How It All Adds Up: Factors That Affect Mathematics Achievement for Eighth Grade Students in the United States

by

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Abstract

The sample of this study consisted of 1,077 eighth grade students and 442 eighth grade teachers from nine states—Alabama, California, Connecticut, Colorado, Florida, Indiana, Massachusetts, Minnesota, and North Carolina during the TIMSS 2011 study. The instrument used to measure student and teacher self-efficacy, student task value, and teacher preparations were student and teacher questionnaire. The instrument used to measure mathematics achievement was TIMSS mathematics assessment for eighth grade. For this study, two scales were used from the student and teacher questionnaire, which included a total of 46 questions.

The independent variables were student and teacher self-efficacy, student task value, and teacher preparation. The dependent variable was mathematics achievement. The demographic data revealed that of the study's sample of teachers, 311 (70%) were female and 131 (30%) were male; the age range for teachers was between 40 and 49 years old. The demographic data also revealed that of the study's sample of students, 5,180 (49%) were male and 5,297 (51%) were female; the average age of students was 14 years old.

A hierarchical linear model was conducted to determine if self-efficacy and perceived task value predict eighth grade student achievement in mathematics. The test revealed that there was a statistically significant amount of variance in mathematic achievement (outcome variable) at the teacher level, which supported the use of HLM. Based on the random intercept model, the researcher concluded that student self-efficacy predicted eighth grade mathematics achievement.

The regression with means as outcomes model assessed student mean achievement as related to teacher self-efficacy and teacher preparation. The results indicated that student mean achievement as related to teacher self-efficacy was statistically significant.

Teacher self-efficacy was statistically significant when predicting mathematics achievement after accounting for student level predictors. Teacher preparation was not statistically significant when predicting mathematics achievement after accounting for student level predictors. The result of the chi-square reveals that there is statistical significance residual variance in the slopes.

Acknowledgments

"Throw me to the wolves and I will return leading the pack" Unknown

To my Committee Chair, Dr. Margaret Ross, to Dr. Jill Salisbury-Glennon, and to Dr. Joni Lakin: thank you for allowing me the opportunity to redeem myself and for your dedication toward my successful journey. To my University Reader, Dr. Jared Russell: thank you for agreeing to accept this assignment at the last minute. To my editor, Amber Simpson: thank you for burning some night oil with me.

To the "boss man," Dr. B. Donta Truss: you are truly a man after God's own heart. Continue to be that great leader who develops other leaders. Thank you for mentoring me, and I will definitely pay it forward.

I would like to thank my husband, Johnny, who had patience, love, and support for me during this time. I love you and value you with all my heart. I know it was hard, but you weathered the storm. I promise to return to my motherly and wifely duties that I have been neglecting. I am truly grateful to have you on my team (#TeamParadiseClan). There is an African Proverb that says "If you want to go fast, then go alone. If you want to go far, then go together." So, I look forward to see where God is going to take us on our next journey.

To my only begotten son, Johnny: thank you for being unique, fun, and, most of all, my son. I love you and appreciate your maturity. Keep God as the head of your life as you grow and develop in to be this awesome leader and man that you are. I am so blessed that God has chosen me to be a steward over your life. I want you to set your goals high and let nothing or no one stop you.

I would like to thank my parents. To my mother, Tarnetta: thank you for being a mom that is supportive, loving, caring, and a prayer warrior. I know that God has more for you on this earth, and I look forward to enjoying these days with you. To my daddy, Herman: it has been very exciting getting to know you and sharing my educational goals with you. I love you and truly enjoy the laughter we share together.

To my family, too many to name, but you know who you are. Thank you for everything. Words cannot express how much your help along this path has eased my stress. Without all of your contributions, there would be no "Dr. Shamarick Paradise".

Psalms 37:4 – Take delight in the Lord, and he will give you the desires of your heart.

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List of Abbreviations

ANOVA	Analysis of Variance
CFA	Confirmatory Factor Analysis
ESEA	Elementary and Secondary Education Act
ESSA	Every Student Succeeds Act
GPA	Grade Point Average
HSLS	High School Longitudinal Study
HLM	Hierarchical Linear Modeling
IEA	The International Association for the Evaluation of Educational Achievement
IRB	Institutional Research Board
LOT-R	Life Orientation Test-Revised
MANOVA	Multivariate analysis of variance
MSLQ	Motivated Strategies for Learning Questionnaire
NCES	National Center for Education Statistics
PALS	Patterns of Adaptive Learning Scales
SAT	Stanford Achievement Test
SEM	Structural Equation Modeling
TIMSS	Trends in International Mathematics and Science Study
US	United States

Chapter I. Introduction

This research study measures the relationships among the United States eighth grade student mathematics achievement (number, algebra, geometry, and data choice), student and teacher self-efficacy, student task value, and teacher preparation. This chapter provides the statement of the problem, the purpose of the study, the significance of the study, the research questions, the hypotheses, the limitations, the assumptions of the study, and definitions for key terms.

Statement of the Problem

Skouras (2014) identified teacher preparation, teacher self-efficacy, student motivation, and student self-efficacy as a few factors that affect student achievement in mathematic. Research has shown that student academic success begins in a classroom where teachers have high expectations of their students; in turn, students are positively motivated to actively participate in their learning process (Jung, Brown, & Karp, 2014; Shi, 2014). Students' interest in learning math begins prior to their arrival at school. Pre-school students are "thinking mathematically" (Greenes, 1999) and have the ability to solve complex problems. In addition, understanding the social context as to how students learn can assist with improving student academic achievement (Skouras, 2014).

Stevens, Harris, Aguirre-Munoz, and Cobbs (2009) suggested that middle school teachers should master elementary mathematics concepts to effectively teach middle school math; however, teachers should also possess the ability to teach and enhance the self-efficacy of a culturally and socially diverse middle school student population in the subject of math. In order to achieve the academic success, pre-service and in-service middle school math teachers should participate in effective professional development activities to develop and enhance their abilities to effectively disseminate the required mathematics curriculum. The United States has focused on funding the development of math teachers within the areas of content knowledge, teaching strategies, inter-professional skills, and classroom management (Wilson, Floden, & Ferrini-Mundy, 2002). According to Blackbourn et al. (2008), teacher education researchers are calling for teachers to be subject-matter experts and possess the critical thinking skills that are necessary to make moment-to-moment decisions, which are critical to responsive classroom teaching, as well as individualized student learning.

Conceptual/Theoretical Framework

Urdan and Schoefelder (2006) defined motivation as "a complex part of human psychology and behavior that influences how individuals choose to invest their time, how much energy they exert in any given task, how they think and feel about the task, and how long they persist at the task" (p. 332). Student self-efficacy, task value, teacher self-efficacy, and teacher preparation are parts of a framework school administrators can use to determine the effect of motivation on student mathematics achievement. This framework addresses the classroom environment for mathematics, focusing on how student and teacher motivation constructs predict mathematics academic achievement (Bandura, 1993; Bong, 2000; Carroll et al., 2009; Pajares & Urdan, 2006; Schunk, 2003; Zimmerman, Bandura, & Martinez-Pons, 1992). It is based on the belief that the key to mathematics achievement is the correlation between teacher and student motivation constructs in the classroom. Researchers (e.g., Ames, 1992; Maehr & Midgley, 1991) have attributed student success or academic achievement to the increased value that is placed on motivation. Because it was intended to develop a sense of ownership in the classroom, this framework is appropriate for school administrators to use to gauge student mathematics achievement. The constructs of motivation (i.e., self-efficacy, task value, and teacher preparation) are the elements needed to foster students' achievement (Urdan & Schoefelder, 2006).

Purpose of the Study

The purpose of this study was to measure the relationships among the United States eighth grade student mathematics achievement (number, algebra, geometry, and data choice), student and teacher self-efficacy, student task value, and teacher preparation. Both teacher and student data were analyzed using Trends in International Mathematics and Science Study (TIMSS) 2011 version for eighth graders. TIMSS (2011) student and teacher questionnaires were used to collect data. The eighth grade student questionnaire was used to measure student demographics, home and school environments, self-efficacies, and attitudes toward learning mathematics.

The eighth grade math teacher questionnaire was used to measure general teaching experience, experience teaching mathematics, educational background, and professional development. This research will provide a better understanding of the impact of teacher self-efficacy and preparation on middle school student achievement in mathematics. In addition, this study was built on what is currently known about self-efficacy, student achievement, and teacher preparation.

Research Questions

The following research questions were investigated in this study:

1) Does student self-efficacy predict eighth grade student achievement in mathematics (summing across algebra, geometry, numbers, and data choice domains)?

2) Does student perceived task value predict eighth grade student achievement in mathematics (summing across algebra, geometry, numbers, and data choice domains)?
3) Does teacher self-efficacy predict eighth grade class mean math achievement (summing across algebra, geometry, numbers, and data choice domains)?
4) Does teacher preparation predict eighth grade class mean math achievement (summing across algebra, geometry, numbers, and data choice domains)?
5) Does teacher self-efficacy predict within classroom effects of student level predictors within the classroom?
    a) How much variation in intercepts (classroom means) is explained by teacher self-efficacy?
    b) How much variation in the effect of student self-efficacy and perceived task value slope on math achievement is explained by teacher self-efficacy?
6) Does teacher preparation predict within classroom effects of student level predictors within the classroom?
    a) How much variation in intercepts (classroom means) is explained by teacher preparation?
    b) How much variation in the effect of student self-efficacy and perceived task value slopes on math achievement is explained by teacher preparation?

Hypotheses

There were six main research hypotheses examined in this study:

1) Student self-efficacy will positively predict eighth-grade student achievement in mathematics (summing across algebra, geometry, numbers, and data choice domains).
2) Student perceived task value will positively predict eighth-grade student achievement in mathematics (summing across algebra, geometry, numbers, and data choice domains).
3) Teacher self-efficacy will be associated with eighth-grade class mean math achievement (summing across algebra, geometry, numbers, and data choice domains).
4) Teacher preparation will be associated with eighth-grade class mean math achievement (summing across algebra, geometry, numbers, and data choice domains).
5) There will be variation in the level-1 slopes and level-1 intercepts based on teacher self-efficacy within the classroom.
6) There will be variation in the level-1 slopes and level-1 intercepts based on teacher preparation within the classroom.

Significance of the Study

There remains a paucity of research into the relationships among student and teacher self-efficacy, teacher preparation, and student task value in mathematics achievement. Numerous research projects and studies that investigate the relationship between various academic achievement and motivation constructs, as the review of literature reveals (Pajares & Graham, 1999; Graham & Morales-Chicas, 2015; Urdan & Schoenfelder, 2006; Gutman, 2006; Jung, Brown, & Karp 2014; Shi, 2014; Stevens et al., 2009; Ames, 1992; Maehr & Midgley, 1991; Hardré & Sullivan, 2009; Radel, Sarrazin, Legrain, & Wild, 2010; Skinner & Belmont, 1993). However, to date and to my knowledge, no studies have been conducted to specifically address the issue of student and teacher self-efficacy, teacher preparation, and student task value in mathematics achievement for eighth grade students in the United States.

As a result of this study, school administrators and district leaders will be able to examine eighth grade students' and teachers' motivation factors with other students across nine states in the United States to compare students' mathematics achievement in the classroom. Additionally, individuals in the position to effect change can seek to improve the quality of instruction, student self-efficacy, and student perception of task value to increase student mathematics achievement in eighth grade. Finally, prior studies on the topic primarily address self-efficacy, task value, and achievement goals from student or teacher perspectives (Bong, 2000; Bong, Cho, Ahn, & Kim, 2012; Holzberger, Philipp, & Kunter, 2013). Along with teacher preparation, this study incorporated both teacher and student motivation factors in exploring the gap in mathematics achievement. Considering all of these elements together is important because understanding the motivation factors from students and teachers can influence administrators and district leaders to improve teacher confidence and preparation to ensure success for all students in eighth grade mathematics.

Limitations of the Study

This research had limitations, which should be taken into consideration by the reader throughout the review of this study:

- For this study, the data were limited to eighth grade students from nine states across the United States whose schools were randomly selected to participate in TIMSS 2011 study.
- The TIMSS 2011 public data did not reveal the identity of each school that participated in the study.

- The teacher and student scales used to collect data for the TIMSS 2011 study were self-reported.

Delimitations of the Study

The delimitations of this study were:

- This study examined the effects students nested in a classroom as a whole; therefore, differences between gender and race were not considered.
- Due to the large number of participants in the study population, the population involved in this study focused only on eighth grade students located within the United States.

Assumptions of the Study

This study was conducted based on the following assumptions:

- The participants answered the questionnaire independently.
- The students completed the mathematics assessment independently.
- The eighth grade mathematics participants represented the total eighth grade mathematics student population across the United States.

Definition of Terms

The definitions of key terms used in this study are as follows:

Academic Achievement: In this study, academic achievement was measured using the results from the TIMSS 2011 mathematic assessment content domain.

Framework: This consists of TIMSS 2011 mathematics assessment and student and teacher questionnaires.

Mathematics Content Domain: Refers to algebra, geometry, numbers, and data choice.

Self-efficacy: One's belief in his or her ability to complete a specific task (Bandura, 1997).

Task value: Refers to the benefit for engaging in a task (Wigfield & Eccles, 1992).

Teacher Preparation: For the purpose of this study, the content knowledge, training, or professional development to encourage high academic achievement in students.

Trends in International Mathematics and Science Study (TIMSS) 2011: TIMSS is an international mathematics and science education achievement study used to compare United States fourth and eighth grade students with their international peers on the basis of mathematics and science achievement.

Organization of the Study

This study is organized following a five-chapter format. Chapter I, Introduction, addresses the statement of the problem, the purpose of the study, the significance of the study, research questions, study limitations, assumptions, and definitions of key terms. Chapter II reviews the literature of prior relevant research which was conducted in areas relating to this study. Chapter III expounds upon the purpose of the study, reiterates the research questions, and identifies the methods used to conduct this research. Chapter IV presents the findings of this research. Chapter V provides a summary, the findings and conclusions, the study’s implications, and recommendations for future research.

Chapter II. Review of Literature

Introduction

Chapter I introduces the statement of the problem, the purpose of the study, the significance of the study, the research questions, the hypotheses, the limitations, the assumptions of the study, and definitions for key terms. Chapter II reviews pertinent literature, which considered student and teacher preparation, student and teacher self-efficacy, student and teacher motivation, student engagement, and middle school student achievement in mathematics.

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Motivation

Motivation in the classroom is predicated on the influences of both the teacher and of the student (Hardré and Sullivan, 2009; Radel, Sarrazin, Legrain, & Wild, 2010; Skinner & Belmont, 1993). Urdan and Schoenfelder (2006) described motivation as how much time and energy one chooses to invest in achieving goals. Research has proven that students achieve goals based on their quality of motivation for success (Ames, 1992; Maehr & Midgley, 1991). For academic achievement between age groups and domains, Bong, Cho, Ahn, and Kim (2012) conducted a study to compare the relationships among self-concept, self-efficacy, and self-esteem. They sought to determine if domain-specific relationships had more of an effect on middle school students' academic achievement than on elementary students' academic achievement.

Bong et al. (2012) tested the hypothesis that academic achievement for middle school students has more of an effect than academic achievement for elementary students. To measure self-efficacy and motivation, a questionnaire was developed from Bandura's Self-Efficacy Scale and Motivated Strategies for Learning Questionnaire (MSLQ). Mathematics academic achievement for 234 elementary students was measured through the use of a 3-point Likert-type scale that was evaluated by teachers. Additionally, 512 middle school students' math achievement was measured using the results from their first semester final exam. Using the results of the confirmatory factor analysis (CFA), this study indicated that motivation in middle school mathematics predicts mathematic achievement.

Research by Holzberger, Philipp, and Kunter (2013) examined how teachers' self-efficacy influenced motivation. The results of this study indicated that the quality of instruction and teacher self-efficacy was positively correlated, and teachers adjusted their quality of instruction based on their self-efficacy during the school year. The data were collected using the Professional Competence of Teachers, Cognitively Activating Instruction, and the Development of Mathematical Literacy Scale to measure teachers' self-efficacy and the quality of instruction in a longitudinal study.

Middleton, Leavy, and Leader (2013) examined the relationship between motivational variables and student engagement for students in middle grades with a reformed curriculum. The participants of this study included 327 students in Midwestern school districts. The instruments used to assess students' motivation were The Children's Academic Intrinsic Motivation Inventory (Gottfried, 1985), the Mathematics Attitudes Scales (Fennema & Sherman, 1976; Middleton, Littlefield, & Lehrer, 1992), and the Mathematical Beliefs (Schoenfeld, 1989). The Iowa Test of Basic Skills and the algebra aptitude exam were used to measure the students' mathematical performance. Descriptive statistics, repeated measure analysis of variance (ANOVA), and path analysis were used to analyze the collected data. The results of this study indicated that student motivation is related to creativity in the math curriculum. Research has shown that students who are motivated and engaged socially and emotionally are more likely to succeed in the classroom (Fried & Chapman, 2012).

Student Engagement. Student engagement is defined as the time and effort a student invests in school activities that will result in academic success (Kuh, Kinzie, Buckley, Bridges, & Hayek, 2007; Krause & Coates, 2008). While obtaining their educational goals, students are more successful and avoid negative behavior during adolescence when they are engaged in their academic success (Skinner, Furrer, Marchand, & Kindermann, 2008). Wang, Bergin, C., and Bergin, D. A. (2014) identified classroom engagement and school engagement as two distinct things. The authors believed that engagement in the classroom should include the teacher and the student. In this study, the development of a Classroom Engagement Inventory (CEI) was used to identify factors that contributed to student engagement in the classroom. The study included students of different demographics (e.g., low-socioeconomic), courses (e.g., math and physical education), and grade levels (i.e., grades 4 - 12). The development of the CEI consisted of 35 questions that measured engagement and disengagement (i.e., behavioral, cognitive, and affective) in the classroom.

The first study by Wang et al. (2014) was conducted in April 2010, and the second study was conducted in Spring 2011. Both studies collected data from students in grades 4-12 among thirteen elementary schools, three middle schools, one high school, and a career center. Study 1 and Study 2 examined the results using exploratory factor analysis (EFA) and CFA. The EFA method was used to identify models that best fit the data. The CFA method was used to test the model that best fit the data (Wang et al., 2014).

The results of study 2 identified factors such as cognitive engagement, affective engagement, disengagement, behavioral compliance, and behavioral effortful class participation, which influenced student engagement in the classroom. The findings suggested that students' socioeconomic statuses and genders were significant factors in determining student engagement. Affective and behavioral engagement was found more in girls than boys. Disengagement and free/reduced lunch status were not significant in determining student engagement for boys. The results of this study supported the theory that teacher behavior influences student engagement. The author identified that this study was not conducted in a district where students came from families of high socioeconomic status or districts with racial makeup noted as primarily Black (Wang et al., 2014).

The authors' collection of data from a career center was not discussed in detail, but the data were utilized to measure the effect of student engagement and academic success. Future research, however, could identify differences for student engagement between traditional school settings (e.g., middle and high school) and the career center. These results could be compared using a career-related model. Research has proven that students receiving career-relevant instruction in middle school valued their education and were more engaged (Orthner, Jones-Sanpei, Akos, & Rose, 2013).

Hazel, Vazirabadi, and Gallagher (2013) noted that engagement is stronger when it is present in both the student and his or her school. Therefore, the authors coined the term "student school engagement". The researchers developed a 50-item Student School Engagement Measure (SSEM) questionnaire to measure student school engagement. They further hypothesized that aspiration, belonging, and productivity were related to student success. This questionnaire was administered to 396 eighth graders at three middle schools. The results suggested that the student school engagement model positively supported the relationship between student engagement and the course academic achievement on the district-standardized test. As students transition from middle to high school, an examination of their aspiration, belonging, and productivity may offer suggestions for support in their new environment (Hazel et al., 2013).

Hirn and Scott (2014) observed students' and teachers' behavior in high school settings for grades 9-12. This study measured teacher responses for students with and without challenging behavior in the classroom. The authors defined teaching as being "engaged in the explanation of a concept or topic" and not as a "lack of engagement with any student" (Hirn & Scott, 2014, p. 594). The data were collected using the Multiple Option Observation System for Experimental Studies (MOOSES) Version 3. The results of this study showed that teachers provided more negative feedback to students with challenging behavior than those without challenging behavior.

Moreover, the authors indicated that students with challenging behavior were less engaged, both actively and passively. The students noted as having challenging behavior were off task and more disruptive in class than those without challenging behavior. Other research has demonstrated the benefit of teacher engagement on academic success. For example, the results from Wang et al. (2014) proved that teacher behavioral engagement was correlated with student academic success.

The research of Gregory, Allen, Mikami, Hafen, and Pianta (2014) was similar to that of Hirn and Scott (2014). Gregory et al. (2014) investigated the relationship between teacher and student behavioral engagement; although, in this study teachers, received professional development in the areas of emotional support, classroom organization, and instructional guidance. Their sample included 87 teachers and 1,669 students from 12 different schools in Virginia. Gregory et al. (2014) proposed that behavioral engagement in the classroom would increase for teachers in the experimental group receiving training from My Teaching Partner-Secondary (MTP-S). Gregory et al. (2014) found that student socioeconomic status is significant to students' behavioral engagement in the classroom, which is congruent with the results from Wang et al. (2014). The multilevel model indicated that teachers' behavioral engagement in the classroom increased slightly from fall to spring. The results from teachers who received training could have a positive impact on student academic success the following school year (Gregory et al., 2014).

While previous studies focused on many factors that influenced student engagement for academic success, current research has shown that behavioral engagement, in particular, impacts students' academic success (Gregory et al., 2014; Wang et al., 2014; Hirn & Scott, 2014). Nonetheless, these studies still do not directly measure factors of student engagement that impact the academic success of ethnic groups, particularly Black students.

Darensbourg and Blake (2013) performed a longitudinal study and collected data from 167 students from three school districts who were academically at-risk and entering first grade. The students were administered the Woodstock-Johnson Tests of Achievement, 3rd edition (WJ-

III) to measure their reading and math skills, and the students' achievement value was measured using the Competency Beliefs and the Subjective Task Values questionnaire. Using the Wellborn Scale, the teachers measured the students; behavior engagement. This study examined the relationship between behavioral engagement and academic achievement. These scales were analyzed using structural equation modeling (SEM) and the one-way ANOVA.

The one-way ANOVA indicated significant differences between girls' and boys' reading achievement and behavioral engagement; additionally, the math achievement and reading or math task values indicated no difference. The results supported the hypothesis that behavioral engagement and academic achievement are correlated. There is a relationship between math achievement and behavioral engagement for African-American students. The reading achievement showed some significance, but not enough to reveal a significant difference (Darensbourg & Blake, 2013). Based on the results the authors suggested, "future studies should examine whether a relationship exists among concrete values, behavioral engagement, and achievement" (p. 1056).

Expectancy Value. Student engagement is directly related to the value students place on their ability to excel in any subject (Eccles, 2008). Expectancy-value theory is known as one of the most influential theories in motivation (Eccles, 1994; Eccles, 2009). Sun, Ding, and Chen (2013) conducted a study to examine the difference between U.S. and Chinese middle school students' expectancy-value motivation. The sample group included 813 students from 14 schools in the U.S. and 806 students from eight schools in China. Using the Self- and Task-Perception Questionnaire, Sun et al. (2013) measured the students' "expectancy belief for success and perceived task value of physical education" (p. 10). They hypothesized "that U.S. and Chinese middle school students were likely to differ in the expectancy-value due to different cultural value systems in general, and the expectancy-value motivation would fluctuate or decline at a different rate as a function of cultural influences" (p.10). To test their hypotheses, the researchers used a CFA and multivariate analysis of variance (MANOVA) to find class means and factor structure between the American and Chinese students. The results of Sun et al. (2013) showed those U.S. students' expectations for success was higher than students in China. Examining the task value for all participating students indicated that the Chinese students found more usefulness for physical education than their U.S. peers. It was concluded that Chinese students held a higher value for education; however, culture does not justify the decline in expectancy-value motivation as "children grow older or experience more schooling" (p.16).

In another study seeking to identify mathematical outcomes for middle school students, Woolley, Strutchens, Gilbert, and Martin (2010) sought to determine if teachers' expectations impact students' motivation. The authors hypothesized as follows:

a) That teacher beliefs and practices would directly influence students' motivational factors, and that in turn those student motivational factors would directly influence student outcomes in mathematics, and
b) The influence of teacher beliefs and practices on mathematical outcomes would be mediated through effects on student motivation (Woolley et al., 2010, p. 46).

The participants included a sub-sample of 933 Black middle school students from 13 schools in 7 school districts. The survey was administered to measure motivation, teacher beliefs and practices, and mathematical outcomes. Woolley et al. (2010) analyzed the survey data using structural equation modeling (SEM) to determine if motivational factors and teachers' beliefs and practices predict mathematical outcome. The analyses revealed that math students' increase in motivation was defined by their teachers' high expectations for student learning. The findings of Woolley et al. (2010) suggested that students' motivation and reformed-oriented practices were highly significant with mathematical outcomes.

Examining expectancy-value as a contributing factor for middle school students' motivation and desire to learn mathematics has been increasing area for research in secondary education. Friedrich, Flunger, Nagengast, Jonkmann, and Trautwein (2015) contributed to this body of research by seeking to examine teacher expectancy and its possible relationship to student mathematical achievement as measured by teacher reports, student self-reports, and student achievement. Friedrich et al. (2015) analyzed data for three relationships; they were as follows:

a) Would teachers' expectancy regarding students' competency predict students' achievement? Further, would the results be significant for both academic achievement outcomes?
b) Would teachers' expectancy effects be mediated by students' expectancy beliefs?
c) Would teachers' average expectancy of the students in their class be associated with students' achievement (p. 4)?

Data for the study were collected three times during the school year, and the reports were administered to 73 math teachers and 1,289 fifth-grade students in February, April, and June. Subsequent data were analyzed using an item response theory to scale the results of the math assessment. Multilevel and regression analyses were used to examine the effects on the individual student coupled with class achievement as a result of the teachers' expectations of the students' success. Results of the study supported the beliefs of Woolley et al. (2010) that teachers' high expectations in the classroom produce great mathematical outcomes from the students (Friedrich et al., 2015).

Friedrich et al. (2015) reported that teachers' expectations of students strongly correlated with the mathematics achievement outcomes. For example, the correlation from the math test and the math grades were "26% and 62%, respectively" (Friedrich et al., 2015, p. 7). The fifth-grade students' self-efficacy of their math achievement slightly correlated with teachers' expectations of their achievement and competence; however, there was no relationship between the students' achievement and the teachers' expectations of the class as a whole.

Self-efficacy

Although published studies provided motivational factors that predict student academic achievement, additional researchers have identified other factors from which to examine student academic success. Betz and Hackett (1986) and Lent, Brown, and Hackett (1994) surmised that the more confidence students have in their ability to achieve academic success, greater becomes the students' opportunities of pursuing their career goals. Bandura, Barbaranelli, Caprara, and Pastorelli (1996) focused on the social cognitive theory's effect on academic achievement. The purpose of their study was to analyze socio-structural, familial, peer, personal class, and social cognitive theory's influence on academic achievement.

Using a principal component factor analysis, Bandura et al. (1996) analyzed the results from a 5-point Likert-type self-efficacy scale. The scales assessed 279 sixth and seventh grade students' academic achievement, self-regulated learning, peer pressure, leisure, and extracurricular activities. The results of this study showed that student academic achievement in social well-being were influenced by socioeconomic status, parental beliefs, student self-efficacy, and pro-social orientation.

Ozturk and Sahin (2014) examined the effects of alternative assessments (e.g., self-reporting and learner journals) on mathematical academic achievement. The researchers found that alternative self-assessment had an effect on fifth-grade students' mathematical achievement, persistence of learning, self-efficacy perception, and attitude. The authors concluded that when students were in control of their learning and evaluated themselves, these ingredients promoted confidence levels and improved the students' attitudes toward learning; thereby, students became highly encouraged to achieve academic success.

Friedel, Cortina, Turner, and Midgley's (2007) study examined students' ability to identify differences between parents' and teachers' achievement goals, associations between the students' goals, self-efficacy, and coping skills. Friedel et al. (2007) surveyed 1,021 seventh graders. The survey was developed using Patterns of Adaptive Learning Survey (PALS; Midgley et al., 1996), Hruda and Midgley (1997) scale, and Academic Coping Inventory (ACI; Tero & Connell, 1984) to measure self-efficacy in mathematics, coping strategies, and goals. The results of the factor analysis for the students supported the hypothesis that student personal goals were strongly related to the performance goals perceived by parents than performance goals perceived by teachers.

The results of the correlation identified a slight difference between the teachers' and parents' goals compared to mastery for the students. The contribution of this study was similar to the findings of other research correlations (e.g., Bandura et al., 1996; Woolley, 2010; Friedrich et al., 2015), which suggested that teachers' and parents' high expectations and perception of students' achievement had a strong positive correlation with students' mathematical achievement (Friedel et al., 2007).

Ozgen (2013) focused on learning styles and mathematical literacy (ML) self-efficacy beliefs. Students who are not taught according to their learning styles tend to have less success with mathematical literacy self-efficacy beliefs. Ozgen (2013) examined the following:

a) Is there a significant relationship between high school students' ML self-efficacy beliefs and their learning styles?

b) Do high school students' ML self-efficacy beliefs significantly differ in relation to their learning styles?

c) Are learning style dimensions a significant predictor of high school students' ML self-efficacy beliefs (p. 93)?

The data were collected using ML self-efficacy scale (Ozgen & Bindak, 2008), Learning Style Inventory Version 3.1 (Kolb, 2005), and a personal information questionnaire (Ozgen, 2013). The statistical analyses that were used are chi-square (χ^2), one-way analysis variance (ANOVA), and multiple linear regression to identify relationships and predictors of ML self-efficacy beliefs.

The four learning styles identified and studied by Ogzen (2013) were: diverger, assimilator, converger, and accommodator. Diverger and converger scored equally among students with high level of ML self-efficacy scale and were considered active learners (e.g., hands-on learning). The results indicated ML self-efficacy beliefs and learning styles were statistically significantly different (Ozgen, 2013). On the other hand, the learning styles were not significantly different; therefore the author concluded that learning styles predict student's self-efficacy belief in ML.

Teacher Efficacy. Pre-service teachers' beliefs in their abilites to teach math would greatly affect their classroom performance (Beswick, 2006; Cakiroglue, 2008; & Cooper & Robinson, 1991). Bates, Latham, and Kim (2011) conducted a qualitative study on 89 early childhood pre-service teachers to examine their self-efficacy of teaching mathematics to their students. A survey was developed to measure math ability and math teaching efficacy. The collected data were analyzed by using a Pearson correlation and independent t-test determine the teachers' mathematics self-efficacy and teachers' self-efficacy with mathematical performance. The results indicated that teachers with higher self-efficacy were more confident in teaching math than their ability to improve math achievement in the classroom. The authors concluded that pre-service teachers' anxiety could negatively impact students' classroom learning; these results were similar to previously cited research.

For creativity in mathematics, another qualitative study reviewed pre-service teachers in their third year of their undergraduate programs. Panaoura and Panaoura (2014) examined ten students' definitions of and ideas about creativity in mathematics. The results indicated that the students were not able to provide 'originality' (Panaoura & Panaoura, 2014, p. 5) without guidance. What they suggested was the definition of creativity in mathematics and their expectations of an experienced teacher. While Panaoura and Panaoura (2014) sought to understand why pre-service teachers could not incorporate creativity in the planning of their lessons, the students replied that "they did not have the necessary self-efficacy to propose their own activities for investigation and especially exploration" (p.7). Researchers have suggested that teacher-education programs should include ways for pre-service teachers to receive more hands-on experience to build self-confidence in mathematical content (Panaoura & Panaoura, 2014; Hosseini & Watt, 2010; Bates et al., 2011).

Muijs and Reynolds (2002) investigated student achievement as it was impacted by teacher's behaviors, beliefs, self-efficacy, and knowledge. The Gatsby Mathematics Enhancement Project Primary was used to evaluate teacher constructs and student achievement. Means and standard deviations for each item were calculated and used to construct a predictive model for student achievement. Structural equation modeling was used to examine the relationships between variables (Muijs & Reynolds, 2002).

Muijs and Reynolds (2002) results indicated teacher behavior, belief, self-efficacy, and knowledge predicted student achievement. Teacher self-efficacy directly impacted teacher behavior and personality, and this was repeated for the other variables. However, teacher self-efficacy indirectly impacted student achievement through teacher behaviors. The authors concluded that teacher behaviors and professional development should be offered prior to the teacher entering the classroom (Muijis & Reynolds, 2002).

Shi (2014) examined the relationship between teacher self-efficacy and instructional practices. As shown in Table 1, Singaporean teachers' efficacy to "answer students' question" (Shi, 2014, p. 593) was statistically significant. Korean teachers' efficacy was statistically significant for showing "students a variety of problem solving strategies" (Shi, 2014, p. 593). "[Providing] challenging tasks for capable students" (Shi, 2014, p.593) was not statistically significant for any country. Korea, Hong Kong, and Japan teacher efficacy in "adapt[ing] […] teaching to engage students' interest" (Shi, 2014, p. 593) was statistically significant. In Korea, Singapore, and Hong Kong, teacher efficacy was statistically significant for "help[ing] students appreciate the value of learning mathematics" (Shi, 2014, p.593). When teacher efficacy variables were controlled statistically, four factors made a unique contribution to instructional practices: (a) answering students' questions; (b) showing students a variety of problem solving strategies; (c) adapting teaching to engage students' interest; and (d) helping students appreciate the value of learning mathematics (Shi, 2014). The author noted teacher efficacy and instructional practices in Asian countries were not consistent.

Table 1

T-value for Teacher Efficacy Scale by Countries

Scale	Korea	Singapore	Hong Kong	Chinese Taipei	Japan
Answer students' questions	-1.53	2.32*	-0.48	0.51	0.46
Show students a variety of problem solving strategies	3.18**	1.48	0.21	1.23	-0.43
Provide challenging tasks for capable students	0.54	0.74	0.23	0.32	1.68
Adapt my teaching to engage students' interest	2.64**	1.83	2.27*	1.76	2.21*
Help students appreciate the value of learning mathematics	2.35*	3.62**	2.03*	1.04	1.30

Note. $^{*}p < .05$, $^{**}p < .01$

Student Efficacy. Several studies reviewed thus far have considered teacher efficacy and how teachers' confidence in students' abilities may affect teachers' and student's classroom performances. In addition, many studies have focused on student efficacy and motivation, as well as how the students' belief in their mathematical abilities may have an effect on their academic success in the mathematic classroom.

Usher and Pajares (2009) reviewed sources of mathematics self-efficacy (Bandura, 1997) for middle school students. The sources of mathematics self-efficacy were mastery experience, vicarious experience, social persuasion, and physiological and affective state. These sources were evaluated in three phases using the Sources of Middle School Mathematics Self-Efficacy Scale (Bandura, 1997). The students rated themselves on the six-point Likert-type scale, ranging from one (not at all confident) to six (completely confident). Phase 1 began with a focus group of 1,111 students in grades six, seven, and eight to develop the scale.

Phase 2 was administered to 824 students in grades six, seven, and eight, and two sources (i.e., vicarious experience and social persuasion) were modified based on the items' poor correlation in phase I while new items were created. In Phase 3, 803 students in grades six, seven, and eight were administered the scales. In this phase, motivation constructs were included to measure convergent and discriminant validity. The motivation variables were added and included engagement from efficacy beliefs (Miller, Greene, Montalvo, Ravindran & Nichols, 1996), mathematics self-concept from Self-Description Questionnaire II (Marsh, 1992), invitational messages from Inviting/Disinviting Index-Revised (Valiante & Pajares, 1999; Usher & Pajares 2006), achievement goals and self-handicapping from the Pattern of Adaptive Learning Survey (PALS; Midgley et al., 2000), and optimism from the Life Orientation Test-Revised (LOT-R; Scheier & Carver, 1985; Pajares, 2001). The authors hypothesized that students in this phase would have "higher ratings in their mathematics competence" and would therefore "tend to report more mastery experience and social persuasions and lower negative arousal than those with lower mathematics competence" (Usher and Pajares, 2009, p. 94).

An exploratory factor analysis was used to examine the results for 24 of 86 items from the Sources of Middle School Mathematics Self-Efficacy Scale to show "evidence for strong content validity, internal consistency, and criterion validity" (Usher and Pajares, 2009, p. 99). In addition, the authors proved a positive correlation between the sources, motivation variables, achievement, and self-efficacy; however, they suggested that qualitative research should be included in future research to gain better insights that are not seen through the lens of quantitative research.

The data collected from the survey and state SAT-10, Gilbert, et al. (2014), were used to explore the relationships between classroom environment and student motivation, student motivation and standardized test performance, and classroom environment and standardized test performance. Gilbert et al. (2014) found that reform practices and performance-avoidance goals were statistically significantly different.

Usher and Pajares (2006) examined self-efficacy beliefs for first-time middle school students. The sample included 468 sixth grade students entering middle school. Hierarchical regression analysis was used to analyze the data collected from self-efficacy scales and semester averages in math, reading, and language arts. The results indicated that self-efficacy correlated with mastery experience, vicarious experience, social persuasion, and physiological state. Another factor that predicted academic self-efficacy was invitation; therefore, the authors noted that girls were more inviting than boys when social persuasion was a predictor of self-efficacy.

Middleton (2013) sought to determine motivation in high school students when entering ninth grade. The data collected in this longitudinal study were from the High School Longitudinal Study of 2009 (HSLS: 09). The sample included students from 944 high schools and 25 ninth graders, with a total sample of 24,000 students. The results revealed self-efficacy significantly influenced mathematics identity and achievement. The author suggested that future research should determine if course selection predicts student interest and achievement.

Zarfin and Lavy (2012) focused on students' responsibility for their own level of learning math, which is known as "autonomy." This process provided students with a sense of self-regulation for goal-setting and motivation in their learning processes (Zarfin & Lavy, 2012). For example, students were able to choose if they wanted to take a low-, medium-, or high-level math exam for placement in the following year's math classroom. The authors selected fifty students from grades 9 and 10 to participate in this study. The students were given three exams and a questionnaire. Categories on the questionnaire included: goals, self-perception of mathematical ability, external factors, performance experience, and motivation (Zarfin & Lavy, 2012). The results of this study indicated that students' confidence improved during the third administration. Students' mathematics behavior was influenced by their perception when students were responsible for their academic success. The outcome of this study was supported by many authors who believed mathematical behavior influenced student self-efficacy (Pajares, 2002; Middleton, 2013; Gilbert et al., 2014; & Usher & Pajares, 2006).

Cognitive Learning

The most commonly-used cognitive learning process in K-12 and higher education environment is Bloom's Taxonomy (Armstrong, n.d.). Table 2 displays the original and revised Bloom's Taxonomy cognitive learning process, beginning with the highest order of thinking to the lowest order of thinking. Bloom, Engelhart, Furst, Hill, and Krathwohl (1956) developed the original Bloom's Taxonomy. A group of cognitive psychologists (Anderson et al., 2001) revised the original Bloom's Taxonomy and now describe the hierarchy of learning with verbs. Bloom's Taxonomy was intended to provide teachers with measurable goals to demonstrate student achievement in the classroom (Krathwohl, 2002).

Table 2

Bloom's Taxonomy

Original	**Revised**
Evaluation	Create
Synthesis	Evaluate
Analysis	Analyze
Applications	Apply
Comprehension	Understand
Knowledge	Remember

In addition, there were several ways of measuring the breadth and depth of knowledge. Krathwohl (2002) identified the four categories of knowledge as: factual (e.g., math symbols, math terms), conceptual (e.g., math formulas), procedural (e.g., steps used in order of operations), and metacognitive (e.g., ability to identify steps needed to solve a math problem). Dabae and Yeol (2014) examined teachers' instructional strategies and students' mathematical learning outcome. This study used data collected from TIMSS 2007 eighth grade mathematics survey. There were 7,377 students and 532 teachers who participated in this study.

Multilevel modeling, exploratory analyses, and modeling fitting was completed to explain instructional strategies' influence on student learning outcome and to determine the relationship between instructional strategies and the student learning outcome (Dabae & Yeol, 2014). The result of this study indicated that teachers' instructional strategies explained 29% of variance for student learning mathematics outcome; therefore, teachers' instructional strategies were useful in student academic achievement. Writing, practicing, and relating were significant and correlated with student math achievement. Writing and relating were negatively correlated with student math achievement (Dabae & Yeol, 2014). In other words, students achieved higher math outcomes when they practiced writing equations.

Roegner (2013) evaluated student mathematics achievement in Linear Algebra—a course for engineers. The author interviewed students who failed the written exam twice. During the interviews, students admitted to spending a lot of time studying for the exam. The exam was scored applying Bloom's hierarchy (i.e., knowledge, comprehension, application of knowledge, analysis, synthesis, and evaluation). The results suggested that students were failing because they were unable to explain "how or why the algorithm works" (Roegner, 2013, p. 84). The author explained that students were only able to apply lower order thinking to the exams, and the university does not offer a course at a lower level to prepare students according to their skill level.

In a mixed method study of elementary students (i.e., grades 3-6), Budak and Kaygin (2015) linked students' cognitive abilities with learning environments. From a sample of 306 selected (noted as gifted) and unselected students (not noted as gifted) from 17 classrooms, Budak and Kaygin (2015) examined the connection between engagement in a classroom and academic achievement. The classroom engagement noted between selected and unselected students was statistically different. The selected students participated in classroom discussions more than unselected students. The selected students answered more questions that required high order thinking and were more attentive to discussions (Budak and Kaygin, 2015).

Budak and Kaygin (2015) also measured differences in cognitive levels between selected and unselected students. The authors found that the cognitive levels between the two groups were statistically different and supported the teacher's comments related to selected students' higher levels of creativity with their math solutions. Moreover, the classroom environment for selected students was not a benefit for these students. In fact, the authors identified that these students were easily bored with the curriculum and lost respect for the course. Budak and Kaygin (2015) suggested that differentiated classrooms should be offered in the curriculum to provide all students with an opportunity to gain a level of higher order thinking.

Mathematics Academic Achievement

An academic achievement initiative began in 1965 when President Lyndon B. Johnson signed the Elementary and Secondary Education Act (ESEA), which is now known as Every Student Succeeds Act (ESSA), which was signed on December 10, 2015, by President Barack Obama (Every Student Succeeds Act, n.d.). The ESSA (n.d.) mandated that students be held to high academic achievement standards, which would prepare them for higher education opportunities. This mandate held teachers and districts accountable for low-income community students where graduation rates were low. According to Shores and Shannon (2007), academic achievement has impacted cognitive learning strategies, motivation, and self-regulated learning in students.

Voight, Shinn, and Nation (2012) explored student academic achievement based on residential mobility. Residential mobility was not necessary deemed negative if parents were moving to take on a new job with higher wages. Although moving could be stressful for the child (Voight, Shinn, & Nation, 2012), it would potentially have a great impact on the student's academic and social skills (Swanson & Schneider, 1999). The data collected for this longitudinal study were collected from a sample of 8,337 students from 11 schools. A latent-growth modeling curve showed that students who moved between grades 3 to 8 experienced a decline in mathematics achievement (Voight et al., 2012). The authors suggested providing a more stable environment in a child's early years could reduce the negative impact of academic achievement for urban students in eighth grade.

Studies have shown that students' transition from middle school to high school leads to greater challenges with academics and social skills (Gutman, 2006; Eccles & Midgley, 1989). Gutman (2006) completed a longitudinal study on 901 students during their last year in elementary school until the beginning of their first year in high school. This study investigated how mastery and performance goals of the student and parent influenced the student's mathematics achievement (Gutman, 2006). The author used PALS (Midgley et al., 1996) to measure student mastery, performance, perceived classroom performance and mastery, and mathematics self-efficacy. The students' mathematics grade point average at the end of their eighth and ninth grade years was used to measure their academic achievement. Open-ended interviews were used to collect parents' mastery and performance goals (Gutman, 2006). The results of this study indicated that students' self-efficacy and mathematic achievement were positive for those who embraced mastery goals, which were similar to the results of Friedel et al. (2007). In contrast, students' performance was not correlated to students' academic achievement. Similarly, parents with high expectations of student mastery goals achieved higher math grades. Gutman (2006) suggested that mastery goals play an important part in high school students' mathematical achievement and recommend that future research investigate student performance goals later in high school.

Romero, Master, Paunesku, Dweck, and Gross (2014) contributed a review article demonstrating the ways in which the "malleability of traits predict [a student's] ability to cope with these academic and emotional challenges" (p. 227). The authors clearly documented the importance of emotion and intelligence theories of middle school students by showing that these theories were related to students' academic success in school. Intelligence theories influenced students' grades and their decisions to take more advanced level math courses (Romero, Master, Paunesku, Dweck, & Gross, 2014). Similarly, emotional theories influenced students' mastery oriented in academic achievement. However, the authors suggested that future studies examine the relationship between emotion theories and academic results.

Some researchers have looked at the influences of self-efficacy, task value, and achievement goals in mathematics. For example, Skaalvik, Federici, and Klassen (2015) examined the impact of teacher support and mathematics self-efficacy on student motivation and mathematics achievement. A diverse sample of 823 middle school students in Norway participated in this study. The instrument used in this study measured students' perception, mathematics self-efficacy, intrinsic motivation, effort, attention, and help-seeking behavior. The researchers noted that student self-efficacy is a common predictor of motivation. Their study reviewed the following three predictor models: (a) model 1 included grades and gender, (b) model 2 included model 1 and teacher emotional support, and (c) model 3 included model 2 and self-efficacy.

Zero mean correlations, regression analysis, and SEM yielded results that supported the relationship between mathematics self-efficacy, effort, intrinsic motivation, help-seeking behavior, and persistence. In addition, teacher emotional support was strongly correlated with help-seeking behavior. Self-efficacy; however, did not appear to influence the relationships among grades in mathematics, effort, help-seeking behavior, intrinsic motivation, and persistence. After entering emotional support into the equation, the relationship between grades in mathematics and motivation constructs declined. Therefore, students' motivation strongly determined performance, given that the student-teacher relationship is positive.

Gaps in the Literature

A systematic review summarizes the extant literature about the influence of mathematics achievement on middle school students' self-efficacy, task value, teacher efficacy, and teacher preparation. This is an emerging area of research, and, as a result, I found that few published analyses exist on this topic. Although my ability to make definitive conclusions with regard to mathematics achievement on middle school students and causal relationships was limited, existing research suggests that certain aspects of the self-efficacy and motivation constructs may shape behavior among achievement in mathematics. Early evidence suggested that self-efficacy, motivation, parental expectation, and teacher preparation may be related to increased mathematics achievement, although further studies of this association are needed in different geographic contexts. The correlation between mathematics achievement on middle school students' self-efficacy, task value, teacher efficacy, and teacher preparation is less clear, given the lack of extant results. However, reasonably consistent support linked self-efficacy and motivation to increased mathematics achievement. The existence of successful predictions of mathematics achievement on middle school students using self-efficacy, task value, teacher efficacy, and teacher preparation remains unclear.

Summary

This chapter provides background information on motivation, student engagement, expectancy value, teacher and student self-efficacy, and cognitive learning while showing how these factors influence student academic achievement in middle school. From the information provided in this literature review, a study on student and teacher self-efficacy and perceived task value will predict student academic achievement in mathematics for students in the eighth grade. Chapter III provides an in-depth look in the methodology of this study and describes the participants in this study.

Chapter III. Methods

Introduction

Chapter 2 reviews the literature, which considered the self-efficacy of student and teacher preparation, motivation, student engagement, and middle school student achievement in mathematics. This chapter reviews the methods, samples, instrument, data collection, and data analysis used to measure the relationships between student and teacher.

Purpose of the Study

The purpose of this study was to measure the relationships among a sample of the United States eighth grade student mathematics achievement (number, algebra, geometry, and data choice), student and teacher self-efficacy, student task value, and teacher preparation. Both teacher and student data were analyzed using Trends in International Mathematics and Science Study (TIMSS) 2011 version for eighth graders. TIMSS (2011) student and teacher questionnaires were used to collect data. The student questionnaire was used to measure student demographics, home and school environments, self-efficacies, and attitudes toward learning mathematics.

The teacher questionnaire was used to measure general teaching experience, experience teaching mathematics, educational background, and professional development. This research will provide a better understanding of the impact of teacher preparation and self-efficacy on middle school student achievement in mathematics. In addition, this study was built on what is currently known about self-efficacy, student achievement, and teacher preparation.

Research Questions

The following research questions were investigated in this study:

1) Does student self-efficacy predict eighth grade student achievement in mathematics (summing across algebra, geometry, numbers, and data choice domains)?
2) Does student perceived task value predict eighth grade student achievement in mathematics (summing across algebra, geometry, numbers, and data choice domains)?
3) Does teacher self-efficacy predict eighth grade class mean math achievement (summing across algebra, geometry, numbers, and data choice domains)?
4) Does teacher preparation predict eighth grade class mean math achievement (summing across algebra, geometry, numbers, and data choice domains)?
5) Does teacher self-efficacy predict within classroom effects of student level predictors within the classroom?
    a) How much variation in intercepts (classroom means) is explained by teacher self-efficacy?
    b) How much variation in the effect of student self-efficacy and perceived task value slopes on math achievement is explained by teacher self-efficacy?
6) Does teacher preparation predict within classroom effects of student level predictors within the classroom?
    a) How much variation in intercepts (classroom means) is explained by teacher preparation?

b) How much variation in the effect of student self-efficacy and perceived task value slopes on math achievement is explained by teacher preparation?

Hypotheses

There were six main research hypotheses examined in this study:

1) Student self-efficacy will positively predict eighth-grade student achievement in mathematics (summing across algebra, geometry, numbers, and data choice domains).
2) Student perceived task value will positively predict eighth-grade student achievement in mathematics (summing across algebra, geometry, numbers, and data choice domains).
3) Teacher self-efficacy will be associated with eighth-grade class mean math achievement (summing across algebra, geometry, numbers, and data choice domains).
4) Teacher preparation will be associated with eighth-grade class mean math achievement (summing across algebra, geometry, numbers, and data choice domains).
5) There will be variation in the level-1 slopes and level-1 intercepts based on teacher self-efficacy within the classroom.
6) There will be variation in the level-1 slopes and level-1 intercepts based on teacher preparation within the classroom.

Methods

This study used the Trends in International Mathematics and Science Study (TIMSS) 2011 survey developed by the International Association for the Evaluations of Educational Achievement (IEA) as part of its research design. TIMSS was administered in the United States (US); Alabama (AL), California (CA), Colorado (CO), Connecticut (CT), Florida (FL), Indiana

(IN), Massachusetts (MA), Minnesota (MN), and North Carolina (NC) were the nine states that participated in this study. The TIMSS study consisted of a mathematics assessment, and demographic information was collected in the student and teacher questionnaires. The responses were confidential, and each participant was assigned a unique identifier number.

The study was conducted after obtaining permission from Auburn University's Institutional Review Board (IRB) by the researcher for the use of human subjects for research (see Appendix A). The protocol detailed the study's purpose, research questions, participants, method of analysis, and security of the data. Once permission was approved by Auburn University's IRB, data were organized and analyzed.

The data were retrieved from the TIMSS national public dataset, and unwanted variables were removed. The data were then uploaded in HLM 7 student version to begin statistical analysis.

Sample

The participants for this study consisted of 10,477 (5,297 girls and 5,180 boys) eighth grade students and 442 (311 females and 131 males) teachers from 501 schools in the United States. Data collection took place between April and May in the spring semester of 2011. The researcher retrieved data in October 2015. The participants were eligible to participate in the original data collection if parents did not notify the school in writing stating otherwise; the participants were randomly selected from that pool. Participants for the study were selected using stratified two-stage cluster sampling design (Joncas & Foy 2012).

Schools were selected in the first stage of sampling. The schools selected were identified by stratification variables such as: geographic region (e.g., states or provinces), school type (e.g., public or private), language of instructions, urban or rural area, socioeconomic status, and school performance on national exams (Joncas & Foy 2012). Specifically, the stratification variable used to select schools and states in the United States were: location (e.g., city and rural), region, socioeconomic status, school type, and ethnicity. To get a representative sample from each category, one school was sampled from the population to participate in the study and two schools were sampled as replacement schools. The replacement schools were used if the original sample school decides not to participate in the study. Classes are selected from the schools in the second stage of the sampling technique. The classes are selected using a within school sampling software developed by IEA. If the classes were smaller than the minimum requirement, then two or more classes were combined in a school to create a pseudo class. Classes may not be replaced if a class decides not to participate in the study (Joncas & Foy 2012).

Instrumentation

In 1995, the National Center for Education Statistics (NCES) began administering TIMSS to compare trends in students from the United States with those of students from other countries. TIMSS 2011 mathematics assessment (see Appendix D) measured content and cognitive domain. In this study, the content domain, which includes number (30%), algebra (30%), geometry (20%), and data and chance (20%), were analyzed. The Science and Mathematics Item Review Committee (SMIRC) and the Questionnaire Item Review Committee (QIRC) were formed by TIMSS to update the test items and questionnaires (Mullis, Drucker, Preuschoff, Arora, & Stanco, 2012). The scales for the student and teacher questionnaires were reviewed by the QIRC to make recommendations for updates. The committee will review the completed questionnaires and make suggestions. However, prior to including new items, it was necessary that the old items be retired (Mullis et al., 2012)

SMIRC updated the content and cognitive domains based on the current research findings. Updating topics included rewriting test items for clarity and combining topics to reduce redundancy (Mullis et al., 2012). The mathematics achievement test consisted of 14 test booklets with two mathematics blocks and approximately 200 multiple choice and constructed response items. For this study, the mathematic assessment, teacher questionnaire, and student questionnaire were utilized.

The researchers collected data using a student questionnaire, a teacher questionnaire, and a mathematics assessment (Martin & Mullis, 2012). The student questionnaire (see Appendix B) included questions about home and school experience in mathematics. For this study, the student self-efficacy (nine items) and task value scales (six items) acted as independent variables and mathematics achievement was the dependent variable. The scale items included the following likert scale options: agree a lot (1), agree a little (2), disagree a little (3), and disagree a lot (4). The teacher questionnaire (see Appendix C) included questions about professional development, education background, teaching experience, instructional activities, and materials in mathematics.

Teacher self-efficacy and teacher preparation in mathematics content domain are used to measure mathematics achievement in the classroom. The teacher self-efficacy scale (five items) included the following options: very confident (1), somewhat confident (2), and not confident (3). The teacher preparation scale consisted of the following four subscales: number (five items), algebra (five items), geometry (six items), and data and chance (three items). The scale items included the following options: very well prepared (2), somewhat prepared (3), and not well prepared (4). For both the teacher and student scale, the items were averaged per scale to create the independent variable scores.

Validity

The Standards for Educational and Psychological Testing (2011) defined "validity" as the degree to which evidence and theory support the results of the expected outcome based on the intent of the testing instrument. Therefore, if a high level of validity is present, the instrument should accurately measure the content and cognitive domains of the mathematics assessment. Since TIMSS was intended to measure students' content knowledge and cognitive level for the mathematics assessment, determining the content validity was necessary in the development of the exam and its use as a measurement instrument. National Research Coordinators (NRC) were designated by each country to implement the TIMSS 2011 national study. The NRC also works with experts from their countries to develop test items with scoring guides for the constructed response items (Martin & Mullis, 2012).

These items are reviewed before and after the field test to determine which items to place on the assessment. TIMSS Mathematics Coordinators work with the NRC staff from the countries to provide additional guidance and support for examining the items. The following steps were taken to ensure validity when updating TIMSS framework (i.e., questionnaire and assessment) (Mullis et al., 2012):

- Extensive research of articles, reports, and papers related to the content and educational learning context is completed prior to first meeting with NRC.
- Previous assessment, updates and clarifications are made with TIMSS International Study Center Staff and the mathematics coordinators.
- Recommendations for updates from NRC are suggested for context and content.
- The recommendations suggested by NRC are circulated in an online survey to collect opinions from constituencies in their countries.

- After receiving the results from the survey, the team begins to update the study.
- The expert committee reviews the updates and makes further modification, if needed.
- The final draft is submitted to the NRC for review prior to second meeting.
- The framework is adopted and submitted to all parties.

The information gathered from the committee members suggested that no more than five percent of the framework should be updated during each assessment cycle (Mullis et al., 2012).

Reliability

According to the Standards for Educational and Psychological testing, “reliability” refers to the consistency of test scores when repeating the testing procedure on a population. Reliability requirements were established for TIMSS 2011 mathematics assessment, student questionnaire, and teacher questionnaire. Cronbach’s alpha reliability coefficient was used to measure the internal consistency. Martin, Mullis, Foy, and Arora (2012) identified an acceptable level as 0.6 or 0.7. The path coefficients from the principal component analysis measured the correlation between each item and the scale it represents for the United States. The internal reliability (or closely associated the set of items are as a group) for each scale was: teacher self-efficacy scale (0.69), student self-efficacy scale (0.89), and student task value scale (0.79) (Martin, Mullis, Foy, & Arora, 2012). The United Stated median reliability (based on data for all states combined) for TIMSS 2011 eighth grade mathematics assessment was 0.88 (Foy, Martin, Mullis, & Stanco, 2012). For the United States, the path coefficients (see Tables 3, 4, and 5) from the principal component analysis are described as positive (Martin, Mullis, Foy, & Arora, 2012).

Table 3

Principal Components Analysis Factor Loadings for Student Self-Efficacy

	US
I usually do well in mathematics	0.77
Mathematics is more difficult for me than for many of my classmates	0.74
Mathematics is not one of my strengths	0.81
I learn things quickly in mathematics	0.81
Mathematics makes me confused and nervous	0.71
I am good at working out difficult mathematics problems	0.76
My teacher thinks I can do well in mathematics classes with difficult materials	0.61
My teacher tells me I am good at mathematics	0.61
Mathematics is harder for me than any other subject	0.79

Note. Adapted from *Creating and Interpreting the TIMSS and PIRLS 2011 Context Questionnaire Scales*, by Martin, M. O., Mullis, I. V. S., Foy, P., & Arora, A., 2012, Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.

Table 4

Principal Components Analysis Factor Loadings for Teacher Self-Efficacy

	US
Answer students' questions about mathematics	0.55
Show students a variety of problem solving strategies	0.70
Provide challenging tasks for capable students	0.68
Adapt my teaching to engage students' interest	0.70
Help students appreciate the value of learning mathematics	0.72

Note. Adapted from *Creating and Interpreting the TIMSS and PIRLS 2011 Context Questionnaire Scales,* by Martin, M. O., Mullis, I. V. S., Foy, P., & Arora, A., 2012, Chestnut Hill,
MA: TIMSS & PIRLS International Study Center, Boston College.

Table 5

Principal Components Analysis Path Coefficients for Student Task Value

	US
I think learning mathematics will help me in my daily life	0.77
I need mathematics to learn other school subjects	0.72
I need to do well in mathematics to get into college or university of my choice	0.71
I need to do well in mathematics to get the job I want	0.76
I would like a job that involves using mathematics	0.62
It is important to do well in mathematics	0.66

Note. Adapted from *Creating and Interpreting the TIMSS and PIRLS 2011 Context Questionnaire Scales*, by

Martin, M. O., Mullis, I. V. S., Foy, P., & Arora, A., 2012, Chestnut Hill, MA: TIMSS & PIRLS International Study Center,
Boston College.

A separate principal component analysis was conducted for each scale in the United States. For the teacher self-efficacy scale, the results of the principal component analysis accounted for 45% of the variance. According to Mertler and Vannatta (2010) 70% of the variance accounted for by the identified number of components is optimal. However, Martin, Mullis, Foy, and Arora (2012) identified the amount of variance accounted for by the first component in each of their analyses as acceptable to consider the items to represent a single scale. For the student task value, the results of the principal component analysis accounted for 50% of the variance. Lastly, for the student self-efficacy, the results of the principal component analysis accounted for 55% of the variance (Martin, Mullis, Foy, & Arora, 2012).

Table 6 displays the within country and trend item reliability scoring for the TIMSS 2011 mathematics assessment. These reliabilities measure the accuracy in grading the constructed response items regardless of scorers in each country (Foy, Martin, Mullis, & Stanco, 2012). Each scorer was provided training and a scoring guide. The within country and trend reliability scoring indicated that on average agreement across items correctness was 98% or higher and average 97% for the diagnostic score.

Table 6

United States Scoring Reliability for Constructed Response Items

	Correctness Score Agreement		Diagnostic Score Agreement	
	Average of Exact Percent Agreement	Range of Exact Percent Agreement	Average of Exact Percent Agreement	Range of Exact Percent Agreement

	Across Items	Minimum	Maximum	Across Items	Minimum	Maximum
Within Country Scoring Reliability	98	87	100	97	82	100
Trend Scoring Reliability	98	94	100	97	91	100

Note. Adapted from *Reviewing the TIMSS and PIRLS 2011 Achievement Item Statistics*, by Foy, P., Martin, M. O., Mullis, I. V. S., &
Stanco, G., 2012, Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.

Data Collection

This research study examined the relationships among the United States eighth grade student mathematics achievement (number, algebra, geometry, and data choice) and student and teacher self-efficacy, student task value, and teacher preparation. The data collected and used to measure student mathematics achievement were student achievement scores from the eighth grade mathematics assessment, as well as self-efficacy, task value, and teacher preparation from questionnaires. The International Association for the Evaluation of Educational Achievement (IEA) International Database (IDB) analyzer (Version 3.2) was downloaded and used to merge the following data files: student background questionnaire, teacher background questionnaire, and eighth grade mathematics achievement. This researcher averaged the items within each scale to form a scale score.

Data Analysis

Hierarchical linear modeling (HLM) (also known as multilevel modeling, random coefficient modeling, or mixed effects modeling) is a regression model used to estimate the effects of nested data (Bryk & Raudenbush, 1992). The purpose of HLM is to measure the effect of the explanatory variable (i.e., the variable that explains the reason for the outcome) at different levels of hierarchy assuming independence is violated, equal variance, and normality at level-1 (Bryk & Raudenbush, 1992; Hox, 2002). According to Bryk and Raudenbush (1992) the use of ordinary least squares (OLS) regression assumes independence, normality, and constant variance for random errors. In this study clustering refers to the grouping of students by teacher. Therefore, each teacher contributes only one value per variable for all students in his or her class. Because of the clustering of observations in nested data, violation of independence usually occurs which increases the risk of type I error. In this study, the effects of self-efficacy, teacher preparation, and perceived task values were the explanatory variables used to predict mathematics achievement for students in the U.S. The results of HLM were based on two levels: students and classrooms. The first level yielded intercepts and slopes based on student predictors (i.e., self-efficacy and perceived task values); the second level yielded the intercepts and slopes based on classroom predictors (i.e., teacher preparation and self-efficacy).

HLM is used to separate the variance and covariance, measure the cross-level effects, and improve estimates of individual effects (Bryk & Raudenbush, 1992; Hox, 2002). This study used HLM to account for student level variability as well as teacher level variability in students' mathematics achievement. This method of analysis reduced bias when variances are equal and improved the estimate of effects. In addition, the covariance (or relationships) was different in each classroom because each was independent of one another. For example, if one were to study the amount of influence a teacher has on students' mathematics achievement, self-efficacy, and perceived task values in each classroom, then the relationship between the students and the teachers could vary based on contextual factors (e.g., the environment).

When analyzing nested data, HLM strengthened this study's causal argument because it provided the ability to separate error terms and account for dependencies created by nested data.

These factors violated the assumptions in other statistical models, such as ordinary least squares (OLS). Generally, students are zoned for schools within their community and are not randomly assigned (Osborne, 2000). Therefore, students are not independent of each other and are more likely to come from similar environments with similar values (Osborne, 2000).

As mentioned above, HLM was superior for use with the data in this study because all students were nested in a classroom with homogenous teacher efficacy and preparation. This observation does not support the assumption of independence, and a cross-level effect must be accounted for at the classroom level and not at the individual level.

Intraclass correlation. Intraclass correlation was used to determine the need for HLM or a simpler anaylsis. Hox (2002) defined intraclass correlation (ICC) or rho (ρ) as the amount of variance (student variation) in the dependent variable divided by between-classrooms or class level (τ_{oo}) and within-classrooms or student level (σ^2). *Equation* 1 (O'Dwyer & Parker, 2014) was used to calculate the portion of variance using the parameter estimates:

$$\text{ICC } (\rho) = \frac{\tau_{00}}{\sigma^2 + \tau_{00}}. \quad (1)$$

Huang (2016) explained the results of ICC as an expected range from zero to one. If the ICC is zero or close to zero, then there is no dependency in the data, and HLM is not needed. On the other hand, if the ICC is closer to one than to zero, then there is evidence of dependency in the data. A hierarchical model is suggested if ICC is greater than .05 and less than .25 (Hedges & Hedberg, 2007; Heck & Thomas, 2000; Muthén, 1999).

Centering. Bryk and Raudenbush (1992) defined centering as moving a variable from one location to provide a clear meaning for the intercept at level-1. Group mean centering and grand mean centering were used to choose locations of my predictors variables for a precise meaning of the level-1 intercept and slopes as outcome variables. In this study, student self-efficacy and student perceived task value were entered as group mean centering to analyze the effect of the level-1 and level-2 predictors variables. The level-2 variables, teacher self-efficacy and teacher preparation were entered as grand mean centering which only changed the intercept and is equal to the grand mean of the teacher class mean.

This study required two levels of hierarchical data structure. The level one model (*equation 2*) was used to predict mathematics achievement (Y) for student *i*, taught by teacher *j*:

Level 1 (e.g., students)

$$Y_{ij} = \beta_{0j} + \beta_{1j}(self\ efficacy)_{ij} + \beta_{2j}(task\ value)_{ij} + r_{ij} \quad (2)$$

where:

Y_{ij} = math achievement for individual *i* (i = 1,…,nj) in group *j* (j = 1,…,N),

self-efficacy $(SE)_{ij}$ = individual level total self-efficacy score,

task value $(TV)_{ij}$ = individual level total task value score,

β_{0j} = intercept (class means math achievement),

β_{1j} = student self-efficacy level-1 slope,

β_{2j} = student task value level-1 slope,

r_{ij} = residual error term for the individual student

The model for level two was used to predict intercept in class and regression slopes of self-efficacy and task value in classrooms are *equations* 3, 4, and 5:

Level 2 (e.g., classrooms)

$$\beta_{0j} = \gamma_{00} + \gamma_{01}(teacher\ SE)_j + \gamma_{02}(teacher\ preparation)_j + u_{0j} \quad (3)$$

$$\beta_{1j} = \gamma_{10} + \gamma_{11}(teacher\ SE)_j + \gamma_{12}(teacher\ preparation)_j + u_{1j} \quad (4)$$

$$\beta_{2j} = \gamma_{20} + \gamma_{21}(teacher\ SE)_j + \gamma_{22}(teacher\ preparation)_j + u_{2j} \quad (5)$$

where:

β_{0j} = intercept,

β_{1j} = student self-efficacy slope per teacher,

β_{2j} = student task value slope per teacher,

γ_{00} = mean achievement per classroom (teacher level),

γ_{01} = difference in mean achievement based on teacher self-efficacy,

γ_{02} = difference in mean achievement based on teacher preparation,

γ_{10} = average student self-efficacy slope in classroom,

γ_{11} = the mean difference in student self-efficacy slopes based on teacher self-efficacy,

γ_{12} = the mean difference in student self-efficacy slopes based on teacher preparation,

γ_{20} = average student task value slope in classroom,,

γ_{21} = the mean difference in student task value slopes based on teacher self-efficacy,

γ_{22} = the mean difference in student value slopes based on teacher preparation,

u_{0j} = random error of intercept,

u_{1j} = random error of student self-efficacy slope, and

u_{2j} = random error of student task value slope.

HLM provided the ability to examine relationships between variables on different levels by partitioning the error variance to retrieve a more accurate parameter estimate. Cross level interactions addressed the relationship between student and teacher level predictors. For example, one cross level interaction would address the relationship between student self-efficacy and math achievement based on teacher self-efficacy levels. Another example of cross level interaction would address the relationship between student task value and math achievement based on teacher self-efficacy levels. In addition, dependence was taken into account between teachers and students. The use of HLM accounted for variance on all levels by calculating the ICC and cross-level effects to explore relationships (Bryk & Raudenbush, 1992).

Bryk and Raudenbush (1992) examined the benefit of cross-level effects for testing hypotheses “about how variables measured at one level affect relations occurring at another” (p.6). For the purpose of this study, the following models were developed using HLM 7 statistical software to answer each research question:

- Unconstrained (null) model was developed without predictors to determine the need for HLM,
- random intercepts model was developed to assess the relationship between the student level predictors and eighth grade mathematics achievement,
- means-as-outcome model was developed to examine the relationship between the means of mathematics achievement and teacher level predictors, and
- slopes-and-intercept model was developed to test the interaction between the student and teacher level predictors.

Summary

The purpose of this study was to measure the relationships among the United States eighth grade student mathematics achievement (number, algebra, geometry, and data choice) and student and teacher self-efficacy, student task value, and teacher preparation. The researcher used a national pre-existing dataset to investigate the variables through HLM and descriptive statistics. Chapter IV presents the finding from the study.

Chapter IV. Findings

Introduction

Chapter III reviews the methods, samples, instrument, data collection, and data analysis used to measure the relationships between student and teacher variables and student math achievement. This chapter presents the descriptive and hierarchical linear modeling used to explore mathematics achievement for students while accounting for student self-efficacy, teacher self-efficacy, student task value, and teacher preparation. The chapter begins with the study's descriptive analyses, including examinations of frequencies. It should be noted that the full HLM tables (those which display all nested models discussed here) appear in Appendix C.

Purpose of the Study

The purpose of this study was to measure the relationships among the United States eighth grade student mathematics achievement (number, algebra, geometry, and data choice), student and teacher self-efficacy, student task value, and teacher preparation. Both teacher and student data were analyzed using Trends in International Mathematics and Science Study (TIMSS) 2011 version for eighth graders. TIMSS (2011) student and teacher questionnaires were used to collect data. The student questionnaire was used to obtain student demographics, home and school environments, self-efficacies, and attitudes toward learning mathematics.

The teacher questionnaire was used to measure general teaching experience, experience teaching mathematics, educational background, and professional development. This research will provide a better understanding of the impact of teacher preparation and self-efficacy on middle school student achievement in mathematics. In addition, this study was built on what is currently known about self-efficacy, student achievement, and teacher preparation.

Research Questions

The following research questions were investigated in this study:

1) Does student self-efficacy predict eighth grade student achievement in mathematics (summing across algebra, geometry, numbers, and data choice domains)?
2) Does student perceived task value predict eighth grade student achievement in mathematics (summing across algebra, geometry, numbers, and data choice domains)?
3) Does teacher self-efficacy predict eighth grade class mean math achievement (summing across algebra, geometry, numbers, and data choice domains)?
4) Does teacher preparation predict eighth grade class mean math achievement (summing across algebra, geometry, numbers, and data choice domains)?
5) Does teacher self-efficacy predict within classroom effects of student level predictors within the classroom?
    a) How much variation in intercepts (classroom means) is explained by teacher self-efficacy?
    b) How much variation in the effect of student self-efficacy and perceived task value slopes on math achievement is explained by teacher self-efficacy?
6) Does teacher preparation predict within classroom effects of student level predictors within the classroom?
    a) How much variation in intercepts (classroom means) is explained by teacher preparation?

b) How much variation in the effect of student self-efficacy and perceived task value slopes on math achievement is explained by teacher preparation?

Hypotheses

There were six main research hypotheses examined in this study:

1) Student self-efficacy will positively predict eighth-grade student achievement in mathematics (summing across algebra, geometry, numbers, and data choice domains).
2) Student perceived task value will positively predict eighth-grade student achievement in mathematics (summing across algebra, geometry, numbers, and data choice domains).
3) Teacher self-efficacy will be associated with eighth-grade class mean math achievement (summing across algebra, geometry, numbers, and data choice domains).
4) Teacher preparation will be associated with eighth-grade class mean math achievement (summing across algebra, geometry, numbers, and data choice domains).
5) There will be variation in the level-1 slopes and level-1 intercepts based on teacher self-efficacy within the classroom.
6) There will be variation in the level-1 slopes and level-1 intercepts based on teacher preparation within the classroom.

Descriptive

Using the Statistical Package for the Social Sciences (SPSS, 2012) version 22, a frequency distribution was obtained in Table 7 and Table 8 to identify the number of students and teachers who participated in the TIMSS 2011 study. The sample size, mean, and standard deviation for students' mathematics achievement, student level variables, and teacher level variables were displayed in Table 9. Student and teacher ethnicity and socioeconomic status were not available in the TIMSS 2011 public dataset.

Table 7.

Distribution of Student Participants by Gender

Students	Sample (n)	Percent (%)
Girl	5297	50.6
Boy	5180	49.4
Total	10477	100.00

Table 8.

Distribution of Teacher Participants by Gender

Teachers	Sample (n)	Percent (%)
Female	311	70.4
Male	131	29.6
Total	442	100.0

Table 9.

Descriptive Statistics for TIMSS 2011Eighth Grade Mathematics

	n	M (SD)
Student level variables		
Mathematics Achievement	10477	509.63 (78.52)
Student self-efficacy	10346	2.39 (0.35)
Task value	10386	1.69 (0.57)
Teacher level variables		
Teacher self-efficacy	7821	1.22 (0.27)
Teacher preparation	8051	1.97 (0.27)

Note. n = sample size; M = mean; SD = standard deviation

Research Question 1 and Question 2

Do self-efficacy and perceived task value predict eighth grade student achievement in mathematics (summing across algebra, geometry, numbers, and data choice domains)?

Table 10 displays the results of the unconditional (null) model which is equivalent to the one-way analysis of variance (ANOVA) model. This model is used to establish a baseline for comparing subsequent models in HLM. The grand mean mathematic achievement point estimate is 508.33 with a standard error of 3.19. A 95% confidence interval was calculated $508.33 \pm 1.96(3922.30)^{1/2} = (385.58, 631.08)$, indicating that 95 times out of 100 the mean would fall between 385.58 and 631.08. The estimated variability (σ^2) at the student level was 2113.71 and the teacher level variance (τ_{00}) was 3922.30. The results of the intraclass correlation indicate that approximately 64.98% of the variance of student mathematics achievement lies between the teachers; 35.02% of the variance of student mathematics achievement lies within. The reliability estimates of each teacher's sample average mathematics achievement as an estimate of its true mean was 0.96 (Bryk & Raudenbush, 1992). The chi-square test (χ^2) suggests that there was a significant amount of variance in mathematic achievement (outcome variable) at the teacher level, χ^2 (398) = 13901.23, p < .001. The evidence from the ICC and the chi-square test supports the use of HLM (see Appendix E.).

Table 10.

Results from One-Way ANOVA Null Model (no predictors)

Fixed Effect	Estimate	SE	*t*	*d.f.*	*p*
Average teacher mean, γ_{00}	508.33	3.19	159.41	398	<0.001
Random Effect	Variance Component	*d.f.*	χ^2	*p*	
Intercept1 at Level-2, μ_0	3922.30	398	13901.23	<0.001	
Level-1 effect, *r*	2113.71				

Next, the random intercept model was calculated to test the relationship between the student level predictors (i.e., student self-efficacy and task value) and mathematics achievement within teachers. The results in Table 11 display the student mean mathematics achievement by teacher average. The point estimate was 508.30 with a standard error of 3.19. The relationship between the student self-efficacy and mathematics achievement was statistically significant, with higher levels of self-efficacy indicating higher math achievement (lower self-efficacy values = higher levels of self-efficacy). The relationship between the student task value and mathematics achievement was not statistically significant. Student self-efficacy was estimated to be -15.07 with standard error = 1.99 and t ratio = -10.88; task value was estimated to be -1.87 with standard error = 1.49 and t ratio = -1.26. On average, student self-efficacy increases mathematics achievement by 15.07 points per unit when task value is held constant; task value increases mathematics achievement by 1.87 points per unit when self-efficacy is held constant (lower self-efficacy values and task value scores = higher levels of the construct).

The estimated variances of slopes for student self-efficacy and task value are 173.04 and 165.07, respectively. The chi-square test (χ^2) suggests that there was a significant amount of variance in mathematic achievement (outcome variable) for the slopes of student self-efficacy and task value, $\chi^2(392) = 509.52$, $p < .05$ and $\chi^2(392) = 486.44$, $p < .05$, respectively. The 95% CI expected range of teacher means is $508.30 \pm 1.96(3937.08)^{1/2} = (385.31, 631.28)$. The 95% CI expected range of student self-efficacy slope is $-15.07 \pm 1.96(173.04)^{1/2} = (-40.85, 10.71)$. The 95% CI expected range of student task value slope is $-1.87 \pm 1.96(165.07)^{1/2} = (-27.05, 23.31)$. The reliability estimates of the level-1 intercept (0.970), student self-efficacy slope (0.216), and task value (0.181). These estimates were based on the average of each teacher's intercept and slope if OLS regression was calculated for each teacher, separately (Bryk & Raudenbush, 1992). Compared to the variance in the null model for teachers, the variance in this model was reduced from 2113.71 to 1996.82. The proportion of variance explained at level-1 was reduced by 5.53% when adding student self-efficacy and task value as predictors of mathematics achievement (Bryk & Raudenbush, 1992; Woltman, Feldstain, MacKay, & Rocchi, 2012). The correlation between intercept (classroom means), the effects of student self-efficacy slope, and the effects of student task value slopes are -0.549 (moderate) and -0.192 (low), respectively.

Table 11.

Results from Random Intercepts Model (Level-1 predictors only)

Fixed Effect	Estimate	SE	*t*	*d.f.*	*p*
Overall mean achievement, γ_{00}	508.30	3.19	159.26	398	<0.001
Mean student self-efficacy slope, γ_{10}	-15.07	1.39	-10.88	398	<0.001
Mean student task value slope, γ_{20}	-1.87	1.49	-1.26	398	0.209

Random Effect	Variance Component	*d.f.*	χ^2	*p*
Teacher mean, μ_0	3937.08	392	14684.86	<0.001
Student self-efficacy slope, μ_1	173.04	392	509.52	<0.001
Student task value slope, μ_2	165.07	392	486.44	0.001
Level-1 effect, *r*	1996.82			

Research Question 3 and Question 4

Do teacher self-efficacy and preparation predict eighth grade class means math achievement (summing across algebra, geometry, numbers, and data choice domains)?

The regression with means as outcomes model was calculated to assess the relationship between mathematics, teacher self-efficacy, and teacher preparation (Bryk & Raudenbush, 1992). Table 12 displays the results of the average teacher preparation and teacher self-efficacy. Teacher preparation does not predict eighth grade students' classroom average mathematics achievement at a statistically significant level, p = 0.063. Teacher self-efficacy positively (with low self-efficacy scores = higher levels of self-efficacy) predict eighth grade students' classroom average mathematics achievement at a statistically significant level, p = 0.024. When the average teacher preparation and teacher self-efficacy is zero the eighth grade students' classroom average mathematics achievement is 508.25. The expected range of teacher means after accounting for the effects of teacher self-efficacy and teacher preparation is 508.25 ± $1.96(3841.58)^{1/2}$ = (386.77, 629.73). The variance between teachers decreased slightly (from 3922.30 to 3841.58). Hence, the proportion of variance at the teacher level explained 2.06% in mathematics achievement after accounting for the effects of teacher self-efficacy and teacher preparation. The chi-square test suggested that at least one teacher level predictor was statistically significant [χ^2 (396) = 13652.58, p < .05)]. The conditional intraclass correlation 3841.58/ (3841.58+2113.44) = .6451 or 64.51% was calculated to measure the degree of dependence within teachers after accounting for teacher self-efficacy and teacher preparation (Bryk & Raudenbush, 1992). This ICC has slightly decreased from 64.98% to 64.51% after controlling for the teacher level predictors. Average mathematics achievement per classroom at Level-2 is statistically significant when accounting for teacher self-efficacy and teacher preparation as predictors.

Table 12.

Results from Means as Outcomes Model (Level-2 predictors only)

Fixed Effects	Estimate	SE	*t*	*d.f.*	*p*
Model for teacher means					
Intercept, γ_{00}	508.25	3.15	161.47	396	<0.001
Teacher self-efficacy, γ_{01}	-24.40	10.75	-2.27	396	0.024
Teacher preparation, γ_{02}	-27.23	14.61	-1.86	396	0.063
Random Effects	Variance Component	*d.f.*	χ^2	*p*	
Teacher mean, μ_0	3841.58	396	13652.58	<0.001	
Level-1 effect, *r*	2113.44				

Research Question 5 and Question 6

Do teacher self-efficacy and preparation within classroom effects of student level predictors within the classroom? How much variation in intercepts (classroom means) is explained by teacher self-efficacy and preparation? How much variation in the effect of student self-efficacy and perceived task value slopes on math achievement is explained by teacher self-efficacy and preparation?

The results are displayed in Table 13. The estimate of the variance of the student self-efficacy slope is 173.26 and student task value slope is 168.45 with chi-square test χ^2 (390) = 508.76, $p < .05$) and χ^2 (390) = 485.84, $p < .05$), respectively. The results reveal statistically significant variation among the slopes of student self-efficacy and task value. The correlation between the Level-1 intercept and student self-efficacy slope is -0.549, whereas Level-1 intercept and student task value correlation is -0.179. Teacher self-efficacy point estimate is -24.52 with a standard error of 10.75 and t ratio of -2.28; teacher preparation point estimate is -27.28 with a standard error of 14.63 and t ratio of -1.87. Teacher self-efficacy and teacher preparation were positively related with the classroom average mathematics achievement.

The student self-efficacy slopes based on teacher self-efficacy point estimate is -2.03 with a standard error of 4.48 and t ratio of -0.45; student self-efficacy slope based on teacher preparation point estimate is 7.87 with a standard error of 7.16 and t ratio of 1.10. The cross level interaction between the teacher level predictors and the slopes of the student level predictors were not statistically significant. Bryk and Raudenbush (1992) indicated that the estimate of the variance from the random coefficient model is the baseline. The amount of variance in the intercept of the mean mathematics achievement is explained by teacher self-efficacy and teacher preparation [(3937.08-3855.11) / 3937.08] = 0.0208 or 2.08%. The result of the chi-square χ^2 (390) = 14434.67, $p < .05$ reveals that there is residual variance remaining in the intercepts. The amount of variance in the slope of student self-efficacy for the mean mathematics achievement is explained by teacher self-efficacy and teacher preparation [(173.04-173.26)/173.04] = -0.0013 or -0.13% and [(165.07-168.45)/165.07] = -0.0205 or -2.05%, respectively.

Table 13.

Results from Random Intercept and Slopes Mode (slopes results)

Fixed Effect	Estimate	SE	*t*	*d.f.*	*p*
Model for teacher means					
Intercept, γ_{00}	508.22	3.15	161.34	396	<0.001
Teacher self-efficacy, γ_{01}	-24.52	10.75	-2.28	396	0.023
Teacher preparation, γ_{02}	-27.28	14.63	-1.87	396	0.063
Student self-efficacy slopes, β_1					
Intercept, γ_{10}	15.08	1.38	-10.91	396	<0.001
Teacher self-efficacy, γ_{11}	-2.03	4.48	-0.45	396	0.652
Teacher preparation, γ_{12}	7.87	7.16	1.10	396	0.272
Student task value slopes, β_2					
Intercept, γ_{20}	-1.84	1.49	-1.24	396	0.217
Teacher Self-Efficacy, γ_{21}	7.44	5.27	1.41	396	0.159
Teacher Preparation, γ_{22}	-0.94	5.63	-0.17	396	0.867

Random Effects	*Variance Component*	*d.f*	χ^2	*p*
Teacher mean, μ_0	3855.11	390	14434.67	<0.001
Student self-efficacy slopes, μ_1	173.26	390	508.76	<0.001
Student task value slopes, μ_2	168.45	390	485.84	<0.001
Level-1, r	1996.55			

Summary

The purpose of this study was to measure the relationships among the United States eighth grade student mathematics achievement (number, algebra, geometry, and data choice), student and teacher self-efficacy, student task value, and teacher preparation. This chapter discussed the results of the data analysis. Descriptive data presented in this chapter summarized the student and teacher level variables used in this study. The chapter also provided the results of four HLM models to ascertain if student self-efficacy and perceived task value predict eighth grade student achievement in mathematics and to assess the effects of teacher self-efficacy and preparation. The results of the random coefficient model revealed that the slopes of student self-efficacy were statistically significant in predicting eighth grade student achievement in mathematics. The results of the random coefficient model revealed that the slopes of student perceived task value were not statistically significant in predicting eighth grade student achievement in mathematics.

The results of the regression with means-as-outcomes revealed that the teacher self-efficacy was statistically significant in predicting eighth grade class means math achievement, whereas teacher preparation was not statistically significant in predicting eighth grade class means math achievement. The results of the intercept-and slopes-as-outcome model revealed teacher self-efficacy was statistically significant in predicting classroom slope in student math achievement whereas teacher preparation was not statistically significantly in predicting the classroom slope in student math achievement.

The results of the intercept-and slopes-as-outcome model revealed the 2.08% of the variation in intercepts (classroom means) was explained by teacher self-efficacy and preparation. The results of the intercept-and slopes-as-outcome model did not reveal statistical significance of variation in the slopes of student self-efficacy and perceived task value explained by teacher self-efficacy and preparation. A detailed summary and discussion of the findings and their implications are presented in Chapter V.

Chapter V. Summary, Conclusions, Implications, and Recommendations

Introduction

This study measured the relationships among the United States eighth grade student mathematics achievement (number, algebra, geometry, and data choice), student and teacher self-efficacy, student task value, and teacher preparation. The first chapter introduces the statement of the problem, the study's conceptual/theoretical framework, the purpose of the study, and the research questions. Additionally, it addresses the study's significance, limitations, delimitations, assumptions, definitions of terms, and organization. The second chapter contains the literature review of motivation, student engagement, expectancy value, teacher self-efficacy, student self-efficacy, cognitive learning, mathematics academic achievement, gaps in the literature, and hypotheses. The third chapter describes the study's methods, sample, instruments, reliability, validity, data collection, and data analysis. The fourth chapter explains the results of research questions one, two, and three. This chapter provides conclusions, implications, and recommendations for future research.

Purpose of the Study

The purpose of this study was to measure the relationships among the United States eighth grade student mathematics achievement (number, algebra, geometry, and data choice), student and teacher self-efficacy, student task value, and teacher preparation. Both teacher and student data were analyzed using Trends in International Mathematics and Science Study (TIMSS) 2011 version for eighth graders. TIMSS (2011) student and teacher questionnaires were used. The student questionnaire was used to measure student demographics, home and school environments, self-efficacies, and attitudes toward learning mathematics.

The teacher questionnaire was used to measure general teaching experience, experience teaching mathematics, educational background, and professional development. This research will provide a better understanding of the impact of teacher self-efficacy and preparation on middle school student achievement in mathematics. In addition, this study was built on what is currently known about self-efficacy, student achievement, and teacher preparation.

Research Questions

The following research questions were investigated in this study:

1) Does student self-efficacy predict eighth grade student achievement in mathematics (summing across algebra, geometry, numbers, and data choice domains)?
2) Does student perceived task value predict eighth grade student achievement in mathematics (summing across algebra, geometry, numbers, and data choice domains)?
3) Does teacher self-efficacy predict eighth grade class mean math achievement (summing across algebra, geometry, numbers, and data choice domains)?
4) Does teacher preparation predict eighth grade class mean math achievement (summing across algebra, geometry, numbers, and data choice domains)?
5) Does teacher self-efficacy predict within classroom effects of student level predictors within the classroom?
    a) How much variation in intercepts (classroom means) is explained by teacher self-efficacy?

b) How much variation in the effect of student self-efficacy and perceived task value slopes on math achievement is explained by teacher self-efficacy?

6) Does teacher preparation predict within classroom effects of student level predictors within the classroom?

    a) How much variation in intercepts (classroom means) is explained by teacher preparation?

    b) How much variation in the effect of student self-efficacy and perceived task value slopes on math achievement is explained by teacher preparation?

Hypotheses

There were six main research hypotheses examined in this study:

1) Student self-efficacy will positively predict eighth-grade student achievement in mathematics (summing across algebra, geometry, numbers, and data choice domains).
2) Student perceived task value will positively predict eighth-grade student achievement in mathematics (summing across algebra, geometry, numbers, and data choice domains).
3) Teacher self-efficacy will be associated with eighth-grade class mean math achievement (summing across algebra, geometry, numbers, and data choice domains).
4) Teacher preparation will be associated with eighth-grade class mean math achievement (summing across algebra, geometry, numbers, and data choice domains).
5) There will be variation in the level-1 slopes and level-1 intercepts based on teacher self-efficacy within the classroom.

6) There will be variation in the level-1 slopes and level-1 intercepts based on teacher preparation within the classroom.

Discussion

Chowa, Masa, Ramos, and Ansong (2015) stated that research on student academic achievement has been carried out for many decades. As a result, student academic achievement has been defined as scores in one particular academic subject such as: math, science, English, or history (Chowa, Masa, Ramos, & Ansong, 2015; Asante, 2010; Salami, 2008). Having high academic achievement in mathematics could lead to a rewarding and high-status career (Skouras, 2014). Academic achievement and factors that influence academic success in mathematics has piqued the interest of teachers, parents, students, and researchers (Hemmings, Grootenboer, & Kay, 2011). To date, there has been little research on student self-efficacy, student task value, teacher preparation, and teacher self-efficacy and its influence on mathematics achievement for eighth grade students in the United States. Most of the research involving mathematics academic achievement tends to focus on ethnicity, socioeconomic status, and gender.

The sample for this study consisted of 1,077 eighth grade students and 442 eighth grade teachers from nine states—Alabama, California, Connecticut, Colorado, Florida, Indiana, Massachusetts, Minnesota, and North Carolina during the TIMSS 2011 study. The instrument used to measure student and teacher self-efficacy, student task value, and teacher preparation was eighth grade student and teacher questionnaires. The instrument used to measure mathematics achievement was TIMSS 2011 mathematics assessment for eighth grade students. For this study, two scales were used from the student and teacher questionnaires, which included a total of 46 questions.

The independent variables were student and teacher self-efficacy, student task value, and teacher preparation. The dependent variable was mathematics achievement. The demographic data revealed that of the study's sample of teachers, 311 (70%) were female and 131 (30%) were male; the age range for teachers was between 40 and 49 years old. The demographic data also revealed that of the study's sample of students, 5,180 (49%) were male and 5,297 (51%) were female; the average age of students was 14 years old.

The test revealed that there was a significant amount of variance in mathematics achievement (outcome variable) at the teacher level, which supported the use of HLM. The random intercept model was calculated to test the relationship between the student level predictors (i.e., student self-efficacy and task value) and mathematics achievement at the teacher level. The results of this model indicated that student self-efficacy statistically significantly predicted eighth grade mathematics achievement in the expected direction, whereas the perceived task value did not reach statistical significance.

The regression with means as outcomes model assessed student mean achievement as related to teacher self-efficacy and teacher preparation. The results indicated that student mean achievement as related to teacher self-efficacy was statistically significant in the expected direction. However, teacher preparation did not predict classroom mean mathematics achievement at a statistically significant level.

Teacher self-efficacy was statistically significant when predicting classroom mean mathematics achievement after accounting for student level predictors. Teacher preparation was not statistically significant when predicting mathematics achievement after accounting for student level predictors. Teacher self-efficacy did not significantly predict student self-efficacy slopes. Teacher level predictors did not significantly predict student task value slopes. At

Level-2, teacher self-efficacy predicts student classroom mean math achievement at a statistically significant level whereas teacher preparation does not. The result of the chi-square reveals that there is statistical significance residual variance in the slopes.

Research Question 1: Does student self-efficacy predict grade eighth student achievement in mathematics (summing across algebra, geometry, numbers, and data choice domains)?

A hierarchical linear model was conducted to determine if student self-efficacy predict eighth grade student achievement in mathematics (summing across algebra, geometry, numbers, and data choice domains). The results of the current study supported Hypothesis I, which posited that student self-efficacy positively predict eighth grade student achievement in mathematics. Findings from the analysis conducted to address Research Question 1 indicated that when student self-efficacy increased student achievement in mathematics increased. These results suggested that eighth grade students in the United States report high academic achievement in mathematics when student self-efficacy increases, which was consistent with existing literature (e.g., Chowa et al., 2015; Engin-Demir, 2009; Bandura, 1997).

Research Question 2: Does student perceived task value predict eighth grade student achievement in mathematics (summing across algebra, geometry, numbers, and data choice domains)?

A hierarchical linear model was conducted to determine if student perceived task value predict eighth grade student achievement in mathematics (summing across algebra, geometry, numbers, and data choice domains). The results of the current study did not support Hypothesis II, which posited that student perceived task value positively predict eighth grade student achievement in mathematics. Findings from the analysis conducted to address Research Question 2 did not reach statistically significant. These results were inconsistent with existing literature (e.g., Wigfield & Cambria, 2010; Pekrun, 2009; Cole, Bergin, & Whittaker, 2008; Simpkins, Davis-Kean, & Eccles, 2006), which suggests that task value should predict achievement. Both student self-efficacy and perceived task value correlate with mathematics achievement at a statistically significant level. However, when both are entered into a regression analysis, the unique (after accounting for the relationship between student self-efficacy and perceived task value) relationship between perceived task value and mathematics achievement is not statistically significant.

Research Question 3: Does teacher self-efficacy predict eighth grade class means math achievement (summing across algebra, geometry, numbers, and data choice domains)?

A hierarchical linear model was conducted to determine if teacher self-efficacy predict eighth grade class means math achievement (summing across algebra, geometry, numbers, and data choice domains). The results of the current study supported Hypothesis III, which posited that teacher self-efficacy will be associated with eighth grade class mean student achievement in mathematics. Findings from the analysis conducted to address Research Question 3 indicated that teacher self-efficacy positively predicts class mean student achievement in mathematics. These results suggested that eighth grade students in the United States academic achievement in mathematics positively impacted by teacher self-efficacy which was consistent with existing literature (e.g., Protheroe, 2008; Hoy, Sweetland, & Smith, 2002).

Research Question 4: Does teacher preparation predict eighth grade class means math achievement (summing across algebra, geometry, numbers, and data choice domains)?

A hierarchical linear model was conducted to determine if teacher preparation predict eighth grade class means math achievement (summing across algebra, geometry, numbers, and data choice domains). The results of the current study did not supported Hypothesis IV, which posited that teacher preparation will be associated with eighth grade class mean student achievement in mathematics. Findings from the analysis conducted to address Research Question 4 indicated that teacher preparation was not statistically significant in relation to mathematics achievement. These results were not consistent with existing literature (e.g., Shannag, Tairab, Dodees, & Abdel-Fattah, 2013; Gimbert, Bol, & Wallace, 2007). Some researchers (Shannag, Tairab, Dodees, & Abdel-Fattah, 2013) suggest that confounding variables influenced the relationship between math achievement and teacher preparation.

Research Question 5: Does teacher self-efficacy predict within classroom effects of student level predictors within the classroom? (How much variation in intercepts (classroom means) is explained by teacher self-efficacy? How much variation in the effect of student self-efficacy and perceived task value slopes on math achievement is explained by teacher self-efficacy?)

A hierarchical linear model was conducted to determine if teacher self-efficacy did not statistically significantly predict the effect of classroom slope on eighth grade student achievement in mathematics (summing across algebra, geometry, numbers, and data choice domains). The results of the current did not study supported Hypothesis V, which posited that there will be variation in the level-1 slopes and level-1 intercepts based on teacher self-efficacy. These results suggested that for eighth grade students in the United States, variation in teacher self-efficacy was not statistically significant in predicting the effect of student self-efficacy or student task value classroom slopes.

Research Question 6: Does teacher preparation predict within classroom effects of student level predictors within the classroom? (How much variation in intercepts (classroom means) is explained by teacher preparation? How much variation in the effect of student

self-efficacy and perceived task value slopes on math achievement is explained by teacher preparation?)

A hierarchical linear model was conducted to determine if teacher preparation predict the effect of classroom slope in eighth grade student achievement in mathematics (summing across algebra, geometry, numbers, and data choice domains). The results of the current study did not support Hypothesis VI, which posited that there will be variation in the level-1 slopes and level-1 intercepts based on teacher preparation. These results suggested that for eighth grade students in the United States, variation in teacher preparation did not predict student self-efficacy or perceived task value classroom slopes.

Implications

The results of this study have several implications. First, they imply that student achievements in mathematics is high when students feel confident in solving math problems. Secondly, when teachers feel more efficacious mathematics achievement for eighth grade students is higher. Panaoura and Panaoura (2014) have suggested that pre-service teachers should be involved in more hands-on experiences to foster confidence in content delivery. You, Dang, and Lim (2016) has suggested that teacher training programs should highlight the importance of motivation in the classroom to increase to student achievement. The results of this study may also lead to implementation of a plausible and comprehensive system of training and mentorship with an increased focus on pre-service teachers developing effective original lesson plans that will continue to build teacher confidence in the classroom.

Recommendations

Considering that this study was limited to eighth grade math students' academic achievement in the United States and to only the 2011 TIMSS study, the findings suggest that:

- The study could be extended to science students in the United States.
- This study could be replicated using TIMSS 2011 fourth grade students in mathematics. Given some of the results from this study is inconsistent with results reported in existing literature, further investigation at different grade levels is warranted.
- Researchers could request private data to compare mathematics achievement by states to determine if student and teacher level predictors influence eighth grade mathematics achievement differently. It is possible that state policies or standards would influence results producing state differences.
- Researchers could examine confounding variables relating to teacher preparation and its influence on students mathematics achievement. The results from the current study suggest that teacher preparation does not influence achievement. Some researchers (Goe & Stickler, 2008) suggest that confounding variables, such as: professional development, teacher experience, or teacher preparation programs. Could influence the relationship between teacher preparation and achievement.
- A structural equation model or path analysis can be used to measure the effect of teacher preparation, teacher self-efficacy, and student self-efficacy on eighth grade math achievement. In this way interrelationships among variables could be assessed. It is possible that some variables act as mediating variables. For example, teacher self-efficacy may act as a mediating variable between teacher preparation and achievement.
- The school socioeconomic status can be examined to identify if schools with more funding are able to hire better quality or prepared teachers to increase eighth grade math achievement.

- The results of this study could be compared with other countries to identify if teachers and students are more efficacious, teachers are better prepared, or student task is different from students and teachers in the United States.

Summary

The current study contributes to the existing literature pertaining to students' mathematics academic achievement, specifically by contributing to the limited research focused on the relationships among student self-efficacy, student task value, teacher self-efficacy, and teacher preparation. With the ultimate goal of increasing student interest in technology and economic investments, this study and its implications have the potential to prove useful in guiding future research as well as in informing educational practices at the classroom level. The present study revealed that student self-efficacy predict mathematics achievement with statistical significance, considering teacher effects—a relationship that is also worthy of future exploration, given potential implications for practice. Consistent with prior research, the current findings suggest that teacher self-efficacy is a significant predictor of student mathematics achievement, after accounting for student self-efficacy and student task value. While the present study did not indicate that teacher preparation significantly predicts mathematics achievement, and similarly, teacher self-efficacy did not reveal a significant interaction between student self-efficacy slopes or student task value slopes for mathematics achievement, these relationship are worthy of future study, given that prior research provides support for significant associations among these constructs.

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Appendix A. Auburn University Institutional Review Board (IRB) Approval

AUBURN UNIVERSITY INSTITUTIONAL REVIEW BOARD for RESEARCH INVOLVING HUMAN SUBJECTS

REQUEST FOR EXEMPT CATEGORY RESEARCH

For information or help completing this form, contact: **THE OFFICE OF RESEARCH COMPLIANCE**, 115 Ramsay Hall
Phone: 334-844-5966 **e-mail:** IRBAdmin@auburn.edu **Web Address:** http://www.auburn.edu/research/vpr/ohs/index.htm

Revised 2/1/2014 **Submit completed form to IRBsubmit@auburn.edu or 115 Ramsay Hall, Auburn University 36849.**

Form must be populated using Adobe Acrobat / Pro 9 or greater standalone program (do not fill out in browser). Hand written forms will not be accepted.

Project activities may not begin until you have received approval from the Auburn University IRB.

1. **PROJECT PERSONNEL & TRAINING**

PRINCIPAL INVESTIGATOR (PI):

Name Shamarick Y. Paradise **Title** Doctoral Candidate **Dept./School** EFLT/Education
Address 3541 Cambridge Road, 36111 **AU Email** jonessy@auburn.edu
Phone 334-649-9811 **Dept. Head** Sheri Downer

FACULTY ADVISOR (if applicable):

Name Margaret Ross **Title** Alumni Professor **Dept./School** EFLT/Education
Address 4036 Haley Center
Phone 334-844-3084 **AU Email** rossma1@auburn.edu

KEY PERSONNEL: List Key Personnel (other than PI and FA). Additional personnel may be listed in an attachment.

Name	Title	Institution	Responsibilities

KEY PERSONNEL TRAINING: Have all Key Personnel completed CITI Human Research Training (including elective modules related to this research) within the last 3 years? ☑ YES ☐ NO

TRAINING CERTIFICATES: Please attach CITI completion certificates for all Key Personnel.

2. **PROJECT INFORMATION**

Title: How It All Adds Up: Factors That Affect Mathematics Achievement for 8th Grade Students in the United States

Source of Funding: ☐ Investigator ☐ Internal ☐ External

List External Agency & Grant Number:

List any contractors, sub-contractors, or other entities associate with this project.

List any other IRBs associated with this project (including those involved with reviewing, deferring, or determinations).

FOR ORC OFFICE USE ONLY

DATE RECEIVED IN ORC:	by	APPROVAL	The Auburn University Institutional Review Board has approved this Document for use from 06/08/2016 to 06/07/2019 Protocol # 16-212 EX 1606
DATE OF IRB REVIEW:	by	APPROVAL	
DATE OF ORC REVIEW:	by	INTERVAL F	
DATE OF APPROVAL:	by		
COMMENTS:			

1 of 3

3. PROJECT SUMMARY

a. Does the research involve any special populations?

- [x] YES [ ] NO Minors (under age 19)
- [ ] YES [x] NO Pregnant women, fetuses, or any products of conception
- [ ] YES [x] NO Prisoners or Wards
- [ ] YES [x] NO Individuals with compromised autonomy and/or decisional capacity

b. Does the research pose more than minimal risk to participants? [ ] YES [x] NO

Minimal risk means that the probability and magnitude of harm or discomfort anticipated in the research are not greater in and of themselves than those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests. 42 CFR 46.102(i)

c. Does the study involve any of the following?

- [ ] YES [x] NO Procedures subject to FDA Regulation Ex. Drugs, biological products, medical devices, etc.
- [ ] YES [x] NO Use of school records of identifiable students or information from instructors about specific students
- [ ] YES [x] NO Protected health or medical information when there is a direct or indirect link that could identify the participant
- [ ] YES [x] NO Collection of sensitive aspects of the participant's own behavior, such as illegal conduct, drug use, sexual behavior or use of alcohol
- [ ] YES [x] NO Deception of participants

If you checked "YES" to any response in Question #3 STOP. It is likely that your study does not meet the "EXEMPT" requirements. Please complete a PROTOCOL FORM for Expedited or Full Board Review. You may contact IRB Administration for more information. (Phone: 334-844-5966 or Email: IRBAdmin@auburn.edu)

4. PROJECT DESCRIPTION

a. Subject Population (Describe, include age, special population characteristics, etc.)

Trends in International Mathematics and Sciences Study (TIMSS) 2011 eighth grade math students and eigth grade math teachers located in the United States.

b. Describe, step by step, all procedures and methods that will be used to consent participants.

- [x] N/A (Existing data will be used)

c. **Brief summary of project.** (Include the research question(s) and a brief description of the methodology, including recruitment and how data will be collected and protected.)

The purpose of the study was to measure the relationships among the United States eighth grade student mathematics achievement (number, algebra, geometry, and data choice) and student and teacher self-efficacy, student task value, and teacher preparation.

Research Questions

1. Do self-efficacy and perceived task value predict eighth grade student achievement in mathematics (summing across algebra, geometry, numbers, and data choice domains)?

2. Do self-efficacy and preparation predict eighth grade class mean math achievement in mathematics (summing across algebra, geometry, numbers, and data choice domanins)?

3. Do teacher self-efficacy and preparation predict classroom slope or changes in student math achievement (summing across algebra, geometry, numbers, and data choice domains), based on student level predictors within the classroom?

a) How much variation in intercepts (classroom means) is explained by teacher self-efficacy and preparation?

b) How much variation in slope is explained by teacher self-efficacy and preparation?

Method

Pre-existing and de-identified data will be obtained from TIMSS national public dataset. Hierarchial Linear Model will be used to answer the research questions.

d. **Waivers. Check any waivers that apply and describe how the project meets the criteria for the waiver.**

- [x] **Waiver of Consent (Including existing de-identified data)**
- [ ] **Waiver of Documentation of Consent (Use of Information Letter)**
- [ ] **Waiver of Parental Permission (for college students)**

e. **Attachments.** Please attach Informed Consents, Information Letters, data collection instrument(s), advertisements/recruiting materials, or permission letters/site authorizations as appropriate.

Signature of Investigator Shamarick Paradise Date __________

Signature of Faculty Advisor Margaret Ross Date __________

Signature of Department Head Sherida Downer Date __________

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Appendix B. Student Task Value and Confident Scales

About you

1

Are you a girl or a boy?

Fill one circle only.

Girl --○

Boy --○

2

When were you born?

Fill the circles next to the month and year you were born.

a) Month	b) Year
January -- ○	1993 -- ○
February -- ○	1994 -- ○
March -- ○	1995 -- ○
April -- ○	1996 -- ○
May -- ○	1997 -- ○
June -- ○	1998 -- ○
July -- ○	1999 -- ○
August -- ○	2000 -- ○
September -- ○	2001 -- ○
October -- ○	Other -- ○
November -- ○	
December -- ○	

TIMSS 2011

The TIMSS 2011 Students Confident in Mathematics Scale, Eighth Grade

The Students Confident in Mathematics (SCM) scale was created based on students' degree of agreement to the nine statements described below. See Creating and Interpreting TIMSS and PIRLS 2011 Context Questionnaire Scales for more information on how the scales were formed.

Exhibit 1: Items in the TIMSS 2011 Students Confident in Mathematics Scale, Eighth Grade

How much do you agree with these statements about mathematics?

		Agree a lot	Agree a little	Disagree a little	Disagree a lot
BSBM16A	1) I usually do well in mathematics	○	○	○	○
BSBM16B*	2) Mathematics is more difficult for me than for many of my classmates*	○	○	○	○
BSBM16C*	3) Mathematics is not one of my strengths*	○	○	○	○
BSBM16D	4) I learn things quickly in mathematics	○	○	○	○
BSBM16E*	5) Mathematics makes me confused and nervous*	○	○	○	○
BSBM16F	6) I am good at working out difficult mathematics problems	○	○	○	○
BSBM16G	7) My teacher thinks I can do well in mathematics <programs/classes/lessons> with difficult materials	○	○	○	○
BSBM16H	8) My teacher tells me I am good at mathematics	○	○	○	○
BSBM16I*	9) Mathematics is harder for me than any other subject*	○	○	○	○

* Reverse coded

Confident | Somewhat Confident | Not Confident

12.0 | 9.4

TIMSS 2011

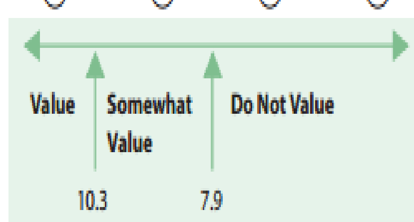
The TIMSS 2011 Students Value Mathematics Scale, Eighth Grade

The Students Value Mathematics (SVM) scale was created based on students' degree of agreement to the six statements described below. See Creating and Interpreting TIMSS and PIRLS 2011 Context Questionnaire Scales for more information on how the scales were formed.

Exhibit 1: Items in the TIMSS 2011 Students Value Mathematics Scale, Eighth Grade

How much do you agree with these statements about mathematics?

		Agree a lot	Agree a little	Disagree a little	Disagree a lot
BSBM16J	1) I think learning mathematics will help me in my daily life	○	○	○	○
BSBM16K	2) I need mathematics to learn other school subjects	○	○	○	○
BSBM16L	3) I need to do well in mathematics to get into the university of my choice	○	○	○	○
BSBM16M	4) I need to do well in mathematics to get the job I want	○	○	○	○
BSBM16N	5) I would like a job that involves using mathematics	○	○	○	○
BSBM14F	6) It is important to do well in mathematics	○	○	○	○



Appendix C. Teacher Confidence and Preparation Scales

About You

1

By the end of this school year, how many years will you have been teaching altogether?

_______________ years

Please round to the nearest whole number.

2

Are you female or male?

Check one circle only.

- Female — ○
- Male — ○

3

How old are you?

Check one circle only.

- Under 25 — ○
- 25–29 — ○
- 30–39 — ○
- 40–49 — ○
- 50–59 — ○
- 60 or more — ○

4

What is the highest level of formal education you have completed?

Check one circle only.

- Did not complete <ISCED Level 3> — ○
- Finished <ISCED Level 3> — ○
- Finished <ISCED Level 4> — ○
- Finished <ISCED Level 5B> — ○
- Finished <ISCED Level 5A, first degree> — ○
- Finished <ISCED Level 5A, second degree> or higher — ○

5

During your <post-secondary> education, what was your major or main area(s) of study?

Check one circle for each line.

	Yes	No
a) Mathematics	○	○
b) Biology	○	○
c) Physics	○	○
d) Chemistry	○	○
e) <Earth Science>	○	○
f) Education–Mathematics	○	○
g) Education–Science	○	○
h) Education–General	○	○
i) Other	○	○

<Grade 8> Teacher Questionnaire — Mathematics 2

TIMSS 2011

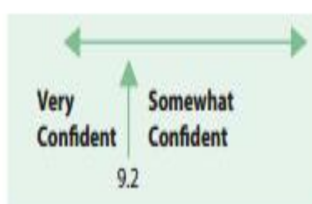
The TIMSS 2011 Confidence in Teaching Mathematics Scale, Eighth Grade

The Confidence in Teaching Mathematics (CTM) scale was created based on teachers' responses to the five statements described below. See Creating and Interpreting TIMSS and PIRLS 2011 Context Questionnaire Scales for more information on how the scales were formed.

Exhibit 1: Items in the TIMSS 2011 Confidence in Teaching Mathematics Scale, Eighth Grade

In teaching mathematics to this class, how confident do you feel to do the following?

		Very Confident	Somewhat Confident	Not Confident
BTBM18A	1) Answer students' questions about mathematics	○	○	○
BTBM18B	2) Show students a variety of problem solving strategies	○	○	○
BTBM18C	3) Provide challenging tasks for capable students	○	○	○
BTBM18D	4) Adapt my teaching to engage students' interest	○	○	○
BTBM18E	5) Help students appreciate the value of learning mathematics	○	○	○



30

How well prepared do you feel you are to teach the following mathematics topics?
If a topic is not in the <eighth-grade> curriculum or you are not responsible for teaching this topic, Please choose "Not applicable."

Check one circle for each line.

	Not applicable	Very well prepared	Somewhat prepared	Not well prepared
A. Number				
a) Computing, estimating, or approximating with whole numbers	○	○	○	○
b) Concepts of fractions and computing with fractions	○	○	○	○
c) Concepts of decimals and computing with decimals	○	○	○	○
d) Representing, comparing, ordering, and computing with integers	○	○	○	○
e) Problem solving involving percents and proportions	○	○	○	○
B. Algebra				
a) Numeric, algebraic, and geometric patterns or sequences (extension, missing terms, generalization of patterns)	○	○	○	○
b) Simplifying and evaluating algebraic expressions	○	○	○	○
c) Simple linear equations and inequalities	○	○	○	○
d) Simultaneous (two variables) equations	○	○	○	○
e) Representation of functions as ordered pairs, tables, graphs, words, or equations	○	○	○	○
C. Geometry				
a) Geometric properties of angles and geometric shapes (triangles, quadrilaterals, and other common polygons)	○	○	○	○
b) Congruent figures and similar triangles	○	○	○	○
c) Relationship between three–dimensional shapes and their two–dimensional representations	○	○	○	○
d) Using appropriate measurement formulas for perimeters, circumferences, areas, surface areas, and volumes	○	○	○	○
e) Points on the Cartesian plane	○	○	○	○
f) Translation, reflection, and rotation	○	○	○	○
D. Data and Chance				
a) Reading and displaying data using tables, pictographs, bar graphs, pie charts, and line graphs	○	○	○	○
b) Interpreting data sets (e.g., draw conclusions, make predictions, and estimate values between and beyond given data points)	○	○	○	○
c) Judging, predicting, and determining the chances of possible outcomes	○	○	○	○

Appendix D. Sample Questions from Eighth Grade Mathematics Assessment

TIMSS USA

ITEM INDEX

Grade 8

Content Domain	Main Topic	Cognitive Domain
NUMBER	Fractions and Decimals	Applying

Ann and Jenny divide 560 zeds

Ann and Jenny divide 560 zeds between them. If Jenny gets $\frac{3}{8}$ of the money, how many zeds will Ann get?

Answer: ________________

Item Number: M032064

SCORING

Correct Response

- 350

Incorrect Response

- 210
- 5/8
- Other incorrect (including crossed out, erased, stray marks, illegible, or off task)

Overall Percent Correct

Education system	Percent correct	
Singapore	76	○
Korea, Rep. of	67	○
Hong Kong-CHN	61	○
Chinese Taipei-CHN	60	○
Finland	48	○
Russian Federation	48	○
Japan	45	○
Israel	43	○
Hungary	40	○
Sweden	37	○
England-GBR	34	○
Australia	34	○
Italy	34	○
Lithuania	33	○
Malaysia	32	○
Norway	30	
Kazakhstan	28	
Turkey	28	
New Zealand	28	
International average	**27**	
United States	**25**	
Slovenia	25	
Ukraine	24	
Armenia	23	●
Georgia	23	●
Tunisia	21	●
Romania	20	●
United Arab Emirates	17	●
Iran, Islamic Rep. of	17	●
Macedonia, Rep. of	16	●
Qatar	16	●
Chile	14	●
Thailand	13	●
Palestinian Nat'l Auth.	12	●
Lebanon	10	●
Bahrain	10	●
Indonesia	9	●
Saudi Arabia	8	●
Oman	7	●
Jordan	7	●
Morocco	6	●
Syrian Arab Republic	6	●
Ghana	3	●

Benchmarking education system		
Quebec-CAN	45	○
North Carolina-USA	40	○
Minnesota-USA	38	○
Massachusetts-USA	36	○
Ontario-CAN	31	
Connecticut-USA	30	
Colorado-USA	29	
Alberta-CAN	29	
Indiana-USA	28	
Dubai-UAE	25	
Florida-USA	23	
California-USA	17	●
Abu Dhabi-UAE	15	●
Alabama-USA	14	●

○ Percent higher than international average
● Percent lower than international average

Ann and Jenny divide 560 zeds (continued)

M032064

Student Responses

Correct Response:

Answer: 350

Incorrect Response:

Answer: $\frac{5}{8}$

Content Domain	Main Topic	Cognitive Domain
ALGEBRA	Algebraic Expressions	Knowing

m boys and n girls in a parade

There were m boys and n girls in a parade. Each person carried 2 balloons. Which of these expressions represents the total number of balloons that were carried in the parade?

A. $2(m + n)$

B. $2 + (m + n)$

C. $2m + n$

D. $m + 2n$

Item Number: M032296

Correct Response:	A

Overall Percent Correct

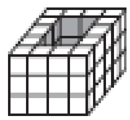
Education system	Percent correct	
Singapore	95	○
Hong Kong-CHN	94	○
Chinese Taipei-CHN	93	○
Korea, Rep. of	91	○
Japan	90	○
Russian Federation	90	○
United States	**88**	○
Lebanon	86	○
Lithuania	86	○
Slovenia	85	○
Israel	82	○
Finland	82	○
Italy	82	○
Ukraine	81	○
Hungary	80	○
Romania	77	○
Kazakhstan	76	
United Arab Emirates	75	○
England-GBR	74	
Australia	73	
International average	**72**	
Georgia	72	
Malaysia	71	
New Zealand	71	
Tunisia	70	
Armenia	69	
Macedonia, Rep. of	67	●
Jordan	67	●
Qatar	65	●
Sweden	65	●
Indonesia	63	●
Turkey	62	●
Iran, Islamic Rep. of	62	●
Thailand	62	●
Bahrain	62	●
Palestinian Nat'l Auth.	62	●
Chile	60	●
Ghana	60	●
Norway	59	●
Morocco	58	●
Oman	58	●
Syrian Arab Republic	48	●
Saudi Arabia	48	●

Benchmarking education system	Percent correct	
Massachusetts-USA	92	○
California-USA	91	○
Minnesota-USA	91	○
North Carolina-USA	90	○
Quebec-CAN	90	○
Florida-USA	87	○
Indiana-USA	87	○
Connecticut-USA	83	○
Dubai-UAE	83	○
Colorado-USA	82	○
Alabama-USA	81	○
Alberta-CAN	76	
Ontario-CAN	76	
Abu Dhabi-UAE	75	

○ Percent higher than international average
● Percent lower than international average

Content Domain	Main Topic	Cognitive Domain
GEOMETRY	Geometric Measurement	Applying

Shape made up of same size cubes



The figure above shows a shape made up of cubes that are all the same size. There is a hole all the way through the shape. How many cubes would be needed to fill the hole?

A. 6

B. 12

C. 15

D. 18

Item Number: M032100

Correct Response:	D

Overall Percent Correct

Education system	Percent correct	
Korea, Rep. of	87	○
Chinese Taipei-CHN	84	○
Japan	80	○
Singapore	77	○
Finland	77	○
Hong Kong-CHN	74	○
Australia	72	○
Lithuania	70	○
New Zealand	68	○
England-GBR	66	○
Hungary	65	○
Slovenia	64	○
Russian Federation	63	○
United States	**60**	○
Norway	58	○
Sweden	57	○
Italy	57	○
Chile	52	○
Ukraine	50	
Israel	48	
Turkey	47	
International average	47	
Malaysia	40	●
Kazakhstan	39	●
Macedonia, Rep. of	38	●
Thailand	38	●
Romania	38	●
Georgia	35	●
United Arab Emirates	35	●
Armenia	35	●
Iran, Islamic Rep. of	30	●
Qatar	30	●
Oman	28	●
Bahrain	27	●
Saudi Arabia	26	●
Indonesia	24	●
Lebanon	23	●
Palestinian Nat'l Auth.	20	●
Tunisia	20	●
Morocco	19	●
Jordan	19	●
Syrian Arab Republic	14	●
Ghana	11	●

Benchmarking education system		
Massachusetts-USA	74	○
Minnesota-USA	72	○
Quebec-CAN	71	○
Indiana-USA	68	○
North Carolina-USA	67	○
Colorado-USA	67	○
Alberta-CAN	67	○
Ontario-CAN	65	○
Connecticut-USA	57	○
Florida-USA	55	○
California-USA	53	
Alabama-USA	48	
Dubai-UAE	38	●
Abu Dhabi-UAE	35	●

○ Percent higher than international average
● Percent lower than international average

Content Domain	Main Topic	Cognitive Domain
DATA AND CHANCE	Chance	Knowing

How likely to get pink candy

A machine has 100 candies and dispenses a candy when a lever is turned. The machine has the same number of blue, pink, yellow, and green candies all mixed together. Megan turned the lever and obtained a pink candy. Peter turned the lever next.

How likely is it that Peter will get a pink candy?

A. It is certain that his candy will be pink.

B. It is more likely than it was for Megan.

C. It is exactly as likely as it was for Megan.

D. It is less likely than it was for Megan.

Item Number: M032132

Correct Response:	D

Overall Percent Correct

Education system	Percent correct	
Korea, Rep. of	84	○
Hong Kong-CHN	71	○
Singapore	71	○
Chinese Taipei-CHN	68	○
Slovenia	67	○
Australia	65	○
Israel	65	○
Japan	64	○
United States	**63**	○
Italy	61	○
Lithuania	60	○
Norway	60	○
Finland	59	○
New Zealand	59	○
England-GBR	58	○
Hungary	58	○
Sweden	55	○
Turkey	54	○
Romania	54	○
Russian Federation	52	
Thailand	52	
Ukraine	50	
Chile	48	
International average	48	
United Arab Emirates	44	●
Saudi Arabia	42	●
Georgia	42	●
Macedonia, Rep. of	40	●
Iran, Islamic Rep. of	40	●
Kazakhstan	40	●
Jordan	37	●
Tunisia	37	●
Qatar	37	●
Armenia	34	●
Bahrain	31	●
Syrian Arab Republic	29	●
Indonesia	26	●
Oman	26	●
Malaysia	25	●
Palestinian Nat'l Auth.	24	●
Morocco	24	●
Lebanon	21	●
Ghana	11	●

Benchmarking education system	Percent correct	
Massachusetts-USA	74	○
North Carolina-USA	68	○
Minnesota-USA	68	○
Quebec-CAN	64	○
California-USA	64	○
Indiana-USA	61	○
Ontario-CAN	60	○
Alberta-CAN	59	○
Connecticut-USA	58	○
Colorado-USA	58	○
Florida-USA	56	○
Alabama-USA	54	
Dubai-UAE	47	
Abu Dhabi-UAE	44	

○ Percent higher than international average
● Percent lower than international average

Appendix E. Hierarchical Linear Model Results

Unconstrained (Null) Model

Specifications for this HLM2 run
Problem Title: Null Model

The data source for this run = newresults
The command file for this run = C:\Users\PARADI~1\AppData\Local\Temp\whlmtemp.hlm
Output file name = E:\AU\Dissertation\TIMSS\hlm2.html
The maximum number of level-1 units = 7624
The maximum number of level-2 units = 399
The maximum number of iterations = 100

Method of estimation: restricted maximum likelihood

The outcome variable is V106_A
Summary of the model specified

Level-1 Model

$V106\_A_{ij} = \beta_{0j} + r_{ij}$

Level-2 Model

$\beta_{0j} = \gamma_{00} + u_{0j}$

Mixed Model

$V106\_A_{ij} = \gamma_{00} + u_{0j} + r_{ij}$

Final Results - Iteration 4
Iterations stopped due to small change in likelihood function

$\sigma^2 = 2113.70693$

τ
INTRCPT1,β_0 3922.29552

Random level-1 coefficient	Reliability estimate
INTRCPT1,β_0	0.964

The value of the log-likelihood function at iteration 4 = -4.069995E+004

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard error	*t*-ratio	Approx. *d.f.*	*p*-value
For INTRCPT1, β_0					
INTRCPT2, γ_{00}	508.332000	3.192904	159.207	398	<0.001

Final estimation of fixed effects
(with robust standard errors)

Fixed Effect	Coefficient	Standard error	t-ratio	Approx. $d.f.$	p-value
For INTRCPT1, β_0					
INTRCPT2, γ_{00}	508.332000	3.188867	159.408	398	<0.001

Final estimation of variance components

Random Effect	Standard Deviation	Variance Component	$d.f.$	χ^2	p-value
INTRCPT1, u_0	62.62823	3922.29552	398	13901.22833	<0.001
level-1, r	45.97507	2113.70693			

Statistics for current covariance components model
Deviance = 81399.907511
Number of estimated parameters = 2

Random Intercept Model

Specifications for this HLM2 run
Problem Title: Random Intercepts Model

The data source for this run = newresults
The command file for this run = C:\Users\PARADI~1\AppData\Local\Temp\whlmtemp.hlm
Output file name = E:\AU\Dissertation\TIMSS\hlm2.html
The maximum number of level-1 units = 7624
The maximum number of level-2 units = 399
The maximum number of iterations = 100

Method of estimation: restricted maximum likelihood

The outcome variable is V106_A
Summary of the model specified
Level-1 Model

$V106\_A_{ij} = \beta_{0j} + \beta_{1j}*(V107\_A_{ij}) + \beta_{2j}*(V108\_A_{ij}) + r_{ij}$

Level-2 Model

$\beta_{0j} = \gamma_{00} + u_{0j}$
$\beta_{1j} = \gamma_{10} + u_{1j}$
$\beta_{2j} = \gamma_{20} + u_{2j}$

V107_A V108_A have been centered around the group mean.
Mixed Model

$V106\_A_{ij} = \gamma_{00}$
$+ \gamma_{10}*V107\_A_{ij}$
$+ \gamma_{20}*V108\_A_{ij} + u_{0j} + u_{1j}*V107\_A_{ij} + u_{2j}*V108\_A_{ij} + r_{ij}$

Final Results - Iteration 31
Iterations stopped due to small change in likelihood function

σ^2 = 1996.81608

τ

INTRCPT1,β_0	3937.08152	-452.99391	-154.49535
V107_A,β_1	-452.99391	173.03560	-30.21131
V108_A,β_2	-154.49535	-30.21131	165.06656

τ (as correlations)

INTRCPT1,β_0	1.000	-0.549	-0.192
V107_A,β_1	-0.549	1.000	-0.179
V108_A,β_2	-0.192	-0.179	1.000

Random level-1 coefficient	Reliability estimate
INTRCPT1,β_0	0.970
V107_A,β_1	0.216
V108_A,β_2	0.181

Note: The reliability estimates reported above are based on only 393 of 399 units that had sufficient data for computation. Fixed effects and variance components are based on all the data.
The value of the log-likelihood function at iteration 31 = -4.056897E+004
Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard error	*t*-ratio	Approx. *d.f.*	*p*-value
For INTRCPT1, β_0					
INTRCPT2, γ_{00}	508.297060	3.195638	159.060	398	<0.001
For V107_A slope, β_1					
INTRCPT2, γ_{10}	-15.070825	1.388030	-10.858	398	<0.001
For V108_A slope, β_2					
INTRCPT2, γ_{20}	-1.873311	1.490707	-1.257	398	0.210

Final estimation of fixed effects
(with robust standard errors)

Fixed Effect	Coefficient	Standard error	*t*-ratio	Approx. *d.f.*	*p*-value
For INTRCPT1, β_0					
INTRCPT2, γ_{00}	508.297060	3.191622	159.260	398	<0.001
For V107_A slope, β_1					
INTRCPT2, γ_{10}	-15.070825	1.385312	-10.879	398	<0.001
For V108_A slope, β_2					
INTRCPT2, γ_{20}	-1.873311	1.489606	-1.258	398	0.209

Final estimation of variance components

Random Effect	Standard Deviation	Variance Component	*d.f.*	χ^2	*p*-value
INTRCPT1, u_0	62.74617	3937.08152	392	14684.86415	<0.001
V107_A slope, u_1	13.15430	173.03560	392	509.52383	<0.001
V108_A slope, u_2	12.84782	165.06656	392	486.44381	0.001
level-1, r	44.68575	1996.81608			

Note: The chi-square statistics reported above are based on only 393 of 399 units that had sufficient data for computation. Fixed effects and variance components are based on all the data.

Statistics for current covariance components model

Deviance = 81137.944212

Number of estimated parameters = 7

Means as Outcomes Model

Specifications for this HLM2 run

Problem Title: Means as Outcome Model

The data source for this run = newresults

The command file for this run = C:\Users\PARADI~1\AppData\Local\Temp\whlmtemp.hlm

Output file name = E:\AU\Dissertation\TIMSS\hlm2.html

The maximum number of level-1 units = 7624

The maximum number of level-2 units = 399

The maximum number of iterations = 100

Method of estimation: restricted maximum likelihood

The outcome variable is V106_A

Summary of the model specified

Level-1 Model

$V106\_A_{ij} = \beta_{0j} + r_{ij}$

Level-2 Model

$\beta_{0j} = \gamma_{00} + \gamma_{01}*(AVERAGE_j) + \gamma_{02}*(V136\_A_j) + u_{0j}$

AVERAGE V136_A have been centered around the grand mean.

Mixed Model

$V106\_A_{ij} = \gamma_{00} + \gamma_{01}*AVERAGE_j + \gamma_{02}*V136\_A_j + u_{0j} + r_{ij}$

Final Results - Iteration 3

Iterations stopped due to small change in likelihood function

σ^2 = 2113.44154

τ

INTRCPT1,β_0 3841.57875

Random level-1 coefficient	Reliability estimate
INTRCPT1, β_0	0.964

The value of the log-likelihood function at iteration 3 = -4.068758E+004

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard error	*t*-ratio	Approx. *d.f.*	*p*-value
For INTRCPT1, β_0					
INTRCPT2, γ_{00}	508.251524	3.161347	160.771	396	<0.001
AVERAGE, γ_{01}	-24.400675	11.302270	-2.159	396	0.031
V136_A, γ_{02}	-27.228983	15.029214	-1.812	396	0.071

Final estimation of fixed effects (with robust standard errors)

Fixed Effect	Coefficient	Standard error	*t*-ratio	Approx. *d.f.*	*p*-value
For INTRCPT1, β_0					
INTRCPT2, γ_{00}	508.251524	3.147738	161.466	396	<0.001
AVERAGE, γ_{01}	-24.400675	10.747986	-2.270	396	0.024
V136_A, γ_{02}	-27.228983	14.614674	-1.863	396	0.063

Final estimation of variance components

Random Effect	Standard Deviation	Variance Component	*d.f.*	χ^2	*p*-value
INTRCPT1, u_0	61.98047	3841.57875	396	13652.58099	<0.001
level-1, *r*	45.97218	2113.44154			

Statistics for current covariance components model

Deviance = 81375.155954

Number of estimated parameters = 2

Random Intercepts and Slopes Model

Specifications for this HLM2 run

Problem Title: Random Intercepts and Slopes Model

The data source for this run = newresults

The command file for this run = C:\Users\PARADI~1\AppData\Local\Temp\whlmtemp.hlm

Output file name = E:\AU\Dissertation\TIMSS\hlm2.html

The maximum number of level-1 units = 7624

The maximum number of level-2 units = 399

The maximum number of iterations = 100

Method of estimation: restricted maximum likelihood

The outcome variable is V106_A

Summary of the model specified

Level-1 Model

$V106\_A_{ij} = \beta_{0j} + \beta_{1j}*(V107\_A_{ij}) + \beta_{2j}*(V108\_A_{ij}) + r_{ij}$

Level-2 Model

$\beta_{0j} = \gamma_{00} + \gamma_{01}*(AVERAGE_j) + \gamma_{02}*(V136\_A_j) + u_{0j}$

$\beta_{1j} = \gamma_{10} + \gamma_{11}*(AVERAGE_j) + \gamma_{12}*(V136\_A_j) + u_{1j}$

$\beta_{2j} = \gamma_{20} + \gamma_{21}*(AVERAGE_j) + \gamma_{22}*(V136\_A_j) + u_{2j}$

V107_A V108_A have been centered around the group mean.

AVERAGE V136_A have been centered around the grand mean.

Mixed Model

$V106\_A_{ij} = \gamma_{00} + \gamma_{01}*AVERAGE_j + \gamma_{02}*V136\_A_j$
$+ \gamma_{10}*V107\_A_{ij} + \gamma_{11}*AVERAGE_j*V107\_A_{ij} + \gamma_{12}*V136\_A_j*V107\_A_{ij}$
$+ \gamma_{20}*V108\_A_{ij} + \gamma_{21}*AVERAGE_j*V108\_A_{ij} + \gamma_{22}*V136\_A_j*V108\_A_{ij}$
$+ u_{0j} + u_{1j}*V107\_A_{ij} + u_{2j}*V108\_A_{ij} + r_{ij}$

Final Results - Iteration 36

Iterations stopped due to small change in likelihood function

σ^2 = 1996.55004

τ

INTRCPT1,β_0	3855.11229	-448.36576	-143.86282
V107_A,β_1	-448.36576	173.25758	-31.28075
V108_A,β_2	-143.86282	-31.28075	168.45139

τ (as correlations)

INTRCPT1,β_0	1.000	-0.549	-0.179
V107_A,β_1	-0.549	1.000	-0.183
V108_A,β_2	-0.179	-0.183	1.000

Random level-1 coefficient	Reliability estimate
INTRCPT1,β_0	0.969
V107_A,β_1	0.217
V108_A,β_2	0.184

Note: The reliability estimates reported above are based on only 393 of 399 units that had sufficient data for computation. Fixed effects and variance components are based on all the data.

The value of the log-likelihood function at iteration 36 = -4.054480E+004

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard error	*t*-ratio	Approx. *d.f.*	*p*-value
For INTRCPT1, β_0					
INTRCPT2, γ_{00}	508.220385	3.163387	160.657	396	<0.001

AVERAGE, γ_{01}	-24.517612	11.306441	-2.168	396	0.031
V136_A, γ_{02}	-27.282792	15.036257	-1.814	396	0.070
For V107_A slope, β_1					
INTRCPT2, γ_{10}	-15.080901	1.389559	-10.853	396	<0.001
AVERAGE, γ_{11}	-2.026012	5.140680	-0.394	396	0.694
V136_A, γ_{12}	7.874007	6.643820	1.185	396	0.237
For V108_A slope, β_2					
INTRCPT2, γ_{20}	-1.836968	1.495071	-1.229	396	0.220
AVERAGE, γ_{21}	7.440524	5.660971	1.314	396	0.189
V136_A, γ_{22}	-0.944653	7.128011	-0.133	396	0.895

Final estimation of fixed effects
(with robust standard errors)

Fixed Effect	Coefficient	Standard error	*t*-ratio	Approx. *d.f.*	*p*-value
For INTRCPT1, β_0					
INTRCPT2, γ_{00}	508.220385	3.150000	161.340	396	<0.001
AVERAGE, γ_{01}	-24.517612	10.753142	-2.280	396	0.023
V136_A, γ_{02}	-27.282792	14.631592	-1.865	396	0.063
For V107_A slope, β_1					
INTRCPT2, γ_{10}	-15.080901	1.382467	-10.909	396	<0.001
AVERAGE, γ_{11}	-2.026012	4.484306	-0.452	396	0.652
V136_A, γ_{12}	7.874007	7.155844	1.100	396	0.272
For V108_A slope, β_2					
INTRCPT2, γ_{20}	-1.836968	1.486307	-1.236	396	0.217
AVERAGE, γ_{21}	7.440524	5.268864	1.412	396	0.159
V136_A, γ_{22}	-0.944653	5.630394	-0.168	396	0.867

Final estimation of variance components

Random Effect	Standard Deviation	Variance Component	*d.f.*	χ^2	*p*-value
INTRCPT1, u_0	62.08955	3855.11229	390	14434.67394	<0.001
V107_A slope, u_1	13.16273	173.25758	390	508.75525	<0.001
V108_A slope, u_2	12.97888	168.45139	390	485.84008	<0.001
level-1, r	44.68277	1996.55004			

Note: The chi-square statistics reported above are based on only 393 of 399 units that had sufficient data for computation. Fixed effects and variance components are based on all the data.

Statistics for current covariance components model

Deviance = 81089.606773
Number of estimated parameters = 7