable mean	Very well prepared mean	Somewhat prepared mean	Not well prepared mean	Not administered mean
Chinese Taipei	162	162	45.4	45.8	8.7	0.0	0.0	608.6	611.8	599.4		
Ghana	170	165	12.8	70.6	10.0	6.6	1.0	314.0	333.0	331.5	338.1	347.7
United States	559	428	9.9	86.3	1.1	2.7	20.8	512.3	513.9	515.0	451.8	499.4

Table C135

Question: How well prepared do you feel you are to teach reading and displaying data using tables, pictographs, bar graphs, pie charts and line graphs?

Country	Sample	Valid N	Not applicable %	Very well prepared %	Somewhat prepared %	Not well prepared %	Not administered %	Not applicable mean	Very well prepared mean	Somewhat prepared mean	Not well prepared mean	Not administered mean
Chinese Taipei	162	162	85.2	8.5	5.1	1.2	0.0	610.0	614.9	587.0	611.4	
Ghana	170	164	5.6	86.6	7.0	0.8	1.0	305.7	332.7	334.3	272.2	347.7
United States	559	428	11.2	83.8	3.9	1.2	20.6	512.9	512.4	504.1	497.0	499.4

Teacher Self-Efficacy

Table C136

Question: In teaching mathematics to this class, how confident do you feel answering students' questions about mathematics?

Country	Sample	Valid N	Very confident %	Somewhat confident %	Not confident %	Very confident mean	Somewhat confident mean
Chinese Taipei	162	162	88.4	11.6	0.0	612.1	587.4
Ghana	170	166	94.2	5.8	0.0	328.7	365.9
United States	559	415	97.2	2.8	0.0	512.8	491.7

Table C137

Question: In teaching mathematics to this class, how confident do you feel showing students a variety of problem solving strategies?

Country	Sample	Valid N	Very confident %	Somewhat confident %	Not confident %	Very confident mean	Somewhat confident mean	Not confident mean
Chinese Taipei	162	162	81.4	18.6	0.0	613.0	593.0	
Ghana	170	166	90.8	9.2	0.0	329.7	342.4	
United States	559	415	91.3	8.7	0.1	512.6	508.9	409.7

Table C138

Question: In teaching mathematics to this class, how confident do you feel providing challenging tasks for capable students?

Country	Sample	Valid N	Very confident %	Somewhat confident %	Not confident %	Very confident mean	Somewhat confident mean	Not confident mean
Chinese Taipei	162	162	65.5	34.5	0.0	612.8	602.6	
Ghana	170	165	76.7	22.8	0.5	333.0	324.5	312.9
United States	559	415	76.4	22.5	1.2	513.8	508.3	485.6

Table C139

Question: In teaching mathematics to this class, how confident do you feel adapting your teaching to engage students' interest?

Country	Sample	Valid N	Very confident %	Somewhat confident %	Not confident %	Very confident mean	Somewhat confident mean	Not confident mean
Chinese Taipei	162	162	43.9	53.2	2.9	622.1	600.6	574.6
Ghana	170	166	90.4	9.6	0.0	329.0	349.1	
United States	559	415	65.1	33.1	1.8	516.7	503.5	509.7

Table C140

Question: In teaching mathematics to this class, how confident do you feel helping students appreciate the value of learning mathematics?

Country	Sample	Valid N	Very confident %	Somewhat confident %	Not confident %	Very confident mean	Somewhat confident mean	Not confident mean
Chinese Taipei	162	162	33.7	61.0	5.4	616.8	607.2	586.3
Ghana	170	166	92.3	7.7	0.0	329.2	351.2	
United States	559	414	67.2	30.9	1.9	514.8	509.3	471.7

Table C141

Scale: Confidence in Teaching Mathematics

Country	Sample	Valid N	Mean	Mode	Min	P5	P10	Q1	Median	Q3	P90	P95	Max
Chinese Taipei	162	162	9.4	9.2	5.1	5.1	7.0	8.2	9.2	10.3	12.0	12.0	12.0
Ghana	170	166	11.2	12.0	5.1	8.2	9.2	10.3	12.0	12.0	12.0	12.0	12.0
United States	559	415	10.6	12.0	5.1	8.2	8.2	9.2	10.3	12.0	12.0	12.0	12.0