

EXPECTANCY–VALUE FACTORS, GENDER, AND ACHIEVEMENT: IS THERE A
DIFFERENCE BETWEEN ALGEBRA AND GEOMETRY?

by

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Dedication

This dissertation is dedicated to my family, especially my wonderful parents, Lori and Michael, and my amazing wife, Kim.

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I would like to thank God, for without His love, support, and comfort, I would have never made it this far. My parents, Lori and Michael, made me the person that I am today, and I appreciate their dedication and sacrifice more than I can express. Finally, my wife Kim has helped me in so many ways, especially mentally and emotionally, and I will be forever grateful.

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List of Abbreviations

Analysis of Variance	ANOVA
California High School Exit Exam	CAHSEE
California Standards Test	CST
Degrees of Freedom	<i>df</i>
Dynamic Strategic Mathematics	DSM
English for Students of Other Languages	ESOL
Institutional Research Board	IRB
Multivariate Analysis of Variance	MANOVA
Motivated Strategies for Learning Questionnaire	MSLQ
Planned Algebraic Reasoning	PAR
Programme for International Student Assessment	PISA
Spontaneous Algebraic Reasoning	SAR
Standards of Learning	SOL
Statistical Package for the Social Science	SPSS
Science, Technology, Engineering, and Mathematics	STEM
Trends in International Mathematics and Science Study	TIMSS

Abstract

EXPECTANCY–VALUE FACTORS, GENDER, AND ACHIEVEMENT: IS THERE A DIFFERENCE BETWEEN ALGEBRA AND GEOMETRY?

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The purpose of this dissertation is to examine the relationship among standardized test scores, classroom grades, and expectancy–value factors. In this study, differences in these factors were analyzed by mathematics course (i.e., geometry and Algebra 2). The literature indicates that researchers have often used factors that incorporated only part of the expectancy–value theory model of motivation. Additionally, although it has been shown that expectancy–value factors affect mathematics standardized test scores and classroom achievement, there has been no investigation of how these factors affect different mathematics courses. The present study investigated variables in the entire expectancy–value theory model to determine differences in student motivation for algebra and geometry. The sample of this study came from a large, diverse public high school ($N = 300$). Analysis included preliminary demographics analysis, multiple hierarchical regression models, and a 2×2 factorial multivariate analysis of variance

(MANOVA). Results of this study suggest that expectancy–value factors, particularly prior achievement and self-concept, impacted student achievement algebra and geometry differently. Furthermore, expectancy–value factors affected standardized test scores and classroom grades differently for each subject. This study marks the beginning of a trend of research that zooms in the lens of expectancy–value theory to focus on specific courses and topics rather than on broad subject areas.

Chapter One

Mathematics achievement in high school is an essential part of a student's academic career. Most students in the United States are required to take Algebra 1, geometry, and Algebra 2 in high school to graduate (Florida Department of Education, 2016; Texas Education Agency, 2016; Virginia Department of Education, 2016). However, research has shown that there is a fundamental difference between the nature of algebra and geometry. Students engage cognitively with algebra and geometry material differently (Battista, 2007; Kaput, 1998). Additionally, individual student achievement within algebra and geometry shows significant differences (Lee & Lee, 1931; Thompson, 2005). These differences in mathematics domains exist when it comes to achievement on norm-referenced (i.e., measuring a variety of skills rather than a specific skill; Huitt, 1996) and state standardized tests as well. However, the differences between algebra and geometry standardized tests are inconsistent; Simzar, Martinez, Rutherford, Domina, and Conley (2015) reported significantly higher results for the California High School Exit Exam (CAHSEE) geometry test than for the CAHSEE algebra test, but significantly higher results for the California Standards Test (CST) algebra test for than the CST geometry test. This alarming difference is important for students who rely on these tests for diploma qualifications and college admissions. Colleges and universities look at students' achievement in mathematics as a whole, and if there are significant differences

between achievement in certain mathematics subjects, it can reflect poorly on the evaluation of student performance. The differences in results by content suggest that it is important to explore the factors involved in the difference between achievement in algebra and geometry to improve educational experiences for all mathematics students.

Differences in achievement between algebra and geometry may be due to the distinct nature of the two subjects. Algebra and geometry curricula have different content and require different cognitive procedures for students. For instance, geometry curriculum often focuses on spatial reasoning, which includes the use of two- and three-dimensional shapes and their properties (Battista, 2007; Virginia Department of Education, 2016). On the other hand, algebra curriculum deals more with numerical literacy and mathematical functions (Kaput, 1989, 1998; Virginia Department of Education, 2016). The inherent differences between algebra and geometry imply that students use different skills in the classroom and on high-stakes assessments; thus, it is worthwhile to explore the way differences emerge in classroom and high-stakes assessments for both algebra and geometry courses.

Cognitive ability is not the only factor that influences mathematics achievement. Motivational factors and gender stereotype beliefs have been shown to affect academic achievement, particularly in mathematics. These factors refer to noncognitive aspects of achievement; that is, factors that are not based on the cognitive processes of the brain during a task (Farrington et al., 2012). Some motivational factors that may influence achievement are interest, value, demographics, and prior achievement (Eccles et al., 1983; Eccles & Wigfield, 1992, 1995). Research has shown that students with high

interest and expectations are more likely to have higher achievement in mathematics (Mitchell, 1993; Durik, Vida, & Eccles, 2006). Additionally, students' beliefs about gender stereotype have been shown to affect achievement. Specifically in mathematics, females sometimes believe that they typically get lower scores than males, and they will, therefore, show lower achievement (Eccles et al., 1983; Steele & Aronson, 1995). However, these motivational differences have only been investigated in mathematics as a whole. Given the differences in outcomes for algebra and geometry, there may also be differences in motivation for each subject. The goal of this study was to determine if the dynamics of and differences between motivation and gender affect geometry and algebra differently.

In terms of motivation, there is no single study that has directly measured all aspects of motivation and how these factors affect algebra and geometry differently. However, certain studies have found some significant differences in students' noncognitive factors for the two subjects. For example, Pokey and Blumenfeld (1990) found higher levels of self-concept (i.e., students' belief in their ability to perform well) and value for algebra students than for geometry students. Furthermore, motivation is higher for students when they are learning content in which they have previously performed well (Guo Parker, Marsh. & Morin, 2015; Schunk & Zimmerman, 2006). Given that many schools in the United States require two courses focused on algebra and only one focused on geometry, there may be motivational differences for students taking these courses. However, there is a gap in the literature: no studies have compared all

types of motivational factors for algebra and geometry students. The present study is an attempt to address this gap.

Research has shown that motivational factors affect student achievement on standardized tests. Knowing the motivational factors that influence students' achievement on standardized tests enables teachers foster and increase students' drive to perform well on these exams. Results of state and national tests can impact students' graduation, college admissions, and job placement (Hiss & Franks, 2015; Virginia Department of Education, 2016); the drive to accomplish these life goals can be reflected in students' motivation to succeed on high-stakes assessments. For example, in an international study, high school students in Germany who took the Programme for International Student Assessment (PISA) mathematics exam reported their levels for several motivational factors, including personal interest and task value. Results showed that self-concept, self-efficacy, goals, interest, enjoyment, and work avoidance were all predictors of achievement on the PISA exam (Kriegbaum, Jansen, & Spinath, 2015). McCutchen, Jones, Carbonneau, and Mueller (2016) conducted a longitudinal study in Grades 3 through 6 and found that students who were more motivated in Grade 3 not only performed better initially, but also developed a mindset of growth and improved throughout the entire study. In the same study, highly motivated students displayed a high level of expectancy, which is the amount that they believe that they will perform well, on their standardized tests. Although this research has shown a connection between motivation and performance on high-stakes assessments, it is unknown whether the specific motivational constructs (e.g., interest, value, self-concept) affect geometry and

algebra differently, or whether motivational factors are the cause of the differences in achievement between geometry and algebra.

Motivational factors have also been shown to influence classroom grades and standardized tests differently. Classroom grades are often the result of long-term interactions in which students acquire skills and knowledge, whereas tests are a one-time opportunity to display knowledge or understanding. The unique nature of these two academic requirements can result in students having different motivations for classroom grades and standardized tests. In a classroom setting, relevance (i.e., to what extent students find the material useful outside the classroom), grades within the same course, and prior achievement in previous courses in the same subject have been shown to affect performance (Wang, Degol, & Ye, 2015). Students who find relevance in a subject may be led to an interest that, in turn, could take them to a career path involving the subjects that interest them the most (Wang, 2012; Wang, et al., 2015). Classroom grades are strong motivating factors for students to learn and put forth effort in a course because they can see the immediate result of their performance and effort in a task or an entire class (Hulleman, Durik, Schweigert, & Harackiweicz, 2008; Simpkins, Davis-Kean, & Eccles, 2006). Prior achievement is also a motivating factor for classroom grades because students have a level of expectation based on their previous performance on similar tasks or courses. Various studies have shown that prior achievement is a significant predictor of achievement on both standardized tests and classroom grades, particularly in mathematics (Kriegbaum et al., 2015; O'Shea et al., 2016). While these noncognitive factors have been shown to impact classroom grades on all courses in mathematics, given

the differences in the nature of geometry and algebra, further research is needed to determine if these motivational factors influence geometry and algebra classroom grades differently.

Expectancy–value theory, a motivational theory, is useful and appropriate in explaining the relationship between motivation and achievement in mathematics, and could illuminate the reasons that there are differences between achievement in algebra and geometry. This theory includes a model of several noncognitive factors that impact achievement, including demographics, self-concept, prior achievement, goals, gender stereotype beliefs, and subjective task value; each of these variables, according to Eccles and colleagues (1983, 1993), influences students’ academic achievement. In expectancy–value theory, goals are separated into short-term (i.e., proximal) goals, which refer to goals in a current course or task, and long-term (i.e., distal) goals, which refer to goals beyond the scope of the current task (Eccles et al., 1983). Prior achievement in previous mathematics classes has also been shown to affect achievement in current mathematics courses (Guo, Parker, 2015; Phan, 2014).

Of the demographic features of expectancy–value theory, gender affects motivation and performance. Gender differences exist in several motivational constructs. For instance, studies have shown that males report higher levels of intrinsic value and utility value, whereas females report higher levels of cost (Gaspard, Dicke, Flunger, Brisson, et al., 2015; Gaspard, Dicke, Flunger, Schreier, et al., 2015; Guo, Marsh, Parker, Morin, & Yeung, 2015; Guo, Parker, et al., 2015). In terms of classroom grades, males typically have higher expectations for their grades, as well as a more positive self-concept

with respect to classroom assignments (Else-Quest, Mineo, & Higgins, 2013; Peklaj, Podlesek, & Pecjak, 2015). Additionally, there are differences in mathematics standardized test achievement by gender. For instance, on the mathematics section of the GRE exam (a graduate school entrance exam), males overall outperformed females. Further analysis revealed that males and females did not show significant differences on test items considered to be easy, but males significantly outperformed females on those items considered to be difficult (Spencer, Steele, & Quinn, 1999). However, these studies did not combine each of the variables into the same analysis, and therefore the interactions among these variables, particularly in each specific subject area, are unknown.

Another relevant construct related to gender is gender stereotype beliefs, which refer to the potential belief that some students may have that one gender is superior at a task or subject than the other. This aspect of expectancy–value theory aligns with the research of Steele and Aronson (1995) on stereotype threat. More specifically in mathematics, gender stereotype threat is a possible explanation of gender differences in mathematics. Gender stereotype threat refers to the notion that when one gender is aware of a performance stereotype against them, they will underperform on that type of task. Little research, however, has been conducted comparing the effects of gender stereotype threat or other variables within expectancy–value theory on specific mathematics subjects, such as geometry and algebra.

Expectancy–value theory also includes a component of subjective task value (Eccles et al., 1983), which has four main constructs: attainment value, intrinsic value,

utility value, and cost (Eccles & Wigfield, 1992). Attainment value refers to a student's desire to perform well academically (Eccles & Wigfield, 1995). Intrinsic value measures how interested students are in a particular subject (Eccles & Wigfield, 2002). Utility value is to what extent a student feels a certain subject or topic is useful (Wigfield & Cambria, 2010). Finally, cost refers to the amount of effort or stress that student feel they need to experience to be successful at a task (Wigfield, 1994). Subjective task value beliefs are a strong predictor of success in a classroom setting (Farrington et al., 2012). Studies in expectancy–value theory, however, often measure students' subjective task value beliefs about mathematics in general (Wigfield & Eccles, 2000) rather than across specific mathematics subjects such as algebra and geometry. As mentioned before, there are significant differences in achievement by mathematics course, but it is unknown whether motivational beliefs are a factor in these differences.

Despite extensive research on expectancy–value theory, mathematics, and gender, little research has been conducted on the differences in certain motivational factors based on algebra and geometry or on how those motivations affect classroom grades and standardized test achievement in the two domains (Simzar et al., 2015). As a result, the present study is an attempt to address this gap in the research through an examination of students' motivational beliefs, classroom grades, and standardized test scores for geometry and algebra (specifically Algebra 2), as well as the differences in these variables by gender.

Introduction and Statement of Research Problem

Mathematics Content

Algebra and geometry, although both considered to be in the same subject, contain distinct concepts that students must master. An algebra course typically contains material involving numeral and symbolic literacy, multiple representations of functions, and the investigation of patterns in numbers (Kaput, 1989, 1998). Geometry content differs from that of with a primary focus on spatial reasoning and the understanding of two- and three-dimensional shapes (Battista, 2007; Clements & Battista, 1992). On the basis of this difference in content, algebra and geometry require different cognitive procedures. Mastery of an algebra course or exam requires students to use algebraic thinking skills, such as manipulation of functions, which are different than skills required to master a geometry course, such as visual competence (Battista, 2007; Kaput, 1998).

However, while students may use certain strategies to succeed in algebra classes, these cognitive skills may not be applicable in geometry classes. For instance, students in geometry require the working memory skills to work with three-dimensional shapes that are not necessary in algebra classes (von Glasersfeld, 1991). These differences in cognition and content may be related to the differences in test performance that have been found in research. For example, in a county in Virginia, passing rates were 69% for Algebra 1, 74% for geometry, and 80% for Algebra 2 (Virginia Department of Education, 2016). Lee and Lee (1931) found that 41% of students showed significant differences in their algebra and geometry test scores, a majority of whom had higher scores for geometry. Because these results came from the same students, the authors argued that an additional factor aside from cognitive ability must be influencing these results (Lee & Lee, 1931). In addition, in a more recent study, Simzar and colleagues (2015) found

significant differences in achievement between the algebra (specifically Algebra 1) and geometry components on two separate standardized tests. Students who took the CAHSEE, a California state standardized test, had significantly higher scores for geometry, whereas students who took the CST, another California high-stakes assessment, had significantly higher scores for algebra. These findings suggest that the differences between the algebra and geometry content and cognition can be related to a gap in test scores. The present study provides a further investigation of this claim.

In the present study, this difference between algebra and geometry was retested, but students' scores in Algebra 2 were used instead of those in Algebra 1. One reason for this choice is the significant overlap between the two content areas. Curriculum used in Virginia, which is where the present study took place, uses five topics in both the Algebra 1 and Algebra 2 courses: these include quadratic equations, direct and inverse variation, and systems of equations and inequalities (Virginia Department of Education, 2016). Due to the large amount of overlap between the two subjects, students in Algebra 2 may have different motivational beliefs depending on whether they are relearning material from Algebra 1 or new material. In addition, most of the Algebra 1 curriculum covers the basic facets of algebra, whereas Algebra 2 is more advanced and expands on the basic skills learned in Algebra 1. Algebra 1 is often referred to as basic algebra, while Algebra 2 is referred to as advanced algebra (Gaertner, Kim, DesJardins, & McClarty, 2014). The advanced nature of Algebra 2 makes it more predictive of college and career readiness (Gaertner et al., 2014). Thus, Algebra 2 was a better choice for the present study, which measured students' achievement and motivational factors for both geometry and algebra.

Expectancy–Value Theory

Expectancy–value theory is an appropriate theory for the present study because it includes many motivational factors and variables that impact academic achievement. In the present study, I included all the variables from the Eccles et al. (1983) model of expectancy–value theory that I was able to measure accurately and appropriately. These variables include demographic information (i.e., age, grade, gender, English language proficiency), gender stereotype beliefs, cultural stereotype beliefs, prior achievement, short-term goals, long-term goals, academic self-concept, and subjective task value (i.e., attainment value, utility value, intrinsic value, cost).

The model published by Eccles and colleagues (1983) includes a *cultural milieu* factor; variables in this factor include gender, demographics and gender role stereotypes as well as students’ perceptions of these stereotypes. In the model, all of these factors fall into the category of “beliefs and behaviors.” Farrington and colleagues (2012) have stated that beliefs are a noncognitive factor of education that certainly influence achievement. More specifically, research has shown that females and ethnic minority students will not perform as well on assessments as their counterparts because they believe they are not as strong in mathematics (Franceschini, Galli, Chiesi, & Primi, 2014; Steele & Aronson, 1995; Tine & Gotlieb, 2013). This factor is relevant for the present study because the diverse sample from which the data were collected. Additionally, several studies have shown that subjective task value variables within expectancy–value theory, particularly intrinsic value and utility value, are predictors of whether or not students are likely to pursue a mathematics-related career (Wang, 2012; Wang et al., 2015). The multifaceted

nature of expectancy–value theory enabled me to examine many aspects of motivation, and determine which factors most strongly predict achievement in geometry and algebra.

Another factor within the Eccles et al. (1983) model of expectancy–value theory is prior achievement in the field. Previous achievement, which according to Wigfield and Eccles (2002) both influences and is influenced by students’ beliefs and behaviors, refers to how a student performed in a course, task, or assessment in the same field earlier in their academic career. Studies have shown that students who have achieved high marks in previous mathematics tasks are more likely to achieve high marks in future mathematics tasks (Kriegbaum et al., 2015; O’Shea et al., 2016). The present study provides several forms of prior achievement, including a final classroom grade and a standardized test score for each previous mathematics course. Therefore, the present study was designed not only to confirm the influence of prior achievement but also to differentiate between the influence of prior classroom grades and prior standardized test scores in both geometry and algebra.

Another category in the Eccles et al. (1983) model is *child’s goals and general self-schemata*, which includes short- and long-term goals and self-concept. Both types of goals are known to be influenced by previous academic experience, beliefs and behaviors, and stereotype perceptions. For instance, students’ short-term goals, such as their goals for an upcoming test or grade, are often based on how they recently performed (Wolters, Yu, & Pintrich, 1996). Long-term goals are also influenced by prior achievement, with the additional influence of students’ stereotype beliefs about their own gender and ethnicity (Navarro, Flores, & Worthington, 2007). Furthermore, academic

self-concept is influenced by many other factors on the Eccles et al. (1983) model of expectancy–value theory, such as prior achievement, interest, and gender (Marsh, Trautwein, Ludtke, Koller, & Baumert, 2005). The interconnectedness of these variables makes expectancy–value theory an appropriate model to use for the present study. While the research has shown that these variables influence one another, no studies have looked at the overall model separately for geometry and algebra.

The final major component of the Eccles et al. (1983) model is subjective task value. Subjective task value refers to what extent a student feels the material is important for current or future value (Wigfield & Eccles, 2002). The four components of subjective task value are (a) attainment value, which is the extent to which the student values achieving high marks for a task; (b) intrinsic value, or interest, which is the extent to which the student finds the material interesting; (c) utility value, which is how valuable or relevant the student finds the material for future academic or career endeavors; and (d) cost, which is the amount of effort that a student feels they need to put forth on a task (Eccles et al., 1983; Wigfield & Eccles, 2000, 2002). It has been shown that all four variables within subjective task value are related in the same domain; for example, for a single student, attainment value, intrinsic value, and utility value may all be high in a mathematics setting, whereas in a science classroom, all three variables may be low for that same student (cost is often negatively correlated with the other three variables of subjective task value; Eccles & Wigfield, 1995). Furthermore, early work in the field has demonstrated that child’s goals and self-schemata have a direct influence on subjective task value; for instance, when self-concept is high, students find more value in the task

(Eccles et al., 1983, Eccles & Wigfield, 1995; Wigfield & Eccles, 2000, 2002). On the basis of the variables within this model, expectancy–value theory provides a sufficient number of factors that can explain differences in achievement. The strong foundation in the literature also demonstrates the relationships among the variables. This model was used in the present study to determine if the relationships within the model are consistent for different subjects within mathematics.

Additionally, expectancy–value theory was chosen for this study because of the domain-specificity of the theory, which is helpful in describing any potential differences between motivational factors regarding the domains of geometry and algebra. It has already been established that students’ beliefs about mathematics are not influenced by beliefs about English or other subjects (Eccles & Wigfield, 1992, 1995; Wigfield & Eccles, 2000), but it has not been shown whether students’ beliefs about early work in algebra (i.e., Algebra 1) result in them holding different beliefs about geometry or advanced algebra (i.e., Algebra 2). Finally, expectancy–value theory is best fit to answer the questions proposed in the present study. The present study is an investigation of students’ beliefs about geometry and algebra, including the students’ self-concept, stereotype beliefs, goals, and value of the content in their future lives. Expectancy–value theory is useful in answering these questions because of the noncognitive components that include self-schemata and subjective task value. Additionally, the existing literature has shown the relationship among these variables (Wigfield & Eccles, 2000, 2002). It was my expectation in designing this study that, while the Eccles et al. (1983) model would hold true for both geometry and algebra, I would find that these factors would not

influence achievement in geometry and algebra to the same extent. Further hypotheses for the present study can be found in Chapter 3.

Gender

In addition to findings that motivational factors and cognition related to mathematical thinking affect achievement on standardized mathematics assessments and classroom grades, researchers have found that gender may also be an overarching factor that influences grades and performance on tests. For example, males were found to have high levels of mathematics self-concept, utility value, and intrinsic value, as well as classroom and standardized test achievement (Guo, Marsh, et al., 2015; Guo, Parker, et al., 2015; Keller, 2007). The relationship between mathematics and gender has been studied for years, but findings have often been inconsistent; some studies have found that males score higher on mathematics standardized assessments (Kaufman, Liu, & Johnson, 2009; Keller, 2012; Kimura, 2000), whereas others have found no such differences (Hoffman & Spatariu, 2008; Liu & Wilson, 2009). Research on differences in mathematics achievement by gender introduced a new facet with the notion of stereotype threat, which may assist in explaining inconsistencies in prior research. Stereotype threat is defined as the concept that groups that are generally thought to perform poorly in a subject will not perform well because of that preconceived notion (Steele & Aronson, 1995). Although the original research concerned stereotype threat as it relates to ethnicity, the same basic concept was applied to the idea that females typically underperform males in mathematics for this same reason (Franceschini et al., 2014; Tine & Gotlieb, 2013). However, despite a large amount of literature that focuses on gender

differences in mathematics, there is little research on the effect of gender differences on results of standardized tests or classroom grades for algebra or geometry.

Researchers have also found differences in motivational factors, such as subjective task value variables by gender. In particular, Gaspard and colleagues (Gaspard, Dicke, Flunger, Brisson, et al., 2015; Gaspard, Dicke, Flunger, Schreier, et al., 2015) found significant differences by gender in intrinsic value, attainment value, utility value, and cost—all four aspects of subjective task value outlined by Eccles and colleagues (1983). Males reported higher levels of intrinsic value and utility value, whereas females reported higher levels of attainment value and cost. This finding is vital to the present study; given that many studies have found that males outperform females in mathematics, these studies inform the decision in the present study to explore the interaction among motivational beliefs, gender, and high school mathematics achievement. Additionally, it is unknown if predictions of classroom grades or high-stakes assessment achievement by gender are different for geometry and higher-level algebra. In the present study, whether these findings are consistent for geometry and algebra was investigated.

Statement of Research Problem

While the existing literature provides an extensive review about mathematics state standardized tests, classroom grades, expectancy–value factors, and the effect of gender on these achievement variables, there are gaps in the literature regarding the relationships among motivation, gender, assessments, and grades within a specific mathematics subject. It is unknown, for example, if gender predicts a different level of achievement as measured by classroom grades or by high-stakes assessment for geometry or algebra

(specifically Algebra 2). Moreover, the inconsistent findings concerning the effects of gender differences on achievement in mathematics drive the need for additional research on this topic. The present study has addressed these gaps by measuring achievement in specific mathematics courses by gender.

Conceptual Framework

Expectancy–Value Theory

In addition to cognition, motivation is an important factor in academic achievement. A framework that outlines a major motivational theory used in this study is expectancy–value theory. Atkinson (1957), one of the earliest prominent developers of this theory, explained that expectations and values influence students’ beliefs about a task. He also popularized the term “task value,” which is a broader construct under which attainment value exists, and argued that task value was intrinsic and could be measured in terms of students’ pride in succeeding (Atkinson, 1957). A more recent version of the theory was put forward in the late 1900s; at that time the term task value was split into more specific constructs, such as utility value and attainment value (Graham & Weiner, 2012). Some additional topics in the field of educational psychology regarding the modern expectancy–value theory included the relationships among expectations, subjective task value, self-schemata, and achievement-related behavior, as well as whether these beliefs change over time (Graham & Weiner, 2012). The longevity of research in expectancy–value theory demonstrates its effect on understanding motivational beliefs of students.

One of the earliest visual models of expectancy–value theory was proposed by Jacqueline Eccles, along with her colleagues in 1983. Figure 1 shows the factors included in this original model. This same model was used in later expectancy–value theory articles by Eccles and Wigfield (2002), which demonstrates the longevity and continuing relevance of the model. For the purposes of this study, *factor* refers to a box in the model, and *variable* refers to an individual aspect within a box.

When applying this model, the researcher begins with a consideration of the student’s *cultural milieu*, the factor in the upper left of the diagram in Figure 1. Eccles and Wigfield (1995) defined cultural milieu as the student’s demographics and any stereotypes this student believes in about gender roles and the subject matter. A student’s demographics include age, ethnicity, and socioeconomic status. A gender role stereotypes refers to a stereotype that exists in the population and is based on gender achievement in the task or subject the researcher is investigating. The Eccles et al. (1983) model distinguishes the stereotype itself from the student’s perception of the gender roles or the student’s beliefs and behaviors. Finally, cultural stereotypes of subject matter are the student’s existing associations with a particular subject. For instance, students may think geometry is difficult class because other students have said it is (Eccles et al., 1983). In the model, the cultural milieu factor is the only one that does not have any arrows pointing to it, because this theory, no factors influence a student’s cultural milieu.

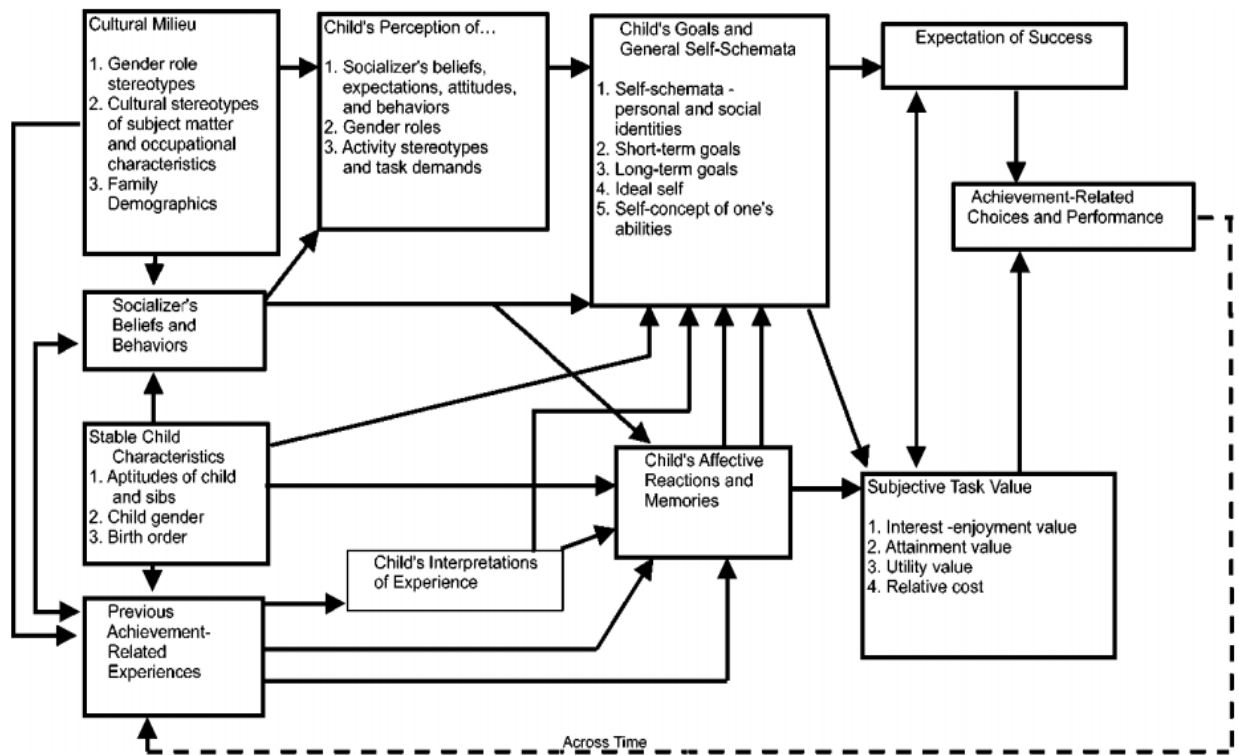


Figure 1. Eccles et al. (1983) model of expectancy-value theory

In the box below cultural milieu, Eccles and colleagues (1983) included a factor for socializer's beliefs and behaviors. Beliefs and behaviors are a broad category, but they are distinct from stereotypes; that is, students' beliefs about stereotypes may be different from the stereotypes themselves (Eccles & Wigfield, 1995). In addition to cultural milieu, several other factors influence the socializer's beliefs and behaviors according to the model, such as stable child characteristics (i.e., characteristics of a child that do not change) and previous achievement-related experiences, which are shown in

the two boxes below socializer's beliefs and behaviors (Eccles et al., 1983). Socializer's beliefs and behaviors and cultural milieu both have arrows pointing to a factor entitled child's perceptions (box to the right of cultural milieu), which includes how the child perceives the socializer's perceptions of gender roles, expectations, and activity stereotypes. Again, students' perceptions about stereotypes and gender roles can be different from the stereotypes themselves; that is, different student may have different perceptions about the same stereotype (Eccles et al., 1983). These factors described in detail represent general beliefs and stereotypes about a given subject, and directly influence many other variables within the expectancy–value theory model.

Another factor within the Eccles et al. (1983) model of expectancy–value theory is *previous achievement-related experiences*, hereby referred to as *prior achievement*. Prior achievement refers to students' success or failure at a previous task in the same domain as a current task (Eccles & Wigfield, 1995). As mentioned previously, expectancy–value theory is a domain-specific theory, meaning that beliefs in a certain subject are not influenced by another subject (Eccles et al., 1983). Thus, the same holds true for prior achievement. Only previous mathematics tasks influence beliefs in mathematics. According to the model, previous experience is influenced both by cultural milieu and by the socializer's beliefs, but a two-way arrow in the model connecting socializer's beliefs and prior achievement indicates that prior achievement also influences beliefs and behaviors. In the present study, prior achievement was measured by using students' previous final grade and end-of-year standardized test score in Algebra 1 or geometry.

The factor with the most components in the Eccles et al. (1983) model of expectancy–value theory is *child’s goals and self-schemata* (second box from the right). Within this factor, the authors included personal identities, short- and long-term goals, ideal self, and self-concept as variables that define goals and self-schemata. In the present study, short-term goals, long-term goals, and self-concept were used to measure students’ self-schemata. For the present study, short-term goals were defined as the student’s goal for the course grade and standardized test score, and the long-term goal will be student’s goal to use the material in the future. Self-concept refers to the students’ beliefs about their ability in a particular domain (Eccles & Wigfield, 1995). In the model, Eccles and colleagues (1983) show that many different factors influence students’ self-schemata, such as their perceptions, beliefs and behaviors, previous experience, their reactions and memories, and their interpretations of experience. The number of factors with arrows pointing to the child’s goals and self-schemata factor suggest that it is important to consider all variables in the model in the present study to determine which have the biggest effect on achievement, as well as which factors influence one another within an algebra or geometry domain.

The final factor in the model proposed by Eccles and colleagues (1983) is *subjective task value* (box on bottom right). The authors defined four main variables of subjective task value within expectancy–value theory: interest (also known as intrinsic value), attainment value, utility value, and cost. Researchers aiming to ascertain expectancy value might use a survey with items designed to measure each of these values. Eccles et al. (1983) defined intrinsic value as students’ enjoyment in learning a

subject. For example, an intrinsic value item might ask students how likely they are to pursue a topic outside of the classroom. Attainment value can be defined as how important students feel it is to succeed on an assessment, perform well in a subject, or apply a subject to the students' lives. An example of an item measuring attainment value asks students to what extent it is important for them to score an A on a mathematics test. Utility value refers to how useful a particular topic is for a student's future aspirations (e.g., college, career; Eccles & Wigfield, 1992). A utility value item would measure to what extent students feel that they will use a task or topic in their future careers. Cost in educational psychology is the amount of work and time that students feel that they need to devote to a subject and whether that work is worth the potential reward (Wigfield & Cambria, 2010). For instance, a student may report being stressed when performing a task; that stress has a high cost for the student. In the expectancy–value model, the subjective task value factor is directly influenced by the *child's goals and self-schemata*, the *expectations of success*, and the *child's reactions and memories* factors (Eccles et al., 1983). Alternatively, subjective task value, according to the model, has a direct influence on achievement-related choices and on expectation of success, which is connected to subjective task value by a double-sided arrow. The fact that subjective task value is the last box of the model indicates that these constructs are the culminating product of all other factors within the Eccles et al. (1983) model and, therefore, it is important to measure this value in the present study as a set of variables that influences achievement in geometry and algebra.

Historically, research on expectancy–value theory has been used in investigating the general subject of mathematics, rather than specific mathematical topics. Many of the scales that are used in measuring expectancy, value, and interest in students address broadly defined subjects and ask students to compare beliefs about the subject under investigation with beliefs about other subjects (e.g., “Compared to most of your other school subjects...”; Wigfield & Eccles, 2000, p. 70). Researchers have found that students’ beliefs and expectations vary by subject (Eccles & Wigfield, 1992, 1995, 2002; Wigfield & Eccles, 2000). Additionally, particularly in mathematics, how much a student values a subject and is interested in that subject can change over time due to early achievement and self-concept gained (or lost) by high (or low) achievement in a certain subject area (Wigfield & Eccles, 2000). However, major pioneers of expectancy–value theory have not differentiated results of their studies by different domain within a single subject; Simzar and colleagues (2015) have suggested that further research in motivation not focus simply on mathematics as a whole, but rather on specific subjects within mathematics (e.g., geometry and algebra). Overall, expectancy–value theory, to date, has been used with a wide-angle lens, taking in an entire content area or subject. In the present study, a zoom lens has been used to narrow in on how specific aspects of the mathematics content are influenced by expectancy–value factors.

Expectancy–value factors and motivation in algebra and geometry. As mentioned previously, few studies have specifically examined how students’ motivational factors differ depending on whether they are studying algebra or geometry. Of those studies in which both subjects have been examined, only some specific motivational

factors or variables were measured, rather than all of the measures within expectancy–value theory. Lopez, Lent, Brown, and Gore (1997) found that female geometry students scored higher than male geometry students, but no gender differences were reflected in the scores for the sample of advanced algebra (i.e., Algebra 2) students. The same study found that correlations between interest and self-concept were higher in the advanced algebra sample than in the geometry sample. Furthermore, overall values for interest, outcome expectations, and emotional arousal (i.e., cost) were all higher for geometry students than for advanced algebra students (Lopez et al., 1997). Pokey and Blumenfeld (1990) studied the expectancy–value beliefs (i.e., the beliefs outlined in expectancy–value theory) of current geometry students about both algebra and geometry. The authors found that both self-concept and value were significantly higher for algebra than for geometry. Additionally, value in algebra did not predict achievement in geometry; value in geometry predicted geometry achievement early in the semester, but not later in the semester. Prior achievement in algebra was significantly correlated with geometry self-concept beliefs but not with geometry subjective task value beliefs (Pokey & Blumenfeld, 1990). Although these studies have similarities with the present study, neither used all the variables that appear in the Eccles et al. (1983) expectancy–value theory model. This gap in the literature justifies the need for the present study to explore the dynamic of expectancy–value factors in the two mathematics domains.

In other studies that were not specifically focused on expectancy–value theory, motivation was examined in either geometry or algebra only, rather than in both courses. These studies were included in the literature review, because although they did not

address both subjects in a single study, creating a synthesis of studies from each subject may provide clues to the differences in students' motivations for algebra and geometry. For a college algebra course, Nguyen (2015) measured four aspects of student motivation specifically for the algebra course: attention, relevance, confidence, and satisfaction. For the purposes of the present study, I have defined relevance similarly to utility value in expectancy–value theory because utility value is defined as how applicable content is to one's life. I have also defined attention similarly to interest because interest is defined as how invested a student is in a subject (Eccles & Wigfield, 1992, 1995). Nguyen found that relevance of the algebra material was the strongest factor in predicting satisfaction with the course. Geno (2010) supported this notion that relevance in algebra is what enhanced students' interest in the content and allowed them to succeed. Thus, although not explicitly defined as an expectancy–value belief, in certain studies, motivation in algebra has been measured by using similarly defined constructs and several valuable findings resulted.

On the other hand, literature on motivation in geometry has shown different results. Several studies have shown that students were more motivated when they had a stronger foundation of basic geometric concepts, such as shapes and Euclidean properties. Similarly, those with a high prior achievement in geometric tasks were more likely to be motivated for future geometric tasks (Burger & Shaughnessy, 1986). Furthermore, Halat, Jakubowski, and Aydin (2008) concluded that the student's age and the difficulty of the curriculum were the strongest factors predicting motivation in geometry; specifically, if a geometry task is beyond the student's cognitive

developmental level, the student is less motivated to complete it. These findings do not agree with the findings for algebra motivation: Whereas the research on algebra motivation has overwhelmingly suggested that relevance of the content is the strongest motivator for students, the geometry motivation research has been predominantly focused on the difficulty of the material and how the content is presented to students. This difference is important because it suggests that there is a difference between students' motivational factors for geometry and algebra, and this provided a rationale for me to study differences in expectancy–value factors of students separately for geometry and Algebra 2.

One additional reason that algebra and geometry may produce differences in motivation is the nature of the content itself. As mentioned previously, geometry and algebra contain distinct mathematical topics that call on different cognitive skills (Battista, 2007; Clements & Battista, 1992; Kaput, 1989, 1998). In general, students tend to be more motivated (i.e., interested in) and see more relevance (i.e., utility) in material in which they perform well (Guo, Marsh, et al., 2015; Guo, Parker, et al., 2015). Additionally, students may feel there are certain levels of cost associated with completing mathematics tasks that they do not enjoy or feel is useful. Therefore, the cognitive differences between algebra and geometry can also cause motivational differences. One goal of the present study is to fill the gap in the literature by exploring differences between student motivation for geometry and Algebra 2 courses.

Gender and expectancy–value beliefs. Within expectancy–value theory, gender and gender stereotype beliefs are both aspects of the Eccles et al. (1983) model. As part

of early expectancy–value literature, Wigfield and Eccles (1992) found differences in mathematics self-concept in elementary students. Specifically, males were more likely to perceive their abilities to be superior to those of females. Many studies have examined the differences in mathematics performance by gender (Kaufman et al., 2009; Keller, 2012; Kimura, 2000). However, as mentioned previously, there have been inconsistent results. Aside from mathematics performance, there are also several gender differences by other expectancy–value variables. For example, mathematical educational aspirations (i.e., long-term goals) have been shown to be higher for males than for females (Watt et al., 2012). Furthermore, Watt (2004) reported that males showed higher levels of subjective task value in mathematics, such as intrinsic interest. The present study was needed to determine if these results were consistent for both algebra and geometry courses.

Students’ beliefs about gender stereotypes have also been shown to affect mathematics achievement for males and females. As mentioned previously, the gender stereotype threat concept set forth by Steele and Aronson (1995) states that females’ mathematics performance declines when these females are presented with the notion that males typically outperform females. Other studies in early expectancy–value literature have shown that differences in gender achievement are due to stereotype beliefs; that is, females’ beliefs about and values related to mathematics are lower because of their perception that they typically do not do as well as males (Eccles et al., 1993). In a similar study, Schmader, Johns, and Barquissau (2004) found that “stereotype endorsement moderates the effects of gender identity salience on women’s test performance” (p. 845).

Specifically, the scores of women who had learned that their identity lay in their gender worsened, whereas the scores of those who were encouraged to embrace their personal identity improved. In the present study, the extent to which all students surveyed (both male and female) believe that there was a difference in mathematics performance in the course they were taking at the time of the study (e.g., geometry and Algebra 2) was measured by gender. This information will expand the field of expectancy–value theory by determining if gender stereotype beliefs are consistent across one subject or vary on the basis of specific domains within one subject, and by determining if the interactions with other expectancy–value variables are different for geometry or algebra.

Previous research has also shown that there are gender differences in expectancy–value beliefs and achievement on mathematics standardized assessments. Only research on high school students has been included in the present study. As mentioned previously, Gaspard, Dicke, Flunger, Schreier, et al. (2015) found that male and female results for each individual subjective task value construct (i.e., attainment value, interest, utility value, and cost) all showed significant differences. It is worth noting that all significant differences “favored” males; that is, males had higher utility value, attainment value, and interest, but a lower level of cost. Furthermore, Guo, Parker, et al. (2015) found that mediating factors, such as prior achievement, provided at least a partial explanation for the higher levels subjective task value beliefs and self-concept beliefs for males. Ryan and Ryan (2005) attempted to make connections among gender, subjective task value, and mathematics achievement. For instance, they found that utility value belief was low in females due to the stereotype that females do not often pursue mathematics-related

careers, and this low utility belief led to low achievement on standardized tests. This finding is consistent with literature on stereotype threat, first introduced by Steele and Aronson (1995). This concept, which can apply to a gender or ethnic stereotype, bases the assertion that females do not perform as well as males on mathematics tasks based purely on the notion that males are typically better at mathematics. A more extensive review of the literature on gender differences is in Chapter 2 of this paper, but these few examples demonstrate that it is worthwhile to include gender as a variable in the present study.

Mathematics Content

Algebra. At the state level, high school students are required to take tests at several levels of mathematics. Because the proposed study will explore relationships and differences involving both algebra and geometry, the theoretical framework of both subjects must be explored. In the present study, a theoretical framework based on Kaput's work was used for algebra. Kaput (1998) categorized algebraic thinking into five strands:

1. Algebra as generalizing and formalizing patterns and regularities, in particular, algebra as generalized arithmetic;
2. Algebra as syntactically guided manipulations of symbols;
3. Algebra as the study of structure and systems abstracted from computations and relations;
4. Algebra as the study of functions, relations, and joint variations;
5. Algebra as modeling;

From a cognitive perspective, there are topics in algebra that students are expected to understand that are more prevalent in algebra than in geometry. Geary, Hoard, Nugent, and Rouder (2015) outline specific cognitive abilities that are used primarily in algebra. For example, students of basic algebra must develop their number and symbol processing abilities, especially when it comes to solving basic algebra equations. Additionally, advanced algebra includes the study of functions more so than geometry. To understand functions fully, students must be able to represent them graphically and algebraically, which requires two different aspects of human cognition (Thomas, Wilson, Corballis, Lim, & Yoon, 2010). Because utility value was used in this study, it is also important to use Kaput's work on meaning. In this work, Kaput (1989) proposed that literal and symbolic equations are more meaningful when graphs, charts, and tables are included. The literature review on algebra and algebraic thinking in Chapter 2 includes an in-depth discussion of meaning in algebra.

Geometry. For geometry, the theoretical framework used in this study is based on the work of Clements and Battista (1992). In their work, the authors outline six levels of geometric thinking known as the van Hiele levels (van Hiele, 1984). These include: pre-cognition, visual, descriptive/analytic, abstract/relational, formal deduction, and rigor/metamathematical. Although these levels are prominently used in geometry research, incorporating them into geometry assessment has become problematic. For example, Gutierrez and Jaime (1998) specified four aspects of geometry that should be tested on geometry standardized tests: recognition, definition, classification, and proof. However, the van Hiele levels are often difficult to assess using this framework because

different levels can exist within one question under the Gutierrez and Jaime framework. Nevertheless, both sets of authors provided strong foundations on which research on geometry and geometric thinking expanded.

Cognitively, there are several aspects of geometry that students are expected to understand. The most prominent topic in geometry involves spatial reasoning. Students in geometry are expected to visualize two- and three-dimensional shapes, perform operations on them, and understand the properties of these objects (Mulligan, 2015; Pittalis & Christou, 2010). Additionally, proofs are often included in the geometry curriculum. To complete geometric proofs, students must follow a strict logical progression using geometric properties, theorems, and postulates to validate a given statement about a shape (Clements & Battista, 1992). These two topics are specific to geometry and require different cognitive abilities than algebra. More specific descriptions of geometry and geometric thinking are described in Chapter 2 of this paper.

Understanding the processes of geometric thinking and how they are similar to and different from algebraic thinking may help to explain any differences that are found in the present study.

Cognitive differences in algebra and geometry. Because the differences between achievement in geometry and Algebra 2 course and state standardized tests are investigated in the present study, it is important to explore the cognitive differences that exist between the two courses. First, the main theories about geometry describe the manipulation of geometric shapes and objects. For instance, the theory of abstraction (von Glasersfeld, 1982, 1991) explains that students in a geometry class cognitively

progress through different levels of understanding of shapes: perceptual, internal, and interior. These levels refer to how working memory is used on two- and three-dimensional shapes, and the geometry curriculum used in the present study includes many units on this topic (Virginia Department of Education, 2016). However, the Algebra 2 curriculum includes minimal reference to two-dimensional shapes and no reference to three-dimensional shapes in the instruction; thus, the working memory abilities described in the Theory of Abstraction are not used. Another cognitive skill specific to the geometry curriculum is proofs. According to Clements and Battista (1992), completing geometric proofs requires a higher level of logical thinking than what is needed for other topics in either geometry or algebra. Additionally, students are often not familiar with or prepared for proofs because courses taken before geometry do not emphasize that level of deductive reasoning (Virginia Department of Education, 2016). The Virginia curriculum includes proofs in the geometry curriculum but not the Algebra 2 curriculum, and thus a different type of cognition is used by students in geometry and Algebra 2.

There are also cognitive abilities in the algebra curriculum that differentiate it from geometry. For example, in his five strands of algebraic thinking, Kaput (1998) includes the topic of functions as a unique part of the algebra curriculum. Working with functions in Algebra 2 is a multi-faceted skill; it requires students to be able to graph functions, interpret characteristics of the graphs and equations of functions, and find compositions and inverses of functions. These many skills make up a large majority of the Algebra 2 curriculum but are not included in the Virginia geometry curriculum; the

only mention of functions in the curriculum is recognition of the basic three trigonometric functions (Virginia Department of Education, 2016). This distinct difference between the two curricula, as well as the others unique aspects of geometry and Algebra 2, indicate that a different type of thinking is required for the two courses.

Standardized mathematics tests. Given that mathematics state standardized test scores are included in the present study, it is important to understand the nature of these tests. Tucker (2011) performed an extensive study of mathematics tests in the state of New York. One of his findings is that tests often put the harder questions at the beginning of the test. This practice fosters anxiety in students from the beginning of the test, which influences the rest of their performance (Andrews & Brown, 2015). Furthermore, Tucker even found that New York uses out-of-date questions (i.e., questions measuring previously used curriculum standards), despite their adoption of new, higher standards. Overall, the author drew the conclusion that “these tests encourage the type of mindless learning that New York had wanted to de-emphasize” (p. 437). This is a powerful claim for a widely used exam, and it may hold true for other state tests. In the state of Virginia, all students in mathematics courses required for graduation (e.g., Algebra 1, geometry, and Algebra 2) take an end-of-the-year standardized assessment known as the Standards of Learning (SOL) exam. An initial analysis of the Virginia Algebra 2 SOL revealed some psychometric inconsistencies, such as misfit items and low separation indices, which threaten the validity of the test (Mazzarella, 2015b). Therefore, it is important to consider this possible problem when analyzing the Geometry and Algebra 2 SOL data.

Purpose Statement and Research Questions

The purpose of this study is to determine if there are differences in expectancy–value factors, state standardized test scores, and classroom grades by specific mathematics courses (e.g., geometry and Algebra 2). This study will also determine if there are differences in these variables by gender. There is little research that examines differences in specific mathematics courses on any level, particularly literature that explores how expectancy–value factors influence different mathematics courses differently. The distinct nature of algebra and geometry, as well as the existing literature that includes findings on differences in some motivational constructs (e.g., interest, self-concept) between the two subjects, suggests that there are significant differences by mathematics course (Lopez et al., 1997; Pokey & Blumenfeld, 1990). Based on this purpose and these stated gaps in the literature, the following research questions were implemented:

1. To what extent do expectancy–value beliefs predict achievement on high-stakes mathematics assessments and classroom grades?
2. Is there a main effect of type of mathematics course (e.g., geometry, Algebra 2), main effect of gender, and an interaction effect between gender and type of mathematics course on expectancy–value factors (i.e., cultural milieu, child’s perception, stable child, previous achievement, child’s goals and general self-schemata, child’s interpretations of experience, expectation of success, subjective task value)?

Educational and Research Implications

In the education field, the findings from this study will provide valuable information for teachers. For instance, the present study shows that certain variables significantly predict test scores, and therefore teachers can be encouraged to focus more attention on fostering a classroom environment that promotes real-world examples and applications of the content. Moreover, understanding the extent to which certain beliefs influence achievement will help teachers make decisions about lessons and preparation for high-stakes assessments. For policy and curriculum makers, it is important to take steps to ensure that the curriculum that students learn incorporates practical content, instead of packing as much material as possible into one year. The findings from this study may prove useful in helping policy makers recognize that the quality and practicality of lessons are more valuable to students than the quantity of lessons in helping them perform well in the classroom and on high-stakes assessments.

In the research field, this study will add to the existing research that has explored the relationship between expectancy–value theory and mathematics, but will be one of the first to do so across algebra and geometry. This study is also the first to explore the entire expectancy–value model (Eccles et al., 1983) for both algebra and geometry separately. Although there has been research into some aspects of expectancy–value theory for a specific mathematics course (Lopez et al., 1997; Pokey & Blumenfeld, 1990), the present study has determined which expectancy–value factors most affect achievement in each mathematics course. Simzar and colleagues (2015) have called for more research into motivational factors specific to math courses. As discussed earlier, expectancy–value theory is domain specific, but no studies have delved deeper into one

domain and separated it by topic (i.e., specific mathematics course). It is my hope that the significant findings of the present study will increase the applications of expectancy–value theory and spark new questions that can be answered by further research. Additionally, the present study tests Farrington et al.’s claim (2012) that motivational factors influence classroom grades more than they influence standardized tests. The present study extends that research by attempting to provide a more complete view of all motivational factors defined by expectancy–value theory (Eccles et al., 1983). Finally, as mentioned previously, there have been inconsistencies in research about gender and mathematics, and a goal of the present study is to clarify some of the uncertainty about gender in mathematics research in general, but also as it relates to specific subjective task value variables and mathematics courses.

In Chapter 2, I first review existing research on algebraic thinking, geometry, and the differences between the contents. Next, I discuss expectancy–value theory in depth, and the motivational attributes used in my research. I refer to extant literature on each expectancy–value variable that I measured and analyzed as part of this research. Then, I discuss the importance of gender and give examples of previous studies that have explored gender differences in cognition and mathematics. In Chapter 3, I conclude with a proposal for the present study that was an attempt to gather and analyze data on these topics as a way to begin to understand the relationships among all of the variables.

Definitions of Key Terms

Expectancy–Value Theory

This theory, popularized by Eccles and Wigfield (1983) encompasses students' expectations and beliefs about the importance and significance of a task or course (Graham & Weiner, 2012). This theory includes a component of subjective task value, which comprises attainment value, utility value, intrinsic value, and cost (Eccles et al., 1983). Expectancy–value theory falls under the broader psychological theory of social cognitive theory (Schunk, 2012).

Expectancy

In the context of expectancy–value theory, expectancy is defined as the extent to which students believe that they can succeed at a task or an assessment or in a class (Midgley, Feldlaufer, & Eccles, 1989).

Attainment Value

Attainment value is the personal value that students see in performing well in a subject (Eccles & Wigfield, 1992). This achievement may pertain to classroom grades, standardized tests, or other academic assessments. This is one of the variables that falls under the broader term *task value*, which was coined by Atkinson (1957).

Personal Interest

Dewey (1913) defined interest as an object, subject, or idea that becomes an accompanying part of one's identity. A modern definition as it relates to expectancy–value theory is how much a student enjoys a particular task or subject (Mitchell, 1993). *Intrinsic value* is often used interchangeably with personal interest (Wigfield & Eccles, 2002).

Utility Value

According to Eccles and Wigfield (1995), utility value is the extent to which a student views a subject matter as important for future endeavors. This importance could pertain to classes to be taken later, career paths, or general everyday usefulness. Wigfield and Eccles (2000) classified utility value as more of an extrinsic value construct, whereas attainment value and personal interest are more intrinsic (i.e., personal) constructs.

Cost

Wigfield and Cambria (2010) defined cost as the amount of work and time that students put into a task or class versus the reward that performing well produces. For students, the cost could be physical, emotional, mental, or psychological. Unlike attainment value, personal interest, and utility value, cost “affects the negative valence of the activity” (Eccles & Wigfield, 1995, p. 216): the other three variables have a more positive connotation.

Self-Concept

Academically, self-concept refers to students’ beliefs about their abilities in a certain task or context (Marsh et al., 2013). Self-concept is context specific, meaning that a student’s levels of self-concept can be different from one academic subject to another.

Goals

In the present study, two types of goals were analyzed: short-term (i.e., proximal) goals and long-term (i.e., distal) goals. Short-term goals refer to the final classroom grade and SOL score that a student hopes to achieve at the end of the current course. Long-term goals, in the context of this study, refer to how and to what extent the curriculum in the

students' current mathematics course will be used in their future careers and lives (Smith & Fouad, 1999).

Stereotype Threat

Stereotype threat is an implied threat to a certain group of people (e.g., defined by ethnicity or gender) on the basis of a preconceived notion of inferiority with respect to completion of a certain task. For instance, females may perform poorly on a mathematics task because they believe in a stereotype that males are, in general, better than females at mathematics (Steele & Aronson, 1995). In the present study, stereotype threat was measured as a perceived belief about gender differences in mathematics performance.

Prior Achievement

Prior achievement refers to the classroom grades and standardized test scores that a student earned in a previous course. Research has shown that prior achievement in a previous course affects students' achievement in a similar course taken later (Smith, 1996). In the context of this study, prior achievement refers to students' high-stakes assessment scores and classroom grades in Algebra 1 or geometry or both.

Standardized Test

A standardized test is any test that a large group of students take to measure aptitude or knowledge of a subject (Addison & McGee, 2015). In the present study, the type of standardized test score that is measured is a state-wide mathematics assessment.

Classroom Grades

Students can receive grades in the classroom or homework assignments, classwork, summative assessments, and formative assessments. In the present study, the

final course grade for each mathematics course was used as the measure of students' classroom grades. I chose this measure because it is an accumulation of all these individual task grades.

Algebra

In Virginia, the algebra content consists of three strands: expressions and operations, equations and inequalities, and functions and statistics (Virginia Department of Education, 2016). Students in the present study learn algebra in two courses: Algebra 1, which is the first course that students are required to pass, and Algebra 2, which is the final required mathematics course necessary for graduation.

Geometry

In Virginia, the geometry content consists of three strands: reasoning, lines, and transformations; triangles; and polygons, circles, and three-dimensional figures (Virginia Department of Education, 2016). Students in the present study took a geometry course after completing Algebra 1 but before taking Algebra 2. Geometry was also necessary for students in the present study to graduate.

Chapter Two

Algebra and Algebraic Thinking

The foundation of the present study is the content of mathematics. It is important to understand the nature of algebra and geometry, given that performance on both subjects were measured in the present study. First, from a cognitive perspective, algebraic thinking is vital to student success on mathematics exams. Algebraic thinking is pertinent to the present study because the standardized mathematics test being used is based on a state's Algebra 2 assessment, and many of the strategies and cognitive processes outlined in this literature are likely used by students during these tests.

As mentioned previously, Kaput (1998, 2007) defined five algebraic thinking strands as follows:

1. algebra as generalizing and formalizing patterns and regularities, in particular, algebra as generalized arithmetic;
2. algebra as syntactically guided manipulations of symbols;
3. algebra as the study of structure and systems abstracted from computations and relations;
4. algebra as the study of functions, relations, and joint variations; and
5. algebra as modeling.

In the first strand, Kaput's focus is primarily on early algebra and the development of numeracy. For instance, in elementary school, students are introduced to the number line and the ways in which a number line can be labeled. This promotes a sense of how numbers progress and the different ways that numbers can be counted (e.g., by 1's, by 10's, by 0.1's; Carraher & Schliemann, 2007). Kaput's second strand, which deals with the use of mathematical symbols, spans a wide range of levels of algebra. In the early years, students use what is referred to by various authors (Milgram, 2005; Schifter, Monk, Russell, & Bastable, 2007) as *missing addend problems*. One example of a missing addend problem is the following: $7 + \underline{\quad} = 15$. Students must determine what number goes in the blank. Milgram (2005) emphasized that this type of problem solving is a crucial part of students' algebraic thinking, and is the first use of a variable in mathematics. As students progress through the secondary level of algebra, symbols become more regular and complex, such as absolute value and summation notation, both of which were topics in the Algebra 2 curriculum for participants in the present study (Virginia Department of Education, 2016).

The last three strands of Kaput's (1998, 2007) algebraic thinking focus more on the secondary level of algebra. The third strand, which is the study of structure and system as a result of computations, can be demonstrated by the example of Carraher and Schliemann (2007) with basic inequalities and equations. Students begin by using inequalities to compare fractions, then eventually use inequalities to solve for an unknown interval, and finally use inequalities to compare rational expressions in advanced algebra courses. This example demonstrates one way that a basic symbol (e.g.,

an inequality symbol) can be used throughout several levels of algebra and progressively be used to make comparisons and understand expressions.

The fourth strand is using functions, relations, and joint variations. From a literal perspective, the Algebra 2 curriculum in the state of Virginia includes direct, inverse, and joint variations, which teach the relationships of numbers around a constant of variation (Virginia Department of Education, 2016). Functions, however, span a large majority of the algebra curriculum in high school. One of the most important aspects of functions is that they are presented through multiple representations. Moss, Beatty, McNab, and Eisenband (2006) have stated that demonstrating functions by using graphs, tables, and equations with variables will help students to understand the value of mathematical operations and variables and shift their algebraic thinking from a one-dimensional cognitive viewpoint to a multilayered and interconnected way of thinking about algebra.

Finally, Kaput proposes that the last strand to algebraic thinking is using algebra in modeling. By his definition, algebra as modeling refers to presenting real-world algebraic problems in a way that promotes using algebra outside of the classroom (Kaput, 1989). Kaput also argues that this is the most important aspect of algebraic thinking because it helps students understand why they are learning the material. However, it is often the least emphasized aspects of algebraic thinking, particularly in the secondary level (Blanton & Kaput, 2005). Modeling is also particularly relevant to the present study because modeling promotes the understanding of how algebra is useful for students' everyday lives and futures, which is the definition of utility value (Eccles & Wigfield, 1992). Thus, these strands defined and explained by Kaput (1998, 2007) give insight not

only into how students learn and perceive algebra but also into how that understanding relates to a subjective task value construct like utility value.

These five algebraic strands, while distinct, should be integrated during instruction. Kaput (1998) argued that, while all strands should be incorporated into learning to maximize algebraic thinking, much of the algebra curriculum in classrooms today focuses only on the second and fourth strands. He further studied the extent to which *spontaneous algebraic reasoning* (SAR) and *planned algebraic reasoning* (PAR) were used effectively in an activity-based urban classroom. For instance, students took part in a lengthy discussion on the results of adding two odd, two even, or an odd and even number. The authors found that when algebra was presented as authentic problem solving, the number of SAR instances outweighed the number of PAR instances. Furthermore, students were able to learn and understand concepts that were well beyond their grade level, such as the representation of an odd number by $2n + 1$ (Blanton & Kaput, 2005). The authors theorized that algebraic thinking is enhanced when the content is presented in realistic and relevant problems. This literature is relevant to the present research because some of these algebraic thinking strands may be used during standardized testing. Additionally, Kaput's discussion of authentic problem solving relates to the topic of question type. Because different strands can be used to solve different types of problems, it is important to understand that these strands may be one possible explanation if there are significant differences in achievement on question types.

One important aspect of algebraic thinking comes from students making algebraic meaning from the mathematics. Students must be able to find meaning within

mathematics if they are to understand abstract algebraic ideas and make connections among the numbers and symbols (Sfard & Linchevski, 1994). Radford (2004) sorted meaning into three categories: algebraic structure, problem context, and exterior of the problem context. Kieran (2007) split that first category down further into two subsections: meaning from the letter-symbolic form of the algebra, and meaning from multiple representations. For example, in terms of symbolic and multiple representations, it is important that a traditional curriculum, such as literal expressions and equations, be merged with authentic problems that show graphs, tables, and pictures (Kaput, 1989). This reality corresponds with Kaput's argument that only one strand of algebra is being used in today's classroom. The information that Kaput outlines informs the present study by providing one possible explanation of how students are prepared for standardized tests; if not all strands are being used, students may not be able to perform to their highest abilities. Additionally, the notion of meaning in mathematics relates to students finding intrinsic value (i.e., interest) in the mathematics that they are learning. Students who have high interest in mathematics are more likely to find meaning in the problems they are doing (Renninger, Ewen, & Lasher, 2002).

The literature on algebra and algebraic thinking is an important foundation for the present study. Understanding the way that students apply their learning during standardized tests and classroom assessments will provide more meaning to results on Algebra 2 SOLs and classroom grades. However, grasping these concepts will not provide the full picture of mathematics achievement; I believe that the dynamic between algebraic and geometric thinking will help to address the research questions regarding the

differences between achievement on Geometry and Algebra 2 SOLs, and geometry and Algebra 2 classroom grades.

Geometry and Geometric Thinking

The second content area explored in the present study is geometry. The core of the subject of geometry is spatial reasoning, which requires students to “see, inspect, and reflect on spatial objects, images, relationships, and transformations” (Battista, 2007, p. 843). For example, true geometric thinking is not simply memorizing the different types of quadrilaterals, but also understanding the properties of each and why each quadrilateral is unique, and how each shape is valuable to real-world applications. Visualization is also an important part of geometric thinking; students are often required to work with two- and three-dimensional objects and explore relationships among angles and sides. Overall, geometry is a valuable subject that requires a unique mathematical mindset, distinct from that used for algebra.

According to Clements and Battista (1992), students need to move through the six levels of van Hiele geometric thinking, including deductive reasoning, to complete higher-level geometry. These six levels are precognition, visual, descriptive/analytic, abstract/relational, formal deduction, and rigor/metamathematical. These levels are hierarchical, meaning that students cannot cognitively advance to the next level without having achieved the previous level. The practicality of these levels can be described using the example of three-dimensional shapes; students advance from simply identifying solids, to stating properties of solids, to proving theorems about solids (Gutierrez, Jaime, & Fortuny, 1991). However, in more recent literature, authors have presented alternative

explanations of how students progress through these levels. Clements and Battista (2001) proposed that students develop these levels simultaneously and at different rates. For instance, students are constantly becoming more cognitively aware of visual and abstract geometry, but the visual knowledge develops faster. Furthermore, the rate at which these levels develop can be influenced by experience, tasks, and exposure to different types of mathematics problems at an early age. This description of how students develop geometric thinking is consistent with social cognitive theory, which claims that students' mathematics knowledge is influenced by more than simply their academic skill, but also by the situations around them. This overlap between theoretical frameworks provides a link between motivational factors described by social cognitive theory, and cognition described in the geometry literature.

The van Hiele theory is not the only major theory describing geometric thinking. Another theory regarding geometric thinking is the theory of abstraction (Battista, 2007). This theory, which describes three levels of abstraction, is based on the notion that students use mental models to understand objects and the actions that can be performed on these objects (von Glasersfeld, 1991). The first level of abstraction is perceptual, which is when students understand what an object is but cannot visualize it or perform operations on it. The second level, internalization, occurs when students are able to visualize geometric shapes and objects mentally (i.e., without seeing them), but do not understand the composition of an object enough to perform mental actions (i.e., operations) on them. Finally, at the third level, interiorization, students can use working memory to do more than just remember what an object or shape looks like; rather, they

can also use an object in a situation other than the one in which they learned it (Steffe, 1998). In other words, when students have reached this level, a geometric object can be freely operated on mentally, and becomes separate from its original context (Steffe & Cobb, 1988). This theory describes a strictly cognitive way in which students view and think about geometry, and gives insight into what students in the present study may have been undergoing. It also may provide a deeper understanding of why some students get better grades in geometry class or on tests than others.

A third prominent theory describing geometric thinking is concept learning. Concept learning deals with the formation of categories of geometric objects. According to Pinker (1997), there are two main types of categories used in concept learning: fuzzy and formal. Fuzzy categories exist when students generally understand an object but are not taught official properties of the object. These categories are often developed outside of an academic setting when students identify similarities among shapes on their own. Formal categories are developed when students fully understand the properties of a geometric shape, and these categories are often formed over time. The difference between the two categories can be demonstrated by a rhombus and a parallelogram. Students who fully understand the properties of both shapes realize that a rhombus is always a parallelogram because a parallelogram is a shape whose opposite sides are parallel; this is an example of a formal category. However, students who have not fully understood this relationship believe that the two shapes are completely distinct, an example of a fuzzy category (Battista, 2007). Forming concepts and categories is an important part of

geometric thinking, and understanding how they form may help to explain the geometry achievement that was examined in the present study.

Many previous studies have investigated how these theories have played out practically in the classroom. Recent literature has emphasized the use of computer-enhanced geometry environments. For example, programs such as Geometer's Sketchpad and Cabri have been shown to help accelerate the advancement of students through the van Hiele levels (Battista, 2001). One reason for this success is the students' ability to interact with shapes rather than simply looking at stationary shapes. Students can drag sides and angles to reshape objects, as well as create items with given angle and side measurements (Battista, 2007). Using technology to learn enables students to form knowledge on their own, which allows them to feel more invested with the material. This increased investment is relevant to the present study because use of these programs may enhance students' motivational beliefs about geometry.

Aside from technology, specific topics in geometry have been studied extensively as well. For example, measuring length, area, and volume are emphasized in geometry courses. Each type of measurement requires a certain level of mental sophistication, according to many researchers (Barrett & Clements, 2003; Battista, 2003, 2004). By the time students enter high school, they have often reached a sophisticated level of measurement ability. However, some have not had enough experience, both inside and outside of the classroom, to rise to a higher level of measurement ability in high school, such as being able to measure the volume of an irregular three-dimensional object or the area of a shaded region. This finding is important to the present study because the level of

measurement sophistication that students possess certainly will affect their performance on the state standardized test.

Cognitive Comparison of Algebra and Geometry

The focus of the literature reviewed in the previous two sections was details about the nature of geometry and algebra content. It is important to identify the differences between the two contents, given that the present study measured differences in classroom grades, standardized test scores, and motivational beliefs by specific mathematics course. One such difference is the nature of the theories used to describe algebraic and geometric thinking. For example, the theory of abstraction (von Glasersfeld, 1982, 1991) describes the way in which students think about, understand, and mentally operate on geometric objects. The majority of high school algebra content does not deal with the analysis or manipulation of two- or three-dimensional objects (Virginia Department of Education, 2016), and thus the theory of abstraction does not accurately describe algebraic thinking. Algebraic thinking, as Kaput (1998) describes, deals more with functions and symbols, which requires a different type of mathematical thinking. Another main difference in the two contents is the topic of proofs. While proofs are not directly related to spatial reasoning and other items in the geometry curriculum, proofs are often included in geometry courses in many states (Virginia Department of Education, 2016). Proofs are justifications of mathematical truths through arguments that use known theorems or mathematical properties (Clements & Battista, 1992). A certain level of logical thinking, which is not developed in algebra courses in Virginia, is required to complete these proofs. These distinctions in ways of thinking about the two types of mathematics content

support the notion that there are differences in achievement and motivational beliefs by course.

Despite differences between algebra and geometry, the literature includes several discussions of the similarities in the cognitive thinking processes and content of the two subjects. For instance, Banchoff (2008) argues that students gain more confidence when they realize the connections between the two topics. This confidence can result in a stronger working memory and future success in mathematics. In terms of the content itself, certain topics occur in both the geometry and Algebra 2 curriculum. In the geometry content in the school in which the present study was conducted, students are asked to work with formulas, such as the distance formula or the formulas for the area of shapes (Virginia Department of Education, 2016). Finding distances or areas by using these formulas requires basic algebra skills, such as plugging in values and using the order of operations. Another major overlap between the two subjects is coordinate mathematics. In algebra, students are expected to graph function on a coordinate plane, as well as analyze patterns of points and graphs. In geometry, students often graph shapes on a coordinate plane to measure distance and apply geometric transformations (Virginia Department of Education, 2016). Therefore, the content of the two courses coincides in certain topics. In terms of the theories describing the two contents, there are also some similarities. In algebra, finding meaning is an important part of helping students understand and connect with the material (Radford, 2004; Sfard & Linchevski, 1994). Similarly, in geometry, it has been shown that interacting with objects, either by hand or electronically, allows students to become more familiar with the content and understand

how it is applicable to their lives (Battista, 2007). Overall, the theories that best describe algebra and geometry, as well as the content itself, show similarities that it was important to consider in the analysis carried out for the present study.

High-Stakes Assessments

Given that algebra and geometry are unique mathematical domains, measuring achievement by using high-stakes assessments for each of these subjects allows researchers to understand the cognitive and noncognitive aspects of each subject. As mentioned in Chapter 1, high-stakes assessments are very prevalent in high school, and are often used to create accountability for students and teachers. Two main categories of standardized assessments are used in the United States. First, nationally used criterion-referenced tests are often implemented to determine admission into college or graduate school, as well as certification for a position or career. These tests can be broad and cover a variety of topics to test students' well roundedness (e.g., SAT, ACT, GRE), or they can be subject specific to determine if a student is qualified to work in a given profession (e.g., NCLEX for nurses). Second, state standardized assessments are often used throughout students' K–12 academic careers, and are usually subject-specific courses in which the student is enrolled. Many of these tests are norm-referenced, which means that they measure a variety of skills rather than one specific skill (Huitt, 1996). Often, these tests are used for graduation requirements; for example, in the state of Virginia, students are required to complete and pass the Algebra 1, geometry, and Algebra 2 courses, but are only required to pass one of the SOL exams for those courses (Virginia Department

of Education, 2016). The present study focused only on state standardized tests, particularly the Geometry and Algebra 2 SOL exams.

In order to understand the nature of state standardized testing, it is important to examine the movement of new standards in states. In the 1990s, many educational systems lacked accountability at the state level. As a result, state government began to monitor student results more closely (Porter, Archbald, & Tyree, 1990). Policies and laws, such as No Child Left Behind, were passed to monitor students' progress on standardized tests (Thomas, 2005). These types of regulation have had an effect on educators' teaching styles, evaluation, and accountability. For instance, new stricter standards and more emphasis on standardized testing has been shown to make teachers feel less in control of their lessons, which can result in teaching to the test (Madaus, 1988). Teachers have even reported constantly referring to the list of standards and the released versions of the assessments as the main driving force in their instruction (Mazzarella, 2015a; Thomas, 2005). In terms of evaluation, many districts have increased the importance of student achievement on state standardized tests in teachers' end-of-the-year assessments; for example, in Virginia, 40% of a teacher's evaluation on how their students perform on the SOL exams (Virginia Department of Education, 2016). Not only do the new standards put more emphasis on how well students do on one exam in a course, but they also essentially force teachers to teach toward these assessments, thus leaving them little freedom in their classrooms.

The standards used in the creation of the state tests are also changing the way that teachers evaluate students in the classroom. Pollio and Hochbein (2015) claimed that

teachers' grading standards were not consistent with the new standards that the state released. They found that teachers were grading more on students' effort and work completion than on their understanding of and achievement in the subject. To meet these expectations of the county and state, teachers had to evolve their grading methods into a standards-based grading system. Nevertheless, these new grading methods showed a positive effect on students and teachers. For instance, the researchers found that twice as many students in the group whose work was graded according to the standards-based system received an A or B in an Algebra 2 class and passed the state Algebra 2 assessment than in the group whose work was graded according to the old method. Furthermore, the standards-based grading system was much more effective in identifying students who were at risk of not passing or graduating (Pollio & Hochbein, 2015). This study is extremely relevant to the present study for several reasons. First, students in this study were assessed on the basis of their Algebra 2 classroom grades and state standardized test scores, which are the subject and performance measure used in the present study. The finding that both classroom grades *and* standardized test scores increased because of an intervention validates the use of both units of performance in the present study. Second, this study brings up a valid limitation of the present study, which is that teachers' grading methods may be varied and cause some differences in the data. While teachers in the participating school are required to make a weighted grading system that minimizes the weight of students' *completion only* grades (e.g., homework may count for a maximum of 10%; source not cited for confidentiality), I am aware of some teachers who will boost students grades despite this restriction. As a result, some

classroom grades may be affected by this method and may not give a completely accurate depiction of students' classroom achievement.

While Farrington and colleagues (2012) have asserted that noncognitive factors influence classroom grades more than standardized tests, some research has shown that results of standardized and high-stakes tests can also be influenced by noncognitive (e.g., motivational) factors. One qualitative study explored the extent to which students were motivated to perform well on state-mandated standardized mathematics tests. A variety of responses from students reflect their feelings about these tests, which ranged from performance-avoidance goals (e.g., "I just don't want to do bad") to extrinsic motivation (e.g., "I can show it to my grandmother for her praise"). The results of the data analysis showed that a majority of students did not have intrinsic motivation, but rather just wanted to finish the test and meet the minimum requirements (Ryan, Ryan, Arbuthnot, & Samuels, 2007). The results regarding intrinsic motivation are relevant to the present study in that attainment value, personal interest, and perceived task difficulty are all intrinsic motivational factors. However, the Ryan, et al. (2007) study did not specify the types of intrinsic motivation, which the present study does. Nevertheless, this finding regarding the importance of interest in mathematics brings up a glaring issue: what are the effects of high school students not seeing the merit in high-stakes assessments? If students do not take these tests seriously, the accountability of teachers, schools, and districts will be affected.

As described in Chapter 1, many state standardized tests across the country are now administered on the computer (Virginia Department of Education, 2015). This

change has enabled assessments to include technology-enhanced questions (e.g., drag-and-drop, fill-in-the-blank, and multiple-select) instead of only multiple-choice questions. Chapter 1 of this paper claimed that the use of computers in standardized tests is problematic and may cause validity issues and unfair circumstances for some students (Honigsfeld & Giouroukakis, 2011; Powell, 2012; Shapiro & Gebhardt, 2012). The participants in the present study took their state mathematics tests on the computer. Thus, I believe it is important to explore the literature about computer-based assessments to understand results from the present study regarding students' test scores.

Several researchers have looked at the differences between mathematics achievement on computer-based tests and on paper-and-pencil tests. Threlfall, Pool, Homer, and Swinnerton (2007) created a study in England that compared student achievement on paper-and-pencil mathematics assessments to achievement on assessments on a computer by using assessments with exactly the same questions. Results showed that out of seven mathematical categories, students who took the computerized version of the exam scored higher on five of them. The authors attributed this difference in scores to the interactive tools that students had access to on the computer (e.g., moving items across the screen; Threlfall et al., 2007). A similar study compared the results of a paper-and-pencil test to those of a computer-based test in an American elementary school classroom. The researchers found that some computer-based measures tended to be significantly less reliable than their paper-and-pencil counterparts. Furthermore, there were inconsistencies among these computer-based measures (Shapiro & Gebhardt, 2012). These findings suggest that changing an assessment from paper and pencil to computer

based requires analysis to ensure that the validity is still strong, even if the original paper-and-pencil test on which the computer version of the assessment is based was found to be valid and reliable.

Expectancy–Value Theory

As mentioned previously, cognitive ability alone is not the only factor in academic achievement. Motivational factors play a vital role in how well a student performs on a task or school subject. One theory that proposed a model of these motivational factors and how they affect academic success is expectancy–value theory. The roots of expectancy–value theory go back to the mid-1950s with the work of Atkinson (1957). Atkinson mainly focused on the relationship between students' motivation to succeed, motivation to avoid failure, expectations, the theoretical probability of success, and the task presented. His main claim was twofold:

1. Performance level should be greatest when there is uncertainty about the outcome, whether the motive to achieve or the motive to avoid failure is stronger within an individual.
2. Persons in whom the achievement motive is stronger should prefer intermediate risk, while persons in whom the motive to avoid failure is stronger should avoid intermediate risk, preferring instead either very easy and safe undertakings *or* extremely difficult and speculative undertakings. (p. 371)

Atkinson (1964) continued this work by proposing a model represented by $P_s \times I_s$, where P_s represents the probability of success on a task and I_s represents the value of succeeding

on the task. One of the earliest studies that tested Atkinson's claims was conducted by Battle (1965). Her study of middle school mathematics students included measure of absolute attainment value (i.e., the importance of doing well in mathematics) and relative attainment value (i.e., the importance of competence in mathematics), as well as the minimal goals and expectancy of the mathematics course. Battle found that students whose goals were equal to their expectancy were more persistent than those students whose goals were greater than their expectancy. However, students whose goals were less than their expectancy were the most persistent, but *only* if their attainment value was high (Battle, 1965). Similar results were found by Battle (1966) one year later, but regarding competence instead of persistence. The articles by Atkinson (1957, 1964) and Battle (1965, 1966) were foundational for expectancy–value theory, and provided a path for future researchers to study expectancy, value, mathematics achievement, and other motivational constructs.

Expectancy–value theory, as defined by Eccles and colleagues (1983), is a complex theory that contains many components of academic motivation. Figure 1, found in Chapter 1, shows the model of this theory, which is the theoretical framework of the present study. The present study is concerned with several aspects of this model. First, the model contains a factor of *cultural milieu*, which includes gender role and cultural stereotypes, as well as demographics. In the context of this study, demographics, which were measured in the present study, refer to the student's age, grade, and ethnicity, and whether the student has taken any English as a Second Language (ESOL) classes. According to the Eccles et al. (1983) model, cultural milieu directly affects *beliefs and*

behaviors, child's perceptions, and previous achievement-related experiences. For instance, gender stereotypes impact the students' beliefs about and perceptions of the stereotypes themselves. Cultural milieu is further discussed later in the chapter.

Second, the present study measured the *child's perceptions*, which is an aspect of the Eccles et al. (1983) model as well. Specifically, this study measured students' perceptions of gender roles in the mathematics course they were taking at the time of this study. According to the model, children's perceptions are directly influenced by cultural milieu (i.e., demographics), and directly influence their goals and self-schemata. The factor *child's goals and self-schemata* is essential within this model and has many variables including short-term goals, long-term goals, ideal self, and self-concept. For the present study, the short-term goals, long-term goals, and self-concept of students for the mathematics course they were taking at the time of the study were measured. Self-schemata are influenced by the greatest number of other boxes in the model, including previous achievement-related experiences and *stable child* characteristics (which includes gender), both of which are variables included in the present study. Literature regarding each variable is discussed in depth within this chapter.

Finally, the directional arrows of the model show that several of these factors influence the final piece of the present study, the subjective task value. This box includes intrinsic value (i.e., interest), attainment value, utility value and relative cost (referred to as *cost* for the remainder of this paper). A bidirectional arrow connects subjective task value and expectation of success (i.e., expectancy), meaning that each factor influences the other. For example, students who are more interested in a task expect to perform

better on that task; this attitude, in turn, decreases the relative cost that a student assigns to the task (Eccles & Wigfield, 1995). According to the model, several factors directly influence subjective task value, including the *child's goals and general self-schemata* and the *child's affective reactions and memories* (Eccles et al., 1983). The arrow pointing from *subjective task value* to achievement-related choices also suggests that the four aspects within the *subjective task value*, as well as expectations of success, influence how students make academic-related decisions. This visual helps explain the complex nature of expectancy–value theory and the variables' interactions. In the remainder of this chapter, each of the model's factors and the research associated with each variable are explained.

Cultural milieu. The first aspect that must be considered in the Eccles et al. (1983) model of expectancy–value theory is cultural milieu. This factor contains variables such as demographics, cultural stereotypes, and gender role stereotypes. In the present study students' cultural milieu was primarily measured through demographic information (e.g., age, grade, ethnicity, English language learner status).

Gender role stereotypes. As mentioned previously, a child's set of beliefs about gender role stereotypes is a variable within the expectancy–value theory model. Stereotype threat originally referred to the notion that ethnic minorities implicitly believed that they were inferior in mathematics, and thus performed lower due to this belief (Steele & Aronson, 1995). However, this notion has expanded to include gender beliefs as well, that is, females are also subject to stereotype threat (Franceschini et al., 2014; Tine & Gotlieb, 2013). The present study measured students' gender stereotype

beliefs through survey items: students were asked to what extent they believed that gender differences existed within the mathematics course they were taking at the time of the study.

The literature has differentiated between implicit and explicit gender stereotype beliefs. Implicit beliefs refer to a person's beliefs on a topic beyond what they explicitly report in a survey or interview (Franceschini et al., 2014). Nosek, Banaji, and Greenwald (2002) studied the effects of implicit stereotype beliefs of college women. The authors found that even women majoring in a mathematics-related field had an implicit belief that men were more suited for mathematics. This belief resulted in females feeling like they did not belong in the field as well as lower standardized test scores (Nosek et al., 2002).

Franceschini and colleagues (2014) also studied implicit gender stereotype beliefs and implicit gender stereotype *lift*, which refers to the belief that males' mathematics performance benefits from the notion that they are superior in mathematics (Walton & Cohen, 2003). The sample consisted of female undergraduate students enrolled in a mathematics course in Italy. The authors found that explicitly stating that females were either superior or inferior to male students significantly affected their mathematics performance. For instance, those who were explicitly told about a stereotype threat against women scored an average of 8.64 questions correctly out of 18, while those who were told about a stereotype *lift* for women scored an average of 11.57 questions correctly out of 18 (Franceschini et al., 2014, p. 275). Although the present study did not explore the implicit effects of gender stereotype beliefs on achievement, it is important to

consider when discussing the results from the measures, assessment scores, and classroom grades.

Other studies have examined the effect of explicit gender stereotype beliefs on mathematics achievement. Schmader et al., (2004) measured stereotype beliefs, self-perceptions, career intentions, and performance in mathematics for female college students majoring in a mathematics-related field. Results showed that women who reported a gender identity scored significantly lower on a mathematics assessment than those who reported a personal identity. Additionally, those women who endorsed the notion that males are superior in mathematics reported significantly lower confidence (i.e., self-concept), performance self-esteem, and likeliness to pursue graduate school in a mathematics-related field (Schmader et al., 2004). In another study that explored explicit gender stereotype threat, Blanton, Christie, and Dye (2002) measured stereotype beliefs of women explicitly by asking to what extent women endorsed the stereotype as true, but also implicitly by measuring whether or not this endorsement was a moderating effect for the evaluation of their own mathematical skills. The authors found that women who believe that women are inferior to men in mathematics were more likely to use their gender as the reason for their poor mathematics skills (Blanton et al., 2002). The present study has modeled these two studies that measure students' gender stereotype beliefs explicitly, and these data were analyzed with all of the expectancy–value beliefs to determine significant correlations; they were also included in regression models to determine if these beliefs significantly predict mathematics achievement in either course.

It is important to acknowledge that in the Eccles et al. (1983) model of expectancy–value theory, the authors distinguish between gender role stereotypes and children’s perceptions of these stereotypes. Although these stereotypes may exist within a population, students may have different perceptions of these gender roles. Therefore, the present study measured students’ perceptions of gender role stereotypes via survey.

Cultural stereotypes. Cultural stereotypes, in the context of the Eccles et al. (1983) expectancy–value theory model, refer to the beliefs of individuals that certain ethnicities typically perform better than other in mathematics. This belief relates directly to the original definition of stereotype threat by Steele and Aronson (1995), and many studies have explored this concept in terms of mathematics, expectancy–value theory, or both.

Cultural stereotype threat has been shown to interact with other factors within the Eccles et al. (1983) model of expectancy–value theory. Aronson and colleagues (1999) measured white men’s mathematics performance when they were presented with an explicit stereotype cue that Asian males perform better on mathematics assessments than white males. The results showed that, despite the fact that white males are not typically thought to be the victims of stereotype threat, significant differences existed between those who received a stereotype threat and those who did not. However, self-concept was found to be a moderating factor on performance between the two groups. Those students who reported a high mathematics self-concept and had no stereotype threat cue scored significantly higher than those who received one, whereas those students who reported a moderate mathematics self-concept actually benefited from the explicit stereotype cue,

scoring significantly higher than the control group (Aronson et al., 1999). This study provides interesting findings for many variables within the expectancy–value theory. First, it suggests that any ethnicity can experience a cultural stereotype if presented, despite previous beliefs about cultural stereotypes. Second, it emphasizes the relationship between self-concept, ethnicity, and cultural stereotypes. This important correlation was explored in the present study.

Some studies have even studied the interaction between cultural and gender stereotypes. Armenta (2010), who studied stereotype threat in Asian-Americans and Latinos, states that “simply being a member of a stereotyped group can affect performance on stereotype-relevant tasks” (p. 94). The study measured mathematics performance for both ethnicities with or without a stereotype prompt, and reported results by gender as well. The author found an interaction effect with ethnicity and stereotype cue in that Asian-American students who received a positive stereotype cue (i.e., stereotype lift) scored significantly higher than those Asian-Americans who received no cue, whereas Latinos who received a negative stereotype cue (i.e., stereotype threat) scored significantly lower than those who did not receive any cue. Furthermore, Armenta recorded gender and self-concept and found that both variables significantly predicted mathematics performance; males and those with high self-concept performed better on a mathematics assessment. This study is relevant to the present study in that it analyzed several aspects of expectancy–value theory: cultural stereotypes, gender, ethnicity, and self-concept. My goal was to expand those results in the present study by measuring these beliefs for all ethnicities for both geometry and algebra.

Family demographics. One final aspect of cultural milieu within the expectancy–value theory model of Eccles and colleagues (1983) is family demographics.

Demographics can refer to a student’s background, including ethnicity, age, grade level, and other cultural aspects such as language. In the present study, I have recorded each of these demographic variables. Two demographic constructs that remain static throughout a student’s academic career are ethnicity and first language. Both ethnicity and English learning status have been shown to be variables that impact academic achievement in the United States.

Ethnicity. Several studies have explored the differences in subjective task value by ethnicity. As mentioned previously, Else-Quest and colleagues (2013) and Watt and colleagues (2012) both studied the interaction between gender and ethnicity, and both studies found that not only were there differences by gender and ethnicity separately, but each ethnicity also produced different gender results. In another study, Andersen and Ward (2013) used data from the High School Longitudinal Study (HSLs), a secondary data set, to compare subjective task value in mathematics and science among high-ability African American, Hispanic, and Caucasian students. The researchers found that mathematics intrinsic value and attainment value were significantly higher for Caucasian students than for African American or Hispanic students. High levels of utility value predicted student persistence (i.e., the desire to continue to succeed) in Hispanic students, but not for African American or Caucasian students. Finally, Caucasian students had a more positive view of cost in mathematics than other groups. Overall, all four main subjective task value variables showed significant differences by ethnicity group.

These studies justify the inclusion of ethnicity as a variable in the present study. The population of the school at which the present study was conducted was very ethnically diverse at the time of the study, with more than 30 countries represented (source not cited for confidentiality). As a result, the students were asked on the measure used in the present study to identify their ethnicity as Caucasian, African American, Asian, or Hispanic. In proposing this study, my hope was to produce findings on ethnicity that would give more insight on how ethnicity affects students' ability to learn geometry and algebra and whether these effects differ by subject.

English language learners. Another variable within family demographics is English language proficiency. Nearly 23% of the students attending the school from which the sample for the present study was drawn were enrolled in English language learner classes at the time of the study, and more than half of the school population had been enrolled in these classes at some point (source not cited for confidentiality). Therefore, the literature on English language learners on mathematics achievement is relevant for the present study.

English proficiency is a major factor for mathematics classrooms with English language learners. It has been found that for students who displayed equal levels of mathematics competence, reading ability fully mediated achievement (Stancavage et al., 2003; Walker, Zhang, & Surber, 2008). Guglielmi (2012) tested these findings and also added a measure of self-concept. The author found that although mathematics self-concept predicted mathematics achievement as reflected in classroom grades for English language learners, English language proficiency did not mediate that relationship, but

only the relationship for English grades. This research suggests that English proficiency influences domains in different ways. The present study extended this literature to determine if there are differences in achievement in algebra or geometry by English proficiency.

The nature of the mathematics problem itself has been shown to affect achievement of English language learners. Martiniello (2009) studied fourth grade students who took a standardized mathematics test, and also analyzed the complexity of the mathematics problem compared with the achievement. Aspects of the problem that Martiniello (2009) measured are linguistic complexity (i.e., the difficulty of the directions in English) and the presence of a visual within the problem. The author found that overall, as expected, those who are not English language learners performed significantly better than English language learners. In terms of the problems, the difference in achievement between the two groups was smaller if the problem included a picture. Linguistic complexity varies from question to question on standardized tests. For problems with a higher level of linguistic complexity, the difference in achievement between the two groups was greater (Martiniello, 2009). This study demonstrates that it is important to consider what type of problem the students are faced with; this consideration is particularly relevant for the present study because of the nature of geometry and algebra. Since geometry is more visual and spatial than algebra (Battista, 2007), it is more likely that classroom assessments and standardized tests will include visuals. Therefore, when the results of English language learners are compared for the two

subjects, it is important to consider that the problems themselves may have contributed to any potential differences.

One aspect of mathematics that is particularly difficult for English language learners is word problems. Martiniello (2008) conducted a mixed methods study in which fourth-grade students answered mathematics word problems and stated what they found most difficult about them. Results showed that those who are not English language learners scored significantly higher in mathematics word problems than English language learners. When asked what made word problems difficult, English language learners stated that problems with long directions give them the most difficulty. Furthermore, the conjugated forms of words are difficult for some English language learners to understand. For instance, some English language learners understood the word “spin” in a problem, but when other forms of the verb, such as “spinning” or “spun” were used, the problem became harder to understand (Martiniello, 2008). Some studies have also described strategies to help English language learners to increase their ability to solve mathematics word problems. Orosco, Swanson, O’Connor, and Lussier (2013) studied how accurately elementary students whose English proficiency ranged from Level 1 (beginner) to Level 4 (technical vocabulary) interpreted word problems. They used an intervention to help improve comprehension called Dynamic Strategic Mathematics (DSM); a teacher using DSM prompts students to find the question, underline key words and numbers, and check their answer. Students in the experimental group were also encouraged to replace difficult words with more common ones, supporting the research of Martiniello (2008). The researchers found that DSM effectively increased English language learners’

performance on word problems as well as the English proficiency level at which the student was classified (Orosco et al., 2013). Although these two studies provide information justifying the inclusion of English proficiency in the present study, the participants in both studies were elementary students; the present study has expanded the literature on English language learners and mathematics by measuring the data of high school students.

Child's goals and self-schemata. One of the most dynamic aspects of the expectancy–value theory model proposed by Eccles and colleagues (1983) is the factor called *child's goals and self-schemata*. While the two terms are combined into one factor within the model, they have distinct definitions. Child's goals refer to the aspirations that a student has in a class, for a task, or for the future, and self-schemata refer to the extent to which the student believes they can accomplish these goals (Eccles et al., 1983). Within this category, students' short-term goals, long-term goals, and academic self-concept are considered. Wigfield and Eccles (1992) argue that self-schemata are valuable in this context because students find value in tasks that allow them to demonstrate various aspects of their self-schemata. The present study measured students' short- and long-term goals in the mathematics courses they were taking at the time of this study, as well as their academic self-concept in that course.

Short-term goals. Short-term goals, also known as proximal goals, refer to a student's academic goals in their current course, an upcoming assessment, or a task in the near future (Brown, 2005). In the present study, short-term goals refer to students' goals for their final classroom grade and the high-stakes assessment in the mathematics course

they were taking at the time of this study. Like other aspects of expectancy–value theory, goals have been found to be specific to subject matter. Smith and Fouad (1999) measured students’ goals across science, social studies, English, and art classes and determined that goals cannot be generalized across subject matter. No studies, however, have compared goals across classes within the same subject matter; Smith and Fouad (1999) even called for further research in goals across similar mathematical domains. Thus, the present study has attempted to expand the literature on goals and determine the differences in goals between geometry and algebra.

Short-term goals of adolescent mathematics students have also been studied. Middleton, Kaplan, and Midgley (2004) studied mathematics achievement goals, which are goals regarding students’ grades and test scores from sixth through seventh grades. The authors found that students’ short-term goals remained consistent across this time span. Furthermore, the study found that students with a higher self-concept set higher short-term goals for themselves, while those with low self-concept set lower goals. Finally, the authors also examined the differences in goals by ethnicity. It was determined that ethnicity was a significant predictor of task goals; specifically, Caucasian students reported significantly higher task goals than African American students (Middleton et al., 2004). This study provides some important connections for the present study, but also some areas for expansion. For instance, the authors found significant connections between goals and ethnicity and between goals and self-concept; these findings confirm the relationships in the expectancy–value theory model proposed by Eccles and colleagues (1983). The present study included the same variables and used the same

hierarchical regression analysis as Middleton et al. (2004). Whereas they studied the goals of middle school mathematics students, the present study not only studied the goals of high school students instead but also differentiated between mathematics courses offered in high school (e.g., geometry and Algebra 2). Additionally, the present study expanded the earlier study in several ways. First, while Middleton et al. only compared results of Caucasian and African American students, the present study collected results from all major ethnic backgrounds usually included on a demographic survey.

Long-term goals. In contrast to short-term (i.e., proximal) goals, long-term (i.e., distal) goals refer to a student's goals for their future academic career or beyond (Brown, 2005). For the present study, long-term goals were defined as the student's hopes for using in the future the material covered in the mathematics course they were taking at the time of the study.

Long-term goals are defined very specifically for this study, but the term has been defined somewhat differently in other studies. Studies have shown that students' long-term goals can affect academic achievement. Tabachnick, Miller, and Relyea (2008) measured several long-term goals of second-year university students, such as extrinsic future goals (e.g., wealth, image) and intrinsic goals (e.g., health, community contributions), as well as proximal goals (e.g., college graduation, passing courses). The authors conducted a path analysis and determined that intrinsic and extrinsic future (i.e., long-term) goals were significantly correlated with one another. Furthermore, whereas intrinsic future goals significantly correlated with proximal goals, extrinsic future goals did not (Tabachnick et al., 2008). This study provides important information relevant to

the present study because it demonstrates the relationship between proximal and distal goals. The present study has defined long-term goals more closely with intrinsic goals (e.g., using the material in a future career), and thus it was expected that the present study would find results similar to those of the Tabachnick et al. study in that proximal and distal goals would be correlated. However, the authors did not measure goals as they relate to a specific subject, which is what the present study did to expand the knowledge in this area.

Findings in some earlier studies indicate that having a combination of proximal and distal goals is ideal as opposed to having only one or the other. Brown (2005) carried out three interventions with government employees: one with a distal goal, one with a distal and proximal goal, and one in which employees were told to “do your best.” The data showed that those who set only a distal goal significantly underperformed those who set both a proximal and a distal goal. Furthermore, there were no differences in performance based on gender by long-term goal (Brown, 2005). According to the author, these results can be applied to those who are learning new skills, even in the classroom. Therefore, this finding is relevant to the present study; those students with strong proximal and distal goals are expected to have higher levels of academic motivation, as well as achievement in both the classroom and on standardized tests.

Academic self-concept. Academic self-concept refers to students’ beliefs about their abilities with respect to a certain task or subject (Eccles & Wigfield, 1995). As with other aspects of expectancy–value theory, academic self-concept is domain specific, meaning that students’ self-concept for one task or subject does not impact their self-

concept in another subject (Marsh, Hau, Artelt, Baumert, & Pescher, 2006; Marsh et al., 2013). The present study is concerned with mathematical self-concept, but going deeper, it also explored the differences between self-concept in algebra and geometry, and whether self-concept affects achievement in each subject differently.

Self-concept has been a popular topic in educational psychology literature over the last few decades. Pajares and Miller (1994) measured mathematics self-concept in high school students using the Self-Description Questionnaire (SDQ). They compared self-concept to other mathematics motivational variables, such as relevance, in addition to comparing it with achievement. The authors found that mathematics self-concept and high school level (both of which are variables in the present study) both have direct effects on mathematics performance. Furthermore, high school level was also found to have an effect on mathematics self-concept; specifically, students in higher grade levels reported higher levels of mathematics self-concept. This finding is relevant to the present study primarily to justify the inclusion of self-concept in the analysis. In addition to being a part of the Eccles et al. (1983) model of expectancy–value theory, Pajares and Miller confirmed the effect of self-concept on academic performance. Additionally, the findings that suggest that grade level directly affect mathematics self-concept and achievement justify the addition of this variable to the analysis.

Academic self-concept has also been measured across time. Marsh (1989) conducted a study measuring students' self-concept throughout elementary school and middle school. He found that from an early age through middle school, self-concept remains constant until early adulthood, when it increases. Marsh and colleagues (2005)

conducted a longitudinal study of mathematics self-concept, interest, and achievement, as well as gender. The participants were seventh grade students who were surveyed at the beginning and end of the year. The results of the study show that mathematics self-concept and interest were highly correlated with one another. Furthermore, Marsh and colleagues (2005) found reciprocal effects of mathematics self-concept and interest, meaning that each construct has an effect on one another. This relationship supports the Eccles et al. (1983) model of expectancy–value theory, in which self-schemata have a direct influence on subjective task value. Thus, this aspect of the study justifies the inclusion of an analysis comparing self-concept and subjective task value in the present study. Marsh and colleagues (2005) also found valuable information regarding self-concept and different aspects of mathematics achievement. According to their data, although mathematics self-concept was significantly correlated with both mathematics grades and test scores, it was more highly correlated with school grades than with standardized test scores. This finding is extremely useful for the present study, which measured to what extent self-concept influenced mathematics achievement in the classroom and on two Virginia high-stakes mathematics assessments, but the present study extended Marsh and colleagues' (2005) study to determine if there were differences in these findings by specific mathematics subject (e.g., geometry and algebra).

More recently, Marsh and colleagues (2013) measured self-concept for mathematics and science, as well as several other motivational constructs (e.g., value, affect), in eight countries (four countries where the official language is Arabic and four countries where the official language is English). The purpose of Marsh's study was to

compare the self-concept variable with other motivational constructs across subjects and countries. The study confirmed domain-specificity of self-concept; that is, correlations between mathematics and science self-concept were not significant for any countries. However, Arab countries reported higher correlations between mathematics and science self-concept than did Anglo countries (Marsh et al., 2013). Because this finding concerns two subjects, it is relevant to the present study. Although there is much overlap between mathematics and science (Else-Quest et al., 2013), Marsh et al. (2013) found low correlations between mathematics self-concept and science self-concept. Thus, the question arises: Despite the fact that algebra and geometry are within the same subject of mathematics, do students' motivations for the two subjects differ? Another relevant finding of the Marsh et al. (2013) study concerns ethnicity. As mentioned previously, demographics and ethnicity are part of the Eccles et al. (1983) model of expectancy–value theory. Examining the data from the Arab and Anglo countries, Marsh and colleagues were able to find some differences between the two groups. For instance, academic self-concept for both mathematics and science was significantly higher for all Arab countries than for all Anglo countries. This finding indicates that demographics and culture play a role in mathematics self-concept, and thus it is important to measure and compare the two constructs in the present study.

In terms of gender, there are inconsistencies in the literature with respect to academic self-concept differences between males and females. Pajares and Miller (1994) found that although males had a slightly higher self-concept than females, it was not a significant difference. On the other hand, Marsh and colleagues (2005) found that males

had a significantly higher level of mathematics self-concept. However, by country, Marsh et al. (2013) found that significant differences in self-concept favored males in Anglo countries, but there were no significant differences in mathematics self-concept in Arab countries. This inconsistency in the relationship between gender and self-concept calls for additional research on the topic, and the present study had attempted to determine if a specific mathematics topic (e.g., algebra or geometry) adds new information to clarify this inconsistency.

Previous achievement-related experiences. Another factor in the Eccles et al. (1983) model of expectancy–value theory is *previous achievement related experience*, or more simply, prior achievement. According to Eccles and Wigfield (2002), a student’s prior achievement influences their beliefs and behaviors, expectations of future success, and their subjective task value of a particular subject. Specifically, the authors state that “children may begin to attach more value to activities in which they do well...” (p. 121). Because prior achievement is an important and well-studied factor in expectancy–value theory literature, it was included in the present study.

Other studies have also drawn connections between prior achievement and other expectancy–value factors. Marsh and Yeung (1998) studied academic self-concept, gender, classroom grade, and test achievement on a large data set across three years. The data showed that prior achievement in mathematics significantly predicted test scores, classroom grades, and self-concept in future years. The researchers also found that self-concept reported in the first year was positively correlated with school grades and test scores in successive years. Furthermore, the study distinguished between the effects of

prior achievement on classroom grades and on standardized tests scores and found different results. For instance, prior achievement on mathematics standardized test scores predicted mathematics standardized test scores in the third year, but prior achievement on mathematics classroom tests did not predict mathematics test scores in the third year. Additionally, few differences were found between males and females in terms of whether prior achievement predicted any other expectancy–value factors (Marsh & Yeung, 1998). This study is important to the present study because it models the comparisons made between prior achievement and other factors in expectancy–value theory that the present study was designed to replicate. Marsh and Yeung (1998) also differentiate between prior achievement for classroom grades and standardized tests. The authors called for future studies to “consider school grades and test scores as separate constructs” (p. 729). Therefore, the present study followed this precedent for geometry and Algebra 2 achievement variables.

In the present study, prior achievement in early algebra was expected to influence achievement in geometry and Algebra 2 as well as other expectancy–value factors. Smith (1996) explored these relationships among high school students, and compared the results based on whether students took early algebra in middle school or high school. The results of her study showed that, as expected, course achievement in 10th grade significantly predicted course achievement in 12th grade. Furthermore, prior mathematics achievement more strongly predicted future mathematics achievement for students who took early algebra before high school. Smith (1996) also determined that ethnicity did not predict the number of years a student spent in advanced mathematics; this finding is relevant to

the present study because of the cultural milieu factor. This study, however, did not distinguish between classroom grades and standardized tests; the present study did extend this prior research by including an exploration of differences between these two variables. Additionally, given that this study found differences by grade, the present study had students record their grade level and used this information as a variable to predict test scores and classroom grades in both geometry and Algebra 2.

In the context of this study, prior achievement refers to both classroom grades and SOL scores for the previous mathematics courses that are required to graduate high school. For geometry students, Algebra 1 grades and scores were recorded, and for Algebra 2 students, Algebra 1 and geometry grades and scores were recorded. The present study had extended the prior literature by determining to what extent prior achievement in a particular mathematical topic influences achievement in a student's current mathematics course.

Subjective task value. As mentioned previously, subjective task value is a main component of the Eccles and colleagues' (1983) model of expectancy–value theory. Subjective task value, which is influenced directly by self-schemata (Eccles et al., 1983), has four variables: attainment value, intrinsic value (i.e., interest), utility value, and cost. While all four are in the same category in the expectancy–value theory model, each one measures a distinct motivational belief (Eccles & Wigfield, 1995); and several scholarly articles have been written about the effect on academic achievement of each of these variables separately.

Attainment value. Attainment value is a specific aspect of subjective task value within expectancy–value theory. It is a motivation construct that is content-specific (Eccles et al., 1993), meaning that a student’s attainment value belief in one subject is not necessarily the same belief in another subject. Early work in attainment value was conducted by Atkinson (1957), who proposed that attainment was “aroused by situational cues” (p. 359). He also suggested that attainment was influenced by the value of the incentive; these incentives, in an academic setting, typically refer to grades based on performance. Battle (1965, 1966) continued the study of attainment value and separated the construct into two categories: absolute and relative. Absolute attainment value is the importance of performing well in a subject (i.e., earning a high grade), whereas relative attainment value is the importance of competence in a subject (i.e., understanding the material). The work regarding attainment value by Atkinson (1957) and Battle (1965, 1966) was revived by Eccles and Wigfield in the early 1980s, who defined attainment value as “the importance of doing well on a task” (Wigfield & Eccles, 2000, p. 72). In recent years, several studies have separated attainment value into the same two constructs that Battle (1965, 1966) used, naming them “importance of achievement” (corresponding to absolute attainment value) and “personal importance” (corresponding to relative attainment value; Gaspard, Dicke, Flunger, Brisson, et al., 2015; Gaspard, Dicke, Flunger, Schreier, et al., 2015). In the present study, students were surveyed on these two sub-constructs of attainment value, which are described in detail later in this section.

Attainment value interacts with other motivational constructs across several academic subjects. Bong (2001) studied the attainment value, self-efficacy, performance

goal, and mastery goal of several students across several subjects in middle school and high school. The results showed that attainment value in high school was one of the most domain-specific variables in the study. Specifically, in terms of mathematics, attainment value was correlated with language and science attainment value in high school at .06, .17, and .44, respectively, and in middle school at .36, .37, and .45, respectively. However, as expected, attainment value was significantly correlated with self-efficacy, performance goals, and mastery goals (Bong, 2001). These findings suggest that attainment value for mathematics is related to other motivational factors, but not necessarily to attainment value for other subjects; this supports the claims of Eccles and Wigfield (1995) that expectancy–value theory is domain specific.

Expectancy–value theory is a growing theoretical framework in the field of physical education research. Yli-PiiPari and Kokkonen (2014) conducted a longitudinal in which they measured all four subjective task value variables for physical education in Grade 6, and again in Grade 9. The researchers’ analysis focused on comparing subjective task value across grades and across genders. Results showed that attainment value significantly predicted effort for males only, but attainment value predicted intrinsic value for females only. In terms of grades, as expected, attainment value in Grade 6 predicted attainment value in Grade 9. Intrinsic value in Grade 6 also predicted attainment value in Grade 9. These results are relevant to the present study because students reported their grade level on the demographics survey. The fact that attainment value (and other subjective task value variables) is relatively consistent across time suggests that there will not be any significant differences in grade level. Additionally, the

differences between males' and females' beliefs warrant the inclusion of this variable in the present study.

Fostering attainment value in early secondary school is important in helping students to sustain this belief throughout their educational careers. In particular, teachers have a strong impact on helping students to develop attainment value (Eccles et al., 1993; Wigfield, Byrnes, & Eccles, 2006). Wang (2012) stated that teachers can foster attainment value by structuring their classroom positively and creating engaging mathematics activities. Furthermore, Wang found that "students' mathematics classroom experiences at seventh grade predict mathematics expectancies/ability self-concepts, subjective task values, and interest at seventh and 10th grades" (p. 1651). The findings of these studies show that teachers have a vital role in creating a classroom environment that promotes attainment value. The present study will add to this literature and show early secondary teachers the importance of teaching lessons that instill in students a strong motivation to succeed.

Attainment value can also differ between males and females. Gaspard and her colleagues (2015b) measured several distinct variables related to motivation in mathematics for ninth grade students. After a factor analysis confirmed the distinction between personal interest, attainment value, utility value, and cost, which are the four aspects of task value according to Eccles and Wigfield (1995), the results of this study showed significant differences between males and females in terms of intrinsic value (i.e., interest), but not in importance in achievement (i.e., attainment value). Despite this difference, the components of the factor analysis of intrinsic value and attainment value

were significantly correlated (Gaspard et al., 2015b). This distinction is important for the present study because each construct may predict mathematics achievement on state tests differently. In addition to providing an analysis of the relationship between the two motivational variables used in the present study, the authors of this research also suggested that further analysis of the differences in gender is needed for these constructs.

Many studies have also examined attainment value as it relates to mathematics. Watt and colleagues (2012) measured mathematics attainment value, along with other subjective task value variables, in high school students in the United States, Canada, and Australia. The authors found that students with high levels of mathematics attainment value had higher overall participation in mathematics class. However, the researchers also found cultural differences within the sample. While attainment value significantly predicted educational aspirations in the United States, it also predicted educational and career aspirations in the mathematics field for students in Canada and Australia (Watt et al., 2012). This finding is relevant to the present study because it suggests a cultural difference between the effects of attainment value, which was examined in the data of the present study. In terms of achievement, Trautwein and colleagues (2012) measured which aspects of motivation best predicted mathematics achievement in a German high school. The data indicated that attainment value only positively predicted mathematics achievement when students' expectancy levels were high. Additionally, mathematics attainment value was positively correlated with prior achievement; that is, the higher a student scored in a previous mathematics grade or assessment, the higher their level of attainment value. Finally, the authors found that females had significantly higher levels of

attainment value than males (Trautwein et al., 2012). These studies not only present the importance of attainment value in a mathematics classroom, but also the interactions between attainment value and other expectancy–value variables, which are a main focus of the present study for both geometry and algebra data.

Differences in attainment value between algebra and geometry. Currently, no studies have measured attainment for both algebra and geometry within the same study. Later in this chapter, I discuss differences in intrinsic value and cost for the two content areas. Intrinsic value and cost are in the subjective task value category as attainment value in the Eccles et al. (1983) model of expectancy–value theory. Furthermore, many studies have emphasized the strong relationships among all variables within subjective task value (Eccles et al., 1983; Eccles & Wigfield, 2002; Marsh et al., 2005). Therefore, literature with findings showing differences in related constructs between algebra and geometry may suggest differences in attainment value between the two subjects.

Importance of achievement. While attainment value has been shown to be a distinct construct from other subjective task value variables, attainment value itself can be broken into multiple separate sub-variables. One such variable is known as importance of achievement. According to Gaspard, Dicke, Flunger, Schreier, et al. (2015), importance of achievement is a student’s perceived significance of performing well on a task. Several studies have found that importance of achievement does not change by grade (Meece, Wigfield, & Eccles, 1990; Frenzel, Pekrun, & Goetz, 2007) or country (Steinmayr & Spinath, 2010). Additionally, these same studies found no gender differences in importance of achievement by gender, which is also supported by Gaspard,

Dicke, Flunger, Schreier, et al. (2015). The distinction in separating attainment value into this subconstruct is important for the present study because according to the results in Gaspard, Dicke, Flunger, Schreier, et al. (2015), this variable is slightly different from “personal importance.” Furthermore, Wigfield and Cambria (2010) called for distinctions in these variables so that stronger conclusions could be drawn in studies with these types of variables. As a result, I thought it was worthwhile to separate all subjective task value variables for the present study.

Importance of achievement was studied before Eccles and Wigfield reintroduced their modified version of expectancy–value theory. Harackiewicz, Sansone, and Manderlink (1985) studied the responses of male students in high school regarding importance of achievement (referred to as “importance” in the study), expectancy, enjoyment, and achievement in completing puzzles. The authors found that the interaction between achievement and importance was a mediator for enjoyment, but importance itself was not a significant mediator. This finding is valuable for the present study because it suggests any significant differences in importance of achievement that are found may be the result of an outside motivational factor.

Personal importance. A second subsection of attainment value that is distinct from importance of achievement is personal importance. Personal importance refers to the value that a student sees in the subject for themselves, rather than for their academic records (Gaspard, Dicke, Flunger, Schreier, et al., 2015). In the same study, personal importance was more strongly correlated with intrinsic value (i.e., personal interest) and utility value, and males had a higher level of personal importance for mathematics than

females did. Other studies have also found similar gender differences in personal importance (Nagy, Trautwein, Baumert, Koller, & Garrett, 2006). In the present study, including personal importance in addition to importance of achievement has helped both to distinguish whether students felt it was important to perform well for their academic careers or for themselves and also to determine to what extent students reported these feelings.

Turner and Schallert (2001) explored personal importance in an undergraduate class on psychopharmacology, which is the treatment of mental disorders with medicine. Students were given a survey in which they answered Likert scale items about personal importance (defined as importance of academic ability in this study), attainment value (defined as task value in this study), and other motivational variables. The researchers found that importance of academic ability was most highly correlated with self-concept of academic ability. Importance of academic ability was, however, not a significant predictor of shame in the classroom. Additionally, the researchers used a hierarchical multiple regression to add certain motivational factors to the model at different intervals. This approach not only yielded additional information about a specific subconstruct of attainment value, but also provided a model for a type of analysis appropriate for the present study, given the large number of subjective task value variables that were measured.

Personal interest. In addition to attainment value, personal interest (i.e., intrinsic value) in a subject is another motivational variable under expectancy–value theory that is often correlated with achievement (Durik et al., 2006). In the context of education, many

researchers use “interest” and “intrinsic value” interchangeably. Mitchell (1993) specified educational interest as interest directly tied to the content of instruction. In the present study, this definition was used to define personal mathematics interest.

It is important to differentiate personal interest (i.e., intrinsic value) from extrinsic motivation and value. A person who is intrinsically motivated is interested in completing a task without any outside rewards aside from the satisfaction of the completed task itself. On the other hand, a person is extrinsically motivated when rewards, such as pay or praise, accompany completion the task or good performance (Wild, Enzle, Nix, & Deci, 1992). Wild and colleagues (1992) also claimed that students’ perceptions of the nature of others’ motivation can influence their interest in a task. In their study, students were exposed to two situations: one in which an individual was motivated intrinsically (e.g., satisfaction) and one in which an individual was motivated extrinsically (e.g., financial). When surveyed, participants indicated that the individual who was motivated intrinsically appeared to display more interest in the task than the individual who was motivated extrinsically. Therefore, the amount and nature of motivation is important not only to individuals performing a task but also to those around them. This notion is relevant to the present study because of the classroom environment in which students are learning mathematics; although students are responding to survey items regarding their own individual motivation, beliefs of others may be a confounding factor that affects the results.

The focus of the present study is intrinsic value rather than extrinsic because intrinsic value is a component of subjective task value. However, the extrinsic aspect of

student motivation is important to understand because some aspects of cost are considered to be extrinsic (Eccles & Wigfield, 1995). In a study comparing the two types of motivation, Hamner and Foster (1975) surveyed groups of undergraduate students after they had completed what the researchers deemed a “boring task” and an “interesting task.” In one group, students were not paid to complete any task. In a second group, students were paid only if they worked on the tasks for at least 20 minutes (i.e., contingent pay). In a third group, students were paid before beginning the task. Results showed that there were no significant differences in interest among the groups assigned the interesting tasks, but students in the contingent pay group reported the highest interest for the boring tasks. Additionally, the overall level of interest for the interesting tasks for all students was significantly higher than that of the boring tasks. The authors concluded that the attractiveness of the task motivated students intrinsically, but extrinsic motivation was valuable for students who did not find interest in a task (Hamner & Foster, 1975). This claim is important for the present study because, although the measure used in this study attempted to determine the intrinsic aspect of student’s motivation for mathematics, extrinsic motivating factors, such as classroom grades, may influence students’ responses to some items. An effort was made to remind students to answer items solely on the basis of the mathematics content, but this confounding variable was a limitation in the present study.

Intrinsic value is an important variable in other science, technology, engineering, and mathematics (STEM) subjects aside from mathematics. For example, DeBacker and Nelson (1999) measured motivational beliefs of high school science students. The

students were given a survey that included subjective task value items measuring intrinsic value, utility value, and attainment value, along with other motivational factors such as performance goal, perceived ability, and self-reported effort. Survey results showed that males assigned significantly higher intrinsic value to science. A hierarchical multiple regression analysis revealed that the level of intrinsic value significantly predicted students' effort and persistence in science. However, when the variables were separated by gender, it was found that intrinsic value significantly predicted effort for males only, while intrinsic value significantly predicted persistence for females only (DeBacker & Nelson, 1999). This study is valuable for the present study because it suggests that intrinsic value plays an important role in a high school classroom beyond simply achievement. Moreover, gender differences are reflected not only in the amount of intrinsic motivation that a student has but also in the predictions that can be made on the basis of intrinsic motivation. In terms of methodology, the DeBacker and Nelson study provided an example of how data analysis was conducted in the present study in which a hierarchical multiple regression was also used by adding in each expectancy value to the model one at a time. In another study, Hulleman et al. (2008) measured college students' levels of intrinsic value, utility value, and mastery goals in for an introductory college psychology course. The researchers found that initial interest and mastery goals had the main effects on intrinsic value in the course. Furthermore, they also found an interaction effect among the variables; specifically, mastery goals "led to more intrinsic value for those students with high levels of initial interest" (p. 404). In a similar study, Senko and Hulleman (2013) studied *situational interest*, which was comprised of interest (referred to

as *catch situational interest*) and utility (referred to as *hold situational interest*). Based on the survey results from an undergraduate psychology class, the authors found that mastery-approach goals (i.e., the desire to understand the material well) predicted high situational interest (i.e., interest and utility), but performance-approach goals (i.e., the desire to obtain good grades) did not significantly predict situational interest. These studies support the interconnectivity among intrinsic value and other motivational variables, even in subjects other than mathematics.

Intrinsic value in mathematics. Intrinsic value (i.e., personal interest) in mathematics has been shown to have a significant direct effect on mathematics achievement. Nagy and colleagues (2006) measured the motivational beliefs about both biology and mathematics for more than 1,000 students in Grade 10 and Grade 12. In addition to the gender differences described previously, the researchers found that intrinsic value significantly predicted achievement in both mathematics and biology. Interest in mathematics also had a direct effect on biology achievement. Furthermore, personal interest in mathematics was also a strong predictive factor in students choosing to enroll in advanced mathematics courses. However, interest in mathematics and interest in biology were not significantly related. This study demonstrates that not only does personal interest influence mathematics achievement but also future academic and career paths in mathematics. Additionally, the distinction between mathematics and biology interest indicate that different courses can elicit different motivational beliefs in students, a notion that is supported by Eccles and Wigfield (1995) and tested between algebra and geometry in the present study. The findings of Nagy et al. are consistent across other

STEM fields. Lawanto, Santoso, and Liu (2012) measured high school students' levels of interest and expectancy in an engineering program. The researchers measured subjective task value using the Motivated Strategies for Learning Questionnaire, a popular measure used to determine motivation. Students reported high levels of interest when they saw the usefulness of the task (i.e., task value), but reported low interest when they did not see any utility in the task. Furthermore, interest was highly correlated with expectancy, which supports the early work on expectancy–value theory (Eccles et al., 1983; Eccles & Wigfield, 1992, 1995). The significant relationship between personal interest and mathematics achievement was further investigated in the present study.

Many additional studies have also shown gender differences in intrinsic value (i.e., personal interest) in a subject. Guo, Parker, et al. (2015) measured several aspects of subjective task value, such as utility and interest, of Australian secondary students, as well as their achievement on a large-scale national mathematics assessment. The authors found that gender differences in mathematics achievement were partially mediated by gender differences in personal mathematics interest. This finding is consistent with other studies that have found that interest is a mediating factor for gender differences in mathematics (Gaspard, Dicke, Flunger, Brisson, et al., 2015; Guo, Marsh, et al., 2015). They noted overall that females have a lower interest in mathematics, which is one deciding factor that prevents them from enrolling in upper-level mathematics courses (Guo, Marsh, et al., 2015). In a similar study, Gaspard, Dicke, Flunger, Schreier, et al. (2015) also found that mathematics intrinsic value (i.e., personal interest) was significantly higher for males than for females. Within the Subjective Task Value, which

was larger overall for males, intrinsic value was the variable with the greatest difference between males and females. The gender differences in interest, as well as other aspects of subjective task value, in these recent studies validate the second research question in the present study.

Findings in other studies have also indicated that personal interest is related to other psychological factors outside of subjective task value. Ozyurek (2005) found statistically significant correlations between interest in a mathematics class and self-efficacy, subject preference (i.e., algebra or geometry), previous mathematics performance, and class expectations. These results were also consistent for undergraduate students who were mathematics majors and not mathematics majors (Ozyurek, 2005). The statistical significance of this study is vital to the present study because it suggests that interest in mathematics can be different in different courses. Therefore, it is worthwhile to study interest and other subjective task value variables as they pertain to geometry and Algebra 2.

Personal interest in mathematics varies throughout a student population. Trautwein, Ludtke, Marsh, Koller, and Baumert (2006) measured interest in ninth grade students on different mathematics tracks: an upper track for gifted mathematics students, a middle track for on-level mathematics students, and a lower track for struggling mathematics students. The researchers found that interest in mathematics was significantly higher in students in the upper track, but there was little difference in interest for students in the middle or lower tracks. Interest was also found to be significantly correlated to both individual achievement on standardized mathematics tests

and the overall school achievement on the same standardized tests (Trautwein et al., 2006). In a different study, the same researchers also found marginally significant results indicating that there were reciprocal effects on mathematics interest and self-concept. In other words, rather than one variable impacting the other, both interest and self-concept impact each other; as interest increases, it causes self-concept to increase, which in turn causes interest to increase again, continuing on in a cyclical nature. These results were also found to be the same for both genders (Marsh et al., 2005). These studies reflect the complex nature of motivational constructs with various student populations; the similarities of these constructs were taken into account in the way this study was conducted and the data analyzed.

Differences in intrinsic value between algebra and geometry. Certain studies have suggested that students assign different intrinsic value in geometry and algebra. Lopez and colleagues (1997) studied several expectancy–value beliefs in two samples of students: one taking geometry and the other taking algebra. They found that for the geometry sample, intrinsic value (i.e., interest) was not significantly correlated with mathematics achievement on a standardized test, whereas the two variables were positively significantly correlated for the algebra sample. Furthermore, the researchers also measured students’ *emotional arousal* for each sample, which very closely relates to cost in the subjective task value factor of expectancy–value theory. Interest and emotional arousal (i.e., cost) were significantly correlated in the geometry sample, but not in the algebra sample (Lopez et al., 1997). The contributions of this study are very important to the present study because they suggest that expectancy–value variables,

particularly intrinsic value and other subjective task value variables, differ depending on whether the student is taking geometry or algebra. Further investigation is needed to verify these results and extend them to other factors within expectancy–value theory.

Utility value. Utility value is the importance that students see in a subject for future use (e.g., daily life, career, or future academics; Eccles et al., 1983). Utility is one of the four main variables outlined by Eccles and Wigfield (1992, 1995), but is one of the two extrinsic constructs within this theory. Although intrinsic value and attainment value are related to the students’ internal feelings and beliefs about the task or subject, utility value and cost are related to the students’ beliefs about how the task or subject will affect their present or future goals (Wigfield & Eccles, 2000). Additionally, in some recent research, utility value has been separated into further subsections. For example, Gaspard, Dicke, Flunger, Schreier, et al. (2015) found that *utility for school*, *utility for daily life*, *social utility*, and *utility for job* were all found to be separate constructs within a survey of high school students with regard to mathematics. Each of these distinct subconstructs was used in the present study.

Utility value also has an influence on students in many subject areas. Hulleman and colleagues (2008) conducted a hierarchical multiple regression analysis on the basis of students’ utility and intrinsic value responses on a survey about college psychology class. They found that utility value directly predicted classroom grade. Furthermore, utility value was also found to be a unique predictor of subsequent interest in an undergraduate psychology setting. This is another example of a study using hierarchical multiple regression to analyze subjective task value variables (DeBacker & Nelson,

1999), which supports the use of that method of analysis in the present study. In a similar study, Chen and Chen (2012) measured utility value in physical education class with both a classroom aspect and an activity aspect. The participants of that study reported very high levels of utility for both the classroom and activity aspects. However, they found that utility value was higher when reported about after school activity than in-class activity. This finding was expected because students participating in these extracurricular activities had chosen to go beyond the required amount of activity. Both of these studies support the notion that utility value is a powerful motivational belief that is applicable to many school classes, even those that are not core subjects.

Similar to the dynamic of interest, both intrinsic and extrinsic factors can influence one's utility value. Deci and Ryan (1987, 2000) claimed that goals can be either intrinsic (e.g., health, happiness) or extrinsic (e.g., wealth, beauty). Therefore, the quality of goals is as strong a motivating factor as their quantity. This concept is known as self-determination theory. Eisenberger, Rhoades, and Cameron (1999) studied self-determination theory in terms of extrinsic goals. While not explicitly stated, the relationship to utility value is that participants believe that completing a task will be useful or beneficial to them in the future. In the Eisenberger et al. study, it was found that paying for the completion of tasks (a type of extrinsic motivation) has a significant direct effect on perceived self-determination, which had a significant direct effect on task enjoyment. Unexpectedly, however, extrinsic utility also had incremental effects on intrinsic motivation. In a more recent study, Vansteenkiste and colleagues (2004) also studied self-determination theory in the context of utility value. In this experimental

study, groups of students were exposed to tasks that were framed them with an intrinsic utility (e.g., satisfaction), an extrinsic goal (e.g., grade), or both types. The findings revealed that framing tasks with both an intrinsic and extrinsic utility decreased stress and increased mastery orientation and performance. From a practical standpoint, the authors stated that “the quality of goals that teachers try to promote matters” (p. 761). Several findings in this study were applied to the present study. First, the method of analysis (MANOVA) was appropriate for the present study because of the multiple variables measured, both categorical (e.g., gender, mathematics course) and continuous (e.g., subjective task value variables). Second, this study provides another example of teachers having an effect on student motivation; that is, teachers have the ability to motivate students in multiple ways; these methods of instilling motivation in students can certainly influence responses on a survey measuring subjective task value. This variety of motivations was considered in the present study by conducting preliminary analysis to measure differences in responses by the students’ teachers, but was also listed as a limitation because of some of the unknown ways in which teachers influenced students.

Although utility value certainly affects achievement, recent literature in utility value has focused on using interventions to increase the extent to which students find a particular task or content useful. For instance, in a high school science classroom, students who kept a journal about why the content they were learning was relevant to them performed better and reported higher interest than those students who did not write in a journal (Hulleman & Harackiewicz, 2009). A similar study was conducted in an undergraduate psychology class, and similar results were found; those who wrote about

how the material was relevant to their lives were more interested in the content by the end of the course than those who did not (Hulleman, Godes, Hendricks, & Harackiewicz, 2010). Canning and Harackiewicz (2015) took these interventions studies one step further and created two types of utility value interventions: directly-communicated and self-generated. They found that in mathematics, directly-communicated utility value can actually damage the interest of students with low mathematics confidence, but self-generated utility value helped all students increase their interest and improve their mathematics performance. The findings of these studies are important because they demonstrate the significance of utility value in the classroom. Not only is it important for students to understand how they can apply learned content outside of the classroom, but having this understanding also fosters stronger feelings of interest within students. This implication for all students indicated that utility value was a useful variable to include in the present study.

As mentioned earlier in Chapter 2, situational interest refers to students' desire to engage in an activity and their beliefs on its meaning in their lives (Durik, Shechter, Noh, Rozek, & Harackiewicz, 2015). Essentially, on the basis of this definition, situational interest encompasses intrinsic value and utility value, two variables within subjective task value. Durik and colleagues (2015) compared two groups of college students who completed multiplication tasks. One group was given utility information about the task; the other group was not. Results showed that the utility information affected students differently; students who had high expectancy benefited from the utility information, whereas students who had low expectancy were impacted negatively by the utility

information. This finding was valid when the dependent variable in the analyses was either overall situational interest or accuracy of the tasks. The findings of this study imply that teachers should attempt to express the usefulness (i.e., utility) of mathematics tasks in the classroom, but also try to increase students' expectations about succeeding in mathematics classes. The findings of the present study reflect a similar implication.

Utility value is often found to be related to mathematics performance and achievement. Guo, Marsh, et al. (2015) found that mathematics utility value and the interaction between mathematics utility value and self-concept both had significant direct effects with mathematics achievement. This finding suggests that even if utility value does not show a direct effect on performance, it can influence other performance-related factors. Penk and Schipolowski (2015) found that utility value had a strong direct effect on reported effort, which had a strong effect on test performance. It has also been found that there are cultural differences in the effects of utility value. For example, for students in East Asia, mathematics achievement was most influenced by *distal* utility value (i.e., value for long-term goals), but for students in Western countries (i.e., Western Europe and the United States), mathematics achievement was most influenced by *proximal* utility value (i.e., value for short-term goals; Shechter, Durik, Miyamoto, & Harackiewicz, 2011). These studies demonstrate that utility value is a vital aspect of predicting mathematics achievement and, therefore, it was included it in the present study to help determine if utility value significantly predicts performance in the classroom and on state mathematics tests.

Comparison of utility value for algebra and geometry. Despite extensive literature on utility value in mathematics, there are no studies that compare students' utility value separately in algebra and geometry courses. However, it is known that all four subjective task value variables (attainment value, intrinsic value, utility value, and cost) are interconnected and correlate with one another (Eccles et al., 1983; Eccles & Wigfield, 2002; Marsh et al., 2005). Given that Lopez and colleagues (1997) found differences in the intrinsic value students assigned to algebra and geometry, utility value also may show a similar relationship given its correlation with intrinsic value. Additionally, when the differing natures of both geometry and Algebra 2 are taken into consideration, the different values students assign to these domains may become clearer. For instance, as mentioned previously, the nature of geometry is visual and spatial (Battista, 2007), allowing students to literally see how the mathematics is applied to a problem. On the other hand, algebra, particularly the topics in Algebra 2, often involve complex functions, formulas, and equations (Kaput, 1998, 2007). These topics have many fewer examples of visual applications in the curriculum (Virginia Department of Education, 2016), which can make it difficult for students to understand how the mathematics will be used in the future. Therefore, these differences in the nature of geometry and algebra may suggest a difference in the level of utility value that students see for the two subjects; the present study tested this hypothesis.

Social utility. As mentioned previously, several subsections of utility exist. Each one of these subconstructs is relevant to the present study because each is a practice feeling or belief that a student may or may not foster for a school subject. Social utility,

in this context, can be defined as the usefulness that students think a subject has for their social life (Gaspard, Dicke, Flunger, Schreier, et al., 2015). No gender differences were found in the social utility results. Overall, in the same study, social utility seemed to be distinct from the other three constructs in that it was more closely related to attainment value, whereas the others were more related to future tasks and goals. This subconstruct is applicable to the present study because the social aspect of the academic setting plays an important role in students' lives.

Utility for school. Utility value is not limited to social constraints. In addition to social utility, utility for school refer to students' belief of how a subject or content will help them in their future academic program (Gaspard, Dicke, Flunger, Schreier, et al., 2015). On the basis of findings from the same study, utility for school has been more strongly correlated with intrinsic value and attainment value than other facets of utility value. Additionally, there were no significant differences in utility for school by gender. Of the four subsections of utility value, utility for school had the lowest mean score. This construct is relevant to the present study, especially for students who are not in their senior year of high school and those who know they will take mathematics courses after high school.

Utility for job. Beyond the classroom, students also have beliefs about the extent to which a particular subject will be used in their occupational lives; these beliefs are known as utility for job (Gaspard, Dicke, Flunger, Schreier, et al., 2015). Utility for job was significantly higher for males than for females in this study. This finding is consistent with those studies that have found that there are differences in utility for job of

those who pursue STEM fields by gender (Wang, 2012; Wang, Degol, & Ye, 2015). Moreover, utility for job had the highest mean of all four subsections of utility value (Gaspard, Dicke, Flunger, Schreier, et al., 2015). Splitting utility into this more specific sets of subconstructs is useful in the present study because of the diverse population in the school where the data was collected and the wide range of post-secondary paths that students typically follow.

Utility for daily life. Another distinct subconstruct within utility value is utility for daily life. This type of utility can be defined as to what extent a subject affects an individual's day-to-day routine outside of school and career (Gaspard, Dicke, Flunger, Schreier, et al., 2015). This specific construct also showed no significant differences by gender. Utility for daily life is relevant to the present study for all students, even those who were not planning to take any more mathematics courses or pursuing a mathematics-related career.

General utility for future life. Finally, general utility for future life has been found to be a distinct subconstruct within utility value (Gaspard, Dicke, Flunger, Schreier, et al., 2015). This variable differs from "utility for daily life" in that general utility for future life implies using a particular skill for a specific future use, whereas utility for daily life implies using a particular skill repeatedly on a daily basis for one or more situations. General utility for future life was found to be higher for males than for females (Gaspard, Dicke, Flunger, Schreier, et al., 2015). This subconstruct is relevant to the present study because it measures students' beliefs about the usefulness of a subject in the long term rather than in the present or in the short term.

Cost. The last of the four main variables in subjective task value is cost. Cost, sometimes referred to as “cost value” (Conley, 2012) or “relative cost” (Eccles et al., 1983), is described as the amount of energy or effort that individuals feel they must exert to complete or be successful at a task (Eccles, 2005; Eccles & Wigfield, 1992, 1995). Every decision, academic or nonacademic, incurs some sort of associated cost (Eccles & Wigfield, 2002). In an academic context, this type of cost refers to what students will have to give up if they are to be successful in a class. Cost is essential within expectancy–value theory. Even though students may see value in a task, cost is another variable that may influence whether they put their full effort into the task (Eccles et al., 1983; Eccles, 1987; Eccles & Wigfield, 2002). Therefore, as a vital component of the theory on which the theoretical framework of the present study was built, it was included as a variable.

Cost has also been shown to impact courses outside of the STEM field. Subjective task value, particularly cost, has been the focus of many studies in the physical education (PE) setting: Chen and Liu (2008, 2009); Chiang, Byrd, and Molin (2011); Chen and Chen (2012); and Zhu and Chen (2013). In all of these studies, the researchers measured subjective task value variables using a survey, but cost was measured by using open ended items, such as, “If you have a choice, would you rather not come to PE? Why?” (Chen & Chen, 2012, p. 297). These answers were scored by using 0 for *no or low cost*, 1 for *moderate cost*, or 2 for *high cost*, and then a composite score was calculated. The results indicated that values for cost were significantly lower than those for the other three subjective task value variables, and that cost was negatively correlated with all physical activity. In addition, students’ levels of cost negatively predict their knowledge

in energy balance, which is a health-related topic. In their discussion of the results, the authors suggested that students' cost beliefs for PE could be "assorted and multidimensional" (Chen & Chen, 2012, p. 306), which means that they are influenced by beliefs about other school subjects, as well as social pressures. This suggestion is relevant to the present study because if what Chen and Chen claim is true, then students' beliefs about cost may be influenced by other subjects. I took this possibility into consideration when discussing and reporting the results of the present study.

In an effort to comprehend cost further, recent literature has included qualitative explorations of cost, an approach that contrasts with the traditional quantitative understanding of cost. Building on previous qualitative studies of cost (Chen & Liu, 2009; Watkinson, Dwyer, & Nielsen, 2005), Flake, Barron, Hulleman, McCoach, and Welsh (2015) categorized cost into four different facets: task effort cost, outside effort cost, loss of valued alternatives cost, and emotional cost. Although these exact subconstructs were not used for the present study, it is important to recognize that cost is multilayered and many recent studies have suggested measuring separate aspects of cost (Flake et al., 2015; Gaspard, Dicke, Flunger, Brisson, et al., 2015; Gaspard, Dicke, Flunger, Schreier, et al., 2015; Perez, Cromley, & Kaplan, 2014). Therefore, these guidelines were followed in the present study, and several variations of the cost construct were measured.

Despite its exclusion from many subjective task value studies, cost has been shown to influence academic-related behaviors, including achievement. Perez, Cromley, and Kaplan (2014) found that in an undergraduate chemistry course, low levels of cost

were correlated with high achievement in the class. Additionally, in that same study, the authors found that students with low cost were less likely to drop out of STEM majors. The same findings exist in adolescent students. In the middle school classroom, students' low cost beliefs correlated with high achievement in both mathematics and science. Furthermore, cost beliefs in mathematics were found to be highly correlated with cost beliefs in science (Kosovich, Hulleman, Barron, & Getty, 2015). Similarly, Conley (2012) found that students with low cost beliefs outperformed students in middle school mathematics with high cost beliefs. Moreover, Conley found that low cost was associated with a positive effect (i.e., a positive feeling or enjoyment) toward mathematics, whereas high cost is associated with a negative effect (i.e., irritation or a bad mood) toward mathematics. Although cost is not often included in studies that use subjective task value, these examples show that cost is an important part of the theoretical framework of the present study, and were, therefore, included in the measure.

Comparison of cost for algebra and geometry. As mentioned previously, findings in the literature suggest there are differences in subjective task value, including cost, between geometry and algebra. Lopez et al. (1997) studied cost and other expectancy–value variables for samples of algebra and geometry students. Cost was found to be overall higher for geometry students than for algebra students. The authors also found that cost more strongly correlated with standardized test achievement in geometry than in algebra (Lopez et al., 1997). Despite this useful comparison, the authors did not measure all factors within the Eccles et al. (1983) model of expectancy–value theory, which is what the present study did to extend these findings.

Effort required. As with utility value, there are also several distinct constructs that describe different aspects of cost. Perez et al. (2014) outlined three similar but separate constructs within cost which were used in the present study: effort required, emotional cost, and opportunity. Also known as *perceived exhaustion*, effort required is defined as how tired, exhausted, or drained a student feels after performing a task or working in a subject (Gaspard, Dicke, Flunger, Schreier, et al., 2015). In the same study, females were found to have significantly higher levels of “perceived exhaustion” than males. Intrinsic value (i.e., personal interest) was found to be highly correlated with effort required as well. Including effort required in the present study is worthwhile, particularly because students often feel exhausted in response to the pressure on them over standardized testing (Herman, Abedi, & Golan, 1994).

Emotional cost. A second subsection of cost is how anxious, annoyed, or worried students believe that a certain subject makes them (Gaspard, Dicke, Flunger, Schreier, et al., 2015; Flake et al., 2015). This construct, known as emotional cost, highlights students’ emotions, as opposed to time or effort put into a task or course. Like effort required, emotional cost was found to be significantly lower for males than for females. Gaspard, Dicke, Flunger, Schreier, et al. (2015) stated that intrinsic value and emotional cost are highly interrelated, which is consistent with the literature (Pekrun, Goetz, Barchfeld, & Perry, 2011). As expected, emotional cost was negatively correlated with all other subjective task value variables included in this study except for all other cost constructs (Gaspard, Dicke, Flunger, Schreier, et al., 2015). Emotional cost is an

important belief to include in the present study because it measures an aspect of cost not accounted for by effort and opportunity.

Opportunity cost. Finally, opportunity cost is a third, separate type of cost distinct from effort required and emotional cost. Opportunity cost, which can also be called *loss of valued alternatives* (Flake et al., 2015), refers to the amount that students feel they would need to sacrifice other activities to be successful in a class or subject (Gaspard, Dicke, Flunger, Schreier, et al., 2015). This aspect of cost has been used in most recent high-school related studies (Conley, 2012; Trautwein et al., 2012). In the Gaspard, Dicke, Flunger, Schreier, et al. (2015) study, there was no difference in opportunity cost between males and females. In the present study, opportunity cost is relevant because many students in the sample were involved with extracurricular activities at the time of the study and were aware of how these particular courses interacted with their clubs, sports, and other obligations outside of the classroom.

Interconnectedness of subjective task value constructs. In mathematics and other subjects, students can assign different value to utility value and other subjective task value variables inside and outside of the classroom. For example, Tossavainen and Juvonen (2015) compared students' views of interest (i.e., intrinsic value), importance (i.e., attainment value) and usefulness (i.e., utility value) of mathematics and music inside and outside the school setting. The researchers also measured these variables from Grade 5 through Grade 12. Data analysis revealed that for both mathematics and music, all subjective task value variables peaked at Grade 5. In terms of interest, music interest consistently exceeded mathematics interest, both inside and outside of the classroom.

Additionally, interest in music was higher outside the classroom than inside the classroom, whereas interest in mathematics was higher inside the classroom than outside the classroom. When students compared mathematics with music, they saw greater usefulness and importance in mathematics, but had higher levels of interest and enjoyment in music (Tossavainen & Juvonen, 2015). There are many takeaways from this study that relate to the present study. First, the researchers separated results by grade level and found significant differences in motivation in both subjects by grade level. The present study, therefore, tested differences by grade level, even though comparisons were made within the same course. Second, the inclusion of several subjective task value constructs and the differences found within them justify the inclusion of these variables in the present study. Third, the differences between student motivation for mathematics and music support the idea of different motivation for different courses, which was tested in the present study.

Although each aspect of subjective task value is distinct (Eccles et al., 1983; Luttrell et al., 2010), the variables discussed thus far (attainment value, utility value, and interest) are all interconnected. Eccles and Wigfield (2002) have proposed that all three of these variables are intrinsic and that changes in one variable can result in a change in another. This phenomenon is particularly true of high-ability mathematics students. Andersen and Cross (2014) examined the subjective task value beliefs of low- and high-achieving students and found that all three variables were positively and significantly correlated. Additionally, the authors found that most high-achieving students were above average in terms of utility, attainment, and interest values. Furthermore, Wang, Degol,

and Ye (2015) found that these values played a vital role in the relationship between gender and STEM careers. Additionally, although gender itself is not a significant predictor of whether a student will pursue a STEM field, task value (consisting of utility, attainment, and interest) fully mediates this relationship. In addition, females often perceive barriers in pursuing STEM fields, even when there are no actual barriers preventing them from doing so (Fouad et al., 2010). The findings of these studies support my belief about the implications of the present study. Although these studies do not specify that having high value beliefs *causes* high achievement, they highlight the profiles of high-achieving students and how they view mathematics and mathematics-related career fields.

Although cost is often grouped in with the other three main subjective task value variables (i.e., attainment value, utility value, and intrinsic value), cost has been described as being different than the others in terms of the nature of the variable. Eccles and Wigfield (1995) have described the label “cost” as having a negative connotation, whereas the other three variables each with the word “value” in the label can be seen as measuring students’ positive beliefs. Wigfield and Cambria (2010) have argued that these connotations are why, in recent literature, cost has often been neglected in studies in which the theoretical framework is based in expectancy–value theory (Conley, 2012). Cost has even been described as the “forgotten component of expectancy–value theory” (Flake et al., 2015, p. 232). However, over the past decade, many more studies have focused on cost, its impact on student achievement, and its role within expectancy–value theory.

Summary of four subjective task value variables. The four main variables of subjective task value—attainment value, intrinsic value, utility value, and cost—provide an extensive description of how students view educational subjects and how those beliefs affect their achievement. Each one of these constructs are intricate in nature, in that there are sub-categories that measure distinct types of beliefs for students (Gaspard, Dicke, Flunger, Brisson, et al., 2015; Gaspard, Dicke, Flunger, Schreier, et al., 2015). To reiterate, the purpose of the present study was to determine if students’ motivational beliefs influenced their classroom and SOL performance for different mathematics courses. I believe that the four variables outlined in this section provide the best description for the motivation measured in the present study and, thus, each construct and subconstruct written in this section was measured in a survey.

Expectations of success. A student’s belief of how complicated a certain subject or assignment is can be referred to as expectation of success, or *expectancy* (Midgley et al., 1989). Students’ expectations of a task impact their motivation and, thus, their achievement. Midgley et al. also used *perceived task difficulty* as a synonym for expectancy, but often use expectancy because the word has a positive connotation. Expectancy was another main factor explored early in the formation of expectancy–value theory by Atkinson (1957) and Battle (1965, 1966). Atkinson defined expectancy as a “cognitive anticipation” (p. 360) of performance on a task on the basis of certain factors, such as setting and prior achievement. Expectancy was also considered to be one of Atkinson’s three components that make up motivation, along with motive and incentive. Battle (1965, 1966) supported Atkinson’s work and often used the term with student

goals. For instance, Battle (1965) argued that students whose goals were consistent with their expectations often displayed moderate to high motivation, but students whose goals were higher than their expectations had little motivation because they often had little possibility of success. Another early definition of expectancy is the subjective probability that the task will result in success or failure (Karabenick & Youssef, 1968). Eccles and Wigfield (1992, 1995) expanded the work on expectancy in their revival and establishment of expectancy–value theory (Eccles et al., 1983), but established a slightly different definition from that of Atkinson (1957) and Battle (1965, 1966). Instead of outcome expectations, Wigfield and Eccles (2000) stated that their studies have focused more on students’ own expectancy of success. Furthermore, expectancy was found to be distinct from interest, attainment value, utility value, and cost (Watt, 2004; Simzar et al., 2015). These studies of expectancy which have spanned decades demonstrate the importance of expectancy in the context of expectancy–value theory, which is the foundational theory of the present study.

As mentioned previously, many motivational constructs are strongly correlated with one another. Fulmer and Tulis (2013) analyzed the interest and perceived difficulty of middle school with respect to a difficult reading. These two variables were measured before, during, and after the task. The results of the study showed that interest was not significantly correlated with perceived difficulty until the final interest measure after the reading, which, at that point, was negatively correlated. The researchers also measured affect, which was defined in the study as a spectrum of positive and negative emotions (Fulmer & Tulis, 2013). The study found that situational affect, which was defined as a

student's emotional response to a particular task, was significantly correlated with perceived task difficulty during and after the task, but not before it (Fulmer & Tulis, 2013). Not only did the researchers introduce an interesting concept of measuring motivational variables at different times during a task, but they also supported prior research that these variables were positively correlated. Senko and Harackiewicz (2005) carried out a similar study, which compared interest with not only perceived task difficulty but also with the variable of introduced perceived goal difficulty, which was defined as the extent to which students believed they could achieve goals that they set for themselves. The researchers found that perceived goal difficulty was a mediating variable between several other motivational constructs (Senko & Harackiewicz, 2005). In a similar study, Penk and Schipolowski (2015) distinguished the effects of high value and high expectancy. The authors concluded that expectancy had a strong direct effect on test performance, but value did not; rather, value had a more significant effect on *effort* than on performance. These findings support the claims that both expectancy and value are significant in predicting test and classroom performance.

Outside of a classroom setting, expectancy is also applicable to jobs and careers. Brooks and Betz (1990) surveyed undergraduate psychology students who completed the necessary academic requirements for jobs such as dentist or nurse. The researchers looked at four aspects of expectancy: expectations of completing the course, expectations of getting a job in the field, expectancy of being able to successfully do the job, and expectations of advancing in the career. The results revealed that expectancy and valence (i.e., attractiveness) of the job were the two strongest factors in likelihood of choosing a

career. Furthermore, the analysis indicated that males were significantly more likely to have high expectancy for “male-dominated occupations” (e.g., engineer, manager), and females were significantly more likely to have high expectancy for “female-dominated occupations” (e.g., social worker, secretary). The findings of this study show that the belief of expectancy goes beyond an academic setting and also stays with a person throughout his or her occupational career. This study is relevant to the present study because STEM fields are typically considered male-dominated fields (Fouad et al., 2010; Wang, 2012), and findings indicate that stereotypes may influence students’ beliefs in the mathematics classroom.

Similar to the studies done on attainment value, research suggests that there are gender differences in mathematics expectancies. Parsons, Adler, and Meece (1984) conducted a groundbreaking study that compared differences in motivational factors between gender and subject (English and mathematics). Results showed that all students, regardless of gender, perceived mathematics as more difficult than English. However, despite this significant difference between subjects, there was very little difference in perceived task difficulty by gender (Parsons et al., 1984). Although this study was designed well and had measures relevant to the present study, it was conducted more than 30 years ago, so it should be replicated to analyze present-day implications. Else-Quest et al., (2013) studied the interaction between ethnicity and gender with respect to mathematics expectancy. Although the interaction effect between ethnicity and gender was not significant, the results showed significant differences in expectancy for males and females across all ethnicities. This finding is critical for the present study because of

the diversity of the present sample; as a result, I measured ethnicity as a demographic in the present study.

Comparison of motivations for algebra and geometry. Based on the literature discussed above, it is apparent that many factors influence a student's motivation, particularly those defined by expectancy–value theory. Despite the extensive research on motivational factors, there is no such literature examining and comparing the differences in student motivation for algebra and geometry. In a study by Simzar and colleagues (2015), students in both Algebra 1 and geometry were asked about their beliefs about *mathematics*, but not specifically the subject in which they were enrolled. Therefore, no conclusions can be drawn about motivational beliefs in each mathematics course individually on the basis of this study. My intention was to fill this gap by asking geometry students to record their subjective task value beliefs specifically about geometry and by asking Algebra 2 students to record their subjective task value beliefs specifically about Algebra 2 and comparing then the responses.

Because there are no single studies that compare motivation in algebra and geometry, it is necessary to look at the literature for each content area individually and make comparisons based on their findings. Prior research has shown that students become less motivated and interested in mathematics when mathematical variables are introduced in pre-algebra (Middleton, 2013). Thus, if a mathematical concept has been shown to impact students' motivation before an introductory algebra course, it is necessary to look at the content beyond pre-algebra to determine if motivation is affected at any other point in the mathematics curriculum. Several studies have found that the

factors that motivate students in algebra are similar to those that are defined as subjective task value in the present study. For instance, Nguyen (2015) studied motivation in a group of students in a community college algebra class. His definition of motivation was based on four characteristics: attention, relevance, confidence, and satisfaction. On the basis of the survey items he administered, these variables seem to correspond with subjective task value. For instance, one item for relevance was: “The things I am learning in this course will be useful to me” (p. 697). This statement is similar to the definition of utility value (Eccles & Wigfield, 1992; Gaspard, Dicke, Flunger, Brisson, et al., 2015; Gaspard, Dicke, Flunger, Schreier, et al., 2015; Skouras, 2014). Attention items (e.g., “I feel curious about the subject matter”) seemed to match those of intrinsic value items (Gaspard, Dicke, Flunger, Brisson, et al., 2015; Gaspard, Dicke, Flunger, Schreier, et al., 2015; Mitchell, 1993). The results of this study indicated that relevance and attention were both significant predictors of satisfaction of the course but that relevance was a stronger predictor (Nguyen, 2015). While the finding is useful to show that certain subjective task value variables play a role in an algebra course, it does not indicate to what extent these beliefs affect achievement in algebra. Additionally, the sample was made up of college students, and the findings may not be generalizable to high school students. The present study attempted to bridge these gaps and further explore the impact of these beliefs specifically on algebra.

Another study that supports the findings of Nguyen (2015) focuses on one class of struggling Algebra 1 students in the state of Michigan. Geno (2010) created an intervention for students who had failed Algebra 1 by using students’ interests (i.e.,

intrinsic value) and relevancy (i.e., utility). During this intervention, teachers emphasized the application of the content the students were learning and also took the students on field trips to local colleges to show how performing well in Algebra 1 would translate to success after school. At the end of the year, the class had an 88% passing rate on the end-of-the-year state standardized mathematics assessment. Of the students that failed, three out of four were only short a few percentage points. Whereas Nguyen measured students' satisfaction in algebra, the dependent variable that Geno (2010) used was the same as that used in the present study: mathematics achievement. Furthermore, the emphasis on interest and utility value in the intervention suggests that increasing these values will lead to improved performance in algebra.

These two examples demonstrate the importance of motivational beliefs in algebra classes, but there is no current research on how subjective task value impacts a geometry course. In fact, the findings from studies that have explored motivation in geometry differ from findings in research that focused on motivation algebra. For example, Burger and Shaughnessy (1986) studied geometry motivation in students spanning first through 12th grades. The study revealed that the amount of geometry present and the age of the students when the geometry was presented influenced motivation throughout the academic careers of the students in the sample; in other words, if students are introduced to certain geometric topics early in elementary school, then they are able to move through the van Hiele levels of cognition (discussed previously) more quickly, and thus they develop more appreciation for the content. Another study produced similar results and also included references to the van Hiele levels. Halat et al.

(2008) conducted an experimental study with sixth grade mathematics students learning geometry content. The control group learned geometry the traditional way, while the treatment group was taught by using a “reform” curriculum in which students inductively solve problems that are based on the van Hiele theory. The results showed that the reform-based problems elicited more motivation from students than the traditional problems. Both studies suggest that the content itself, rather than the relevance or appeal of the problems, tended to motivate students in geometry. This finding is drastically different from findings of the studies in algebra motivation, which have stated that utility and interest were the biggest motivating factors in the subject. A goal of the present study is to determine how this finding compares with this literature in a unique comparison between expectancy–value factors in geometry and Algebra 2 classes.

Although there is a deficiency of studies comparing algebra and geometry in the literature on motivation, the cognitive features of the subjects themselves can lead to motivational differences. For instance, as described previously, Halat and colleagues (2008) and Burger and Shaughnessy (1986) both described the idea of student motivation being influenced by the content and the rate at which they cognitively develop through the stages (i.e., van Hiele levels) of geometry. Because algebra and geometry have fundamental cognitive differences (as described earlier in this chapter), it must follow that algebra motivation must have a different format. In addition, the algebra literature present here suggests that relevance (i.e., utility) and interest were strong motivating factors, which was not the main finding of geometry literature. These arguments are the

rationale for measuring subjective task value of both geometry and Algebra 2 students and comparing the results.

Summary of expectancy–value theory. Overall, expectancy–value theory research provides compelling evidence that motivational factors should be considered just as seriously as cognitive factors when achievement on standardized state mathematics tests and in classrooms is measured. Social cognitive theory research suggests that behavior, environmental, and personal factors influence success as much as cognitive factors. As a result, research should be focused as much on fostering this type of motivation as on understanding the cognitive processes of students. The present study focused on the motivational aspects of student learning.

Gender

Along with motivational factors, one variable that has often been shown to produce differences in mathematics achievement is gender. Gender has been studied extensively in mathematics achievement as it relates to expectancy–value theory (Eccles et al., 1983; Eccles & Wigfield, 1992, 1995). Additionally, gender differences have been found to exist with respect to the use of technology and computer-based assessments (Barkatsas, Kasimatis, & Gialamas, 2009). These connections to other variables within the current framework make gender a relevant part of the present study.

Gender and motivational factors. In much of the expectancy–value theory section of this paper, literature was summarized that showed gender differences in attainment value, intrinsic value, utility value, and cost. For example, several studies have found significant differences between males and females in all four of these variables in

the context of mathematics (Gaspard, Dicke, Flunger, Brisson, et al., 2015; Gaspard, Dicke, Flunger, Schreier, et al., 2015; Guo, Marsh, et al., 2015; Guo, Parker, et al., 2015). In another example, Watt and colleagues (2012) also studied gender differences in expectancy–value motivation, but compared the results across three countries: Australia, Canada, and the United States. Students participating in this study were enrolled in a high school mathematics course. In Australia, females displayed significantly lower intrinsic value than males, while in Canada and the United States, females displayed significantly lower expectancy than males. Moreover, in Australia and Canada, utility value and attainment value predicted females’ pursuit of mathematics careers, whereas in the United States, there was no such direct effect. This difference suggests the interaction between ethnicity and gender in mathematics beliefs and justifies the inclusion of both variables in the present study.

Furthermore, as described previously, the four main subjective task value variables can be separated into subconstructs. Within these subconstructs, several gender differences can be found. Gaspard, Dicke, Flunger, Schreier, et al. (2015) found that males reported higher levels of personal importance (a sub-construct of attainment value) and utility for job (a subconstruct of utility value), whereas females reported higher levels of effort required and emotional cost (two subconstructs of cost). Wang et al. (2015) asserted that gender differences by attainment value, personal interest, and utility value caused significant difference in males’ and females’ career paths. They revealed that these three constructs were all mediating variables between gender and STEM career aspirations. In particular, utility value was the strongest mediator; this finding is

consistent with the very definition of utility value, which is how useful a task will be for one's future goals. Overall, the many studies that report gender differences in subjective task value support the inclusion of this variable in the present study.

One explanation that attempts to address the motivational differences in gender is stereotype threat. Stereotype threat can be defined as the implicit or explicit belief that one group of people (e.g., defined by race or gender) is more capable of completing a task than another (Steele & Aronson, 1995). In the present study, stereotype threat will refer to the threat that exists between genders; that is, the preconceived notion that males outperform females in mathematics. Stoet and Geary (2012) conducted a meta-analysis of studies that measured gender stereotype threat in mathematics. The authors found that there was a cumulative and significant difference between threat and nonthreat groups across all studies. In a later study, Guo, Marsh, et al. (2015) attempted to use subjective task value to explain the gender achievement gap. Guo and his colleagues found that subjective task value variables were mediating variables between gender and mathematics achievement. Additionally, motivational factors may also contribute to this difference. The authors state that "boys are likely to have higher math self-concept, which leads to higher math achievement" (p. 166). Plante, de la Sablonniere, Aronson, and Theoret (2013) expanded on this literature and explored the relationship between gender stereotypes, task value, and classroom performance in mathematics. Although the task value variable was a general measure (i.e., not specifically utility or attainment value), the results showed different results for males and females. For both genders, task value mediated the relationship between gender stereotype and current school

performance, but for males, the gender stereotype had a significant direct effect on classroom performance. These examples show the relationship between educational psychology factors and gender, which the present study attempted to investigate further.

Although many studies have shown gender differences in certain aspects of expectancy–value theory, there are also many findings that did not show any gender differences in this area. For instance, in the same study that reported differences in the four subconstructs, Gaspard, Dicke, Flunger, Schreier, et al. (2015) found no significant differences in utility for school, utility for job, importance of achievement, and opportunity cost. Furthermore, even when significant differences were found by gender, many authors reported a small effect size for this difference (Parsons et al., 1984; Pekrun et al., 2011; Wang, 2012). This inconsistency with other studies is noteworthy and suggests that there are other confounding factors playing into the relationship between gender and expectancy–value.

Gender and mathematics achievement. Gender differences are also important to analyze when it comes to standardized mathematics assessments. Much research has been done on how males and females perform on mathematics tests, particularly standardized assessments. Some studies have shown that there are, in fact, differences in achievement on standardized tests by gender. Liu and Wilson (2009) stated that on many large-scale mathematics assessments, such as the SAT exam, males typically outperformed females. However, their research of the Programme of International Student Assessment (PISA) data in 2000 and 2003 showed that there was no strong correlation between gender and achievement on certain question types (Liu & Wilson, 2009). Hoffman and Spatariu

(2008) also studied mathematics problem solving using a sample of undergraduate students. They found no significant differences between males and females in terms of problem solving accuracy and efficiency (Hoffman & Spatariu, 2008). Finally, Hyde, Lindberg, Linn, Ellis, and Williams (2008) showed that across 10 different state standardized mathematics tests, there were no significant differences between males and females on achievement. Furthermore, this finding was consistent across grade level; no state showed any differences at Grade 8, 10, or 12 (Scafidi & Bui, 2010). The last two studies mentioned are particularly relevant to the present study because the researchers look at state standardized tests, which is what was used as a measure in the present study, instead of a national mathematics assessment. Thus, standardized tests are a sufficient way of measuring and comparing mathematics achievement across other variables in the present study.

Other studies have found that there are significant differences in mathematics standardized test achievement between males and females. A study by Keller (2012) looked at the relationship between gender and achievement on the SAT and ACT exams, which are nationally used college entrance exams. Between 1997 and 2010, although the test scores of both males and females increased slightly over time, males consistently scored significantly higher than females (Keller, 2012). This study supports the findings of a study by Kaufman et al. (2009), who three years earlier, had found that males earned higher scores than females did in mathematics achievement on a standardized test, despite the fact that there was no significant difference between genders regarding fluid or crystallized intelligence. This inconsistency in the studies drives the need for further

and deeper research into whether there are gender differences in mathematics achievement, such as investigating whether these differences differ by specific mathematics topic.

It is important to distinguish between gender performance on standardized tests and in the classroom. Kimura (2000) made this distinction by claiming that whereas girls typically get higher classroom grades than boys, they get lower grades on mathematics aptitude tests. One possible explanation for this difference is in students approach to classroom performance. Gherasim, Butnaru, and Mairean (2013) stated that males were more likely to display performance-avoidance goals (i.e., attempting to do as little work as necessary to pass), whereas females were more likely to display performance-approach goals (i.e., having a more goal-oriented mindset instead of avoiding work). Findings from another study supported this claim and the notion that this phenomenon resulted from a female personality trait, conscientiousness, that creates a stronger desire in females to do well; thus, the interaction between this personality trait and gender significantly affect mathematics achievement at the secondary level (Peklaj et al., 2015). I believe that the findings in these studies make sense in the context of the present study; although males may perform better on a single standardized test, the persistence and conscientiousness of females allows them to perform better in a classroom setting, which extends over the entire school year.

Gender differences in geometry and algebra. Many of the studies outlined above have compared mathematics achievement by gender, but do not specify the type of mathematics. There are, however, select studies in which gender differences in algebra

and geometry have been specifically addressed. In geometry, achievement has been found to differ between males and females. In a study very relevant to the present study, Erdogan, Baloglu, and Kesici (2011) conducted a study with a sample of 200 high school students and determined that women scored significantly higher on a geometry assessment than men. Surprisingly, this was true even though males reported higher levels of self-efficacy beliefs and application of geometry knowledge (which, as defined by the authors, coincides with utility value). The authors also compared students' results on what the term a "mathematics" assessment that was distinct from the geometry assessment, but it was unclear what this mathematics content was and how it differed from geometry. In this comparison, females showed no significant differences between achievement in the two assessments, but males scored significantly higher in geometry than in "mathematics." If the authors were referring to "mathematics" as algebra, then the findings in this study are very important because they provide a basis for comparing data achievement in Algebra 2 and geometry.

There is also evidence that certain topics within the geometry curriculum can reflect gender differences in achievement. For example, in a study of high school geometry students, females scored significantly higher on items that asked about geometric reasoning and logic. These topics included true or false statements, and the inverse and converse of these statements. However, males scored significantly higher on questions that required spatial thinking. These questions include properties of shapes and three-dimensional shapes (Pattison & Grieve, 1984). Casey, Pezaris, and Nuttall (1992) measured differences by gender in achievement in mathematics involving spatial

reasoning, which can be classified as geometry. The authors reported that although they found no significant differences in achievement, a separate spatial ability measure was collected and showed some differences. This spatial ability measure accounted for no variance when predicting female mathematics achievement, but it accounted for a significant amount of variance in predicting males' mathematics achievement. According to the authors, this suggests that males and females are solving the same problems using different methods (Casey, et al., 1992). Although these studies are slightly outdated, they provide evidence of gender differences in achievement in certain mathematics topics.

Many studies have also found that the way in which geometry is taught in the classroom can also result in differences in gender achievement and motivational beliefs. Achor, Imoko, and Ajai (2010) conducted an experimental study to determine if secondary students' achievement and interest would improve if games and simulations were used to teach geometry. Their findings revealed that students in the experimental group (i.e., those who learned using games and simulations) scored significantly higher than those in the control group (i.e., those who learned geometry in the traditional fashion). In terms of gender, there were no differences in achievement in the experimental group, but males reported significantly higher levels of interest than females in the material. Results differed in the control group, in which there were no differences in interest or achievement by gender. These results were supported by Yang and Chen (2010), who also found that differences in achievement between males and females decreased when geometry was taught by using games. The finding about differences in interest by gender suggests that in certain contexts, the specific mathematics course (e.g.,

geometry or algebra) could be a factor causing subjective task value to differ between males and females.

Despite the extensive literature on the effects of gender differences on achievement in geometry, there are fewer studies about these differences with respect to achievement in algebra. One relevant study compares the achievement in algebra of more than 400 Greek high school students. In this study, the authors found no significant gender differences in algebra achievement. Additionally, there were no differences in attitude toward mathematics, which was defined by a mix of questions that included interest in mathematics and the usefulness of the content in the students' future (similar to the definition of utility value). The authors reported no significant differences in attitudes by gender (Skouras, 2014). This finding is intriguing because, considering the literature on geometry achievement as well, there seems to be no differences between the achievement males and females in any specific mathematics course. However, discussion earlier in this chapter covered the literature demonstrating that inconsistent findings exist when it comes to gender in mathematics achievement. Additionally, to date, no researchers have carried out a study comparing gender differences in both algebra and geometry. Therefore, further research is needed to further understand the nature of algebra and geometry achievement for both males and females.

Gender and mathematics technology. Technology can also play a role in the differences both in achievement and motivation between genders. Barkatsas et al., (2009) used the Mathematics and Technology Attitudes Scale (MTAS) to track motivation and attitudes toward using technology to perform mathematics. The study found that students

who were comfortable with technology performed better on classwork and other mathematics assignments. Furthermore, the results also distinguished between genders. Males were more likely to be on either end of the motivation and achievement spectrum than females. All students, however, were open to using technology, and the discussion concluded that technology was a positive mathematical tool (Barkatsas et al., 2009). This finding is particularly relevant to the present study not only because the SOL is taken on the computer, but also because several teachers in the participating school have tried to incorporate technology into lessons across several mathematics courses.

In summary, research into the effects of gender on achievement in mathematics is incorporated into all other topics of the present study. Previous literature has demonstrated that there are gender differences in motivation, mathematics achievement, and technology use, among others. The final research question of the present study asks if student subjective task value, performance on standardized tests and classroom grades, and achievement differ by mathematics course. This question is justified on the basis of the literature and supports including a question asking the participant's gender on the survey and in the analysis.

Gaps in the Literature and Conclusion

The literature discussed in this chapter includes studies that informed the present study. Studies on algebraic and geometric thinking emphasize the similarities and differences between the nature of algebra and geometry, which are an essential part of the proposed study. Additionally, there is a need for a comparison of standardized assessments and classroom grades for these two mathematics subjects. In terms of

motivational factors, the literature on expectancy–value theory, particularly by Eccles and colleagues (1983), provides justification for including measures of attainment value, utility value, intrinsic value, and cost in the present study. Finally, the numerous studies on how gender differences affect achievement, especially in mathematics, validate the inclusion of the asking students’ their gender in the present study.

Despite this extensive literature, there are several gaps in the literature that the present study has attempted to fill. First, while many studies have shown that motivational factors, particularly those outlined in expectancy–value theory, influence student achievement (Eccles & Wigfield, 1992, 1995; Farrington et al., 2012), and these studies have been restricted to subject-specific results. There are currently no studies on how expectancy–value factors impact achievement in algebra or geometry differently. The present study has attempted to fill that gap by measuring students’ beliefs for both geometry and Algebra 2 on the basis of several expectancy–value factors included in the Eccles et al. (1983) model. Second, it has been reported in the literature and reflected in statistics that there are significant differences in the passing rates of state standardized tests by specific mathematics course (Simzar et al., 2015; Virginia Department of Education, 2016). However, there are no studies that have explored the interaction between state standardized test scores, classroom grades, and mathematics course. The analysis performed in the present study will help lead to an understand the effect of geometry and Algebra 2 on classroom and SOL performance. Finally, while many studies have shown that males and females show differences in standardized test performance and classroom tests (Liu & Wilson, 2009; Hoffman & Spataru, 2008; Hyde et al., 2008),

there are no recent studies that explore whether algebra and geometry content results in different grades or assessments on the basis of gender. The results of the present study are an attempt to fill these gaps in the literature.

In Chapter 3 of this paper, I provided an outline of the present study. The goal of the study is to determine if there are differences in expectancy–value factors, classroom grades, SOL achievement, and performance by gender by mathematics class (e.g., geometry and Algebra 2). The participants, methods, and analyses were chosen to address the gap in the literature and give educators and researchers information in the mathematics and motivational fields.

Chapter Three

Research Questions and Design

The purpose of the study was to explore the relationship among expectancy–value factors, classroom grades, high-stakes assessment achievement, and gender for specific mathematics courses by addressing the following research questions:

1. To what extent do expectancy–value beliefs predict achievement on high-stakes mathematics assessments and classroom grades?
2. Is there a main effect of type of mathematics course (e.g., geometry, Algebra 2), main effect of gender, and an interaction effect between gender and type of mathematics course on expectancy–value factors (i.e., cultural milieu, child’s perception, stable child, previous achievement, child’s goals and general self-schemata, child’s interpretations of experience, expectation of success, subjective task value)?

As the basis of the type of research questions, a correlational approach was chosen for the present study. Students were not presented with an intervention, nor were they assigned to one of two or more groups; therefore, the study was neither experimental nor quasi-experimental. Furthermore, the analyses for this study were conducted

quantitatively, because the research questions were used to make predictions and calculate differences.

Participants

The sample size for the study before removing outliers was 340 high school students: approximately 147 students enrolled in on-level (i.e., not honors, remedial, or below-level) Algebra 2 and 193 students enrolled in on-level geometry. This selection criterion was used because students answered items about their beliefs about the course in which they were enrolled at the time of the study. Additionally, I only included students in an on-level geometry or Algebra 2 course in an attempt to minimize differences in skill levels, curriculum, and pacing. Students in the study were attending a large suburban school district during the 2016–2017 school year. Convenience sampling was used because I was a high school mathematics teacher at the time of the study. The 340 students came from eight geometry classes and seven Algebra 2 classes at the school where I was teaching at the time of the study. Eight teachers taught the 15 total classes: five geometry teachers and three Algebra 2 teachers. The years of teaching experience for these teachers of the participating students ranged from two to 20 years. All five geometry teachers followed the same pacing for the same curriculum, and all three Algebra 2 teachers followed the same pacing for the same curriculum; this congruity decreased the effect of teacher as a confounding variable on the results because all teachers taught the same amount of material at relatively the same rate. The present study was fully explained to the teachers of the participants, and they agreed to help in the data collection process and allow their students to participate in the study.

The sample consisted of approximately 139 females and 161 males. The ages of the students at the time of the study ranged from fifteen years to nineteen years. The ethnicity of the students was similar to that of the school demographic: about 34% Hispanic, 26% Asian, 24% Caucasian (not of Hispanic origin), and 18% African American (not of Hispanic origin). From the sample, 16 students had limited English proficiency and about 55% of students received free or reduced lunch on a daily basis. The school at which the data were collected, which consists of students in 9th through 12th grades, is a public school within a large, diverse, suburban community. The school had approximately 2,400 students at the time of the study, and the ethnicity of the students in the sample generally reflected the student body as a whole (source not cited to ensure confidentiality).

Measure

The measure that students completed included the factors described in the Eccles et al. (1983) expectancy–value theory model and the variables within each factor. Table 1 lists the variable measured, how they fit within the model, and how they are defined in the context of the present study. Table 2 lists the source of the items for each scale, as well as the reliability coefficients in the original study from which the items were retrieved.

Table 1

Measure Variables

Variable	Context	Factor in Eccles et al. (1983) model
Age	Age at the time of the study	Child characteristics
Grade	Grade level at the time of the study, as defined by the school	Child characteristics
Gender	Male or female	Child characteristics (child gender)
Ethnicity	Caucasian, African American, Asian-American, Hispanic, or Other	Cultural milieu (family demographics)
ESOL status	Whether student was enrolled at the time of the study in an English for Speakers of Other Languages (ESOL) course	Cultural milieu (family demographics)
Repeater status	Whether student failed the current course last year and is taking it again	Previous achievement-related experiences
Teacher	Teacher of course student was taking at time of the study	N/A (information used in preliminary analysis)
Short-term goals	What the student hoped to score on the SOL and to achieve for the overall classroom grade for the course they were taking at the time of the study	Child's goals and general self-schemata (short-term goals)
Long-term goals	Extent to which student hoped to use course material in future academics and career	Child's goals and general self-schemata (long-term goals)

Table 1 Continued

Variable	Context	Factor in Eccles et al. (1983) model
Expectation of success	Final classroom grade and score on standardized test student hoped to achieve	Expectation of success
Academic self-concept	Extent to which students believe they can perform well in their mathematics class	Child's goals and general self-schemata (self-concept of one's abilities)
Gender stereotype beliefs	Extent to which students believed achievement differed by gender in the class they were taking at the time of the study	Child's perception of gender roles
Intrinsic value	Extent to which students were interested in the material in the class they were taking at the time of the study	Subjective task value (interest–enjoyment value)
Attainment value	Extent to which students valued high marks in their mathematics course at the time of the study	Subjective task value (attainment value)
Utility value	Extent to which students believed geometry (or Algebra 2) would be useful in a career or future academic class	Subjective task value (utility value)
Cost	Amount of work or effort students felt was needed to achieve success in the mathematics class they were taking at the time of the study	Subjective task value (relative cost)
Prior achievement	Final classroom grade and SOL score for Algebra 1 (for geometry students) or Algebra 1 and geometry (for Algebra 2 students)	Previous achievement-related experiences

Table 2

Sources of Likert Items

Variable	Source	Reliability coefficient of items in source
Academic self-concept	Marsh et al. (2013)	.55
Gender stereotype beliefs	Schmader et al. (2004)	.88
Intrinsic value	Gaspard, Dicke, Flunger, Brisson, et al., 2015	.94
Attainment value	Gaspard, Dicke, Flunger, Brisson, et al., 2015	.83–.88
Utility value	Gaspard, Dicke, Flunger, Brisson, et al., 2015	.52–.83
Cost	Gaspard, Dicke, Flunger, Brisson, et al., 2015	.83–.90
Long-term goals	Smith & Fouad (1999)	.87
Cultural stereotype beliefs	Cromley et al. (2013)	.86

Confirmatory factor analysis. A confirmatory factor analysis was conducted by using the Statistical Package for the Social Science (SPSS) computer program for the survey data in each mathematics course to ensure that the items were grouped as intended. A principal components analysis was run with a Promax rotation. The Promax

rotation was chosen because the literature indicates that the variables being used are somewhat correlated (Finch, 2006). Table 3 shows the eigenvalue, percentage of variance, and cumulative variance of each factor with an eigenvalue greater than one. Nine factors had an eigenvalue greater than one; nine variables were also used in the measure of the present study.

Table 3

Eigenvalues and Percentage Variance of Confirmatory Factor Analysis

Component	Eigenvalue	Percentage of variance	Cumulative variance
1	18.56	34.37	34.37
2	6.49	12.01	46.39
3	3.46	6.41	52.79
4	1.95	3.61	56.40
5	1.77	3.28	59.68
6	1.43	2.64	62.32
7	1.39	2.58	64.90
8	1.21	2.24	67.13
9	1.04	1.92	69.05

Table 4 shows the factor loadings and the value of the Cronbach's alpha (i.e., reliability coefficient) for each factor. All factor loadings were greater than or equal to 0.54, which is the acceptable range set by Stevens (1992) and Tabachnick and Fidell (2007) for a confirmatory factor analysis. Items measuring the same variable loaded onto the same variable with one exception: items measuring cost and self-concept loaded onto the same variable. This was not surprising, however, given that Eccles and Wigfield (2002) have stressed the connection between one's self-schemata and subjective task value beliefs. Although these variables load onto the same factor, the expectancy-value model separates them into different factors (Eccles et al., 1983; Eccles & Wigfield, 2002), so I decided to keep these variables separate while conducting subsequent analysis. It should also be noted that while all variables loaded onto the same factor, subscales of variables did not separate onto different factors. For example, all items measuring cost loaded onto the same factor, but the three subsections of cost, described later in this chapter, did not load onto separate factors. Given this result, any analysis conducted regarding subscales of variables must be undertaken with caution.

Table 4

Factor Loadings of Confirmatory Factor Analysis

Variable	Item	Factor loading	A
Cost	C3ER	.89	.94
	C4ER	.87	
	C6EC	.84	
	C7EC	.84	
	C11OC	.82	
	C10OC	.82	
	C2ER	.82	
	C1ER	.77	
	C8EC	.73	
	C5EC	.69	
	C9OC	.66	
Attainment value	AV10PI	.79	.81
	AV2IA	.78	
	AV6PI	.73	
	AV5PI	.73	
	AV9PI	.72	
	AV3IA	.70	
	AV4IA	.69	
	AV1IA	.68	
	AV8PI	.64	
	AV7PI	.62	

Note. C = cost, ER = effort required, EC = emotional cost, OC = opportunity cost, AV = attainment value, PI = personal interest, IA = importance of achievement

Table 4 Continued

Variable	Item	Factor Loading	A
Utility value	UV5DL	.88	.90
	UV12FL	.87	
	UV4DL	.85	
	UV11FL	.84	
	UV3DL	.84	
	UV7SU	.73	
	UV6SU	.71	
	UV8SU	.70	
	UV2US	.68	
	UV10UJ	.66	
	UV1US	.62	
	UV9UJ	.62	
Intrinsic value	IV3	.87	.93
	IV2	.87	
	IV1	.83	
	IV4	.82	
Self-concept	SC3	.77	.91
	SC4	.76	
	SC2	.74	
	SC1	.69	

Note. UV = utility value, DL = utility for daily life, FL = utility for future life, SU = social utility, US = utility for school, UJ = utility for job, IV = intrinsic value, SC = self-concept

Table 4 Continued

Variable	Item	Factor Loading	A
Cultural stereotype	CS3	.86	.86
	CS2	.84	
	CS5	.81	
	CS1	.75	
	CS4	.75	
Expectancy	EX1	.82	.78
	EX2	.70	
Gender stereotype	GS2	.94	.79
	GS1	.94	
	GS3	.54	
Long-term goals	LTG2	.78	.84
	LTG3	.75	
	LTG1	.73	

Note. CS = Cultural Stereotype, EX = Expectancy, GS = Gender Stereotype, LTG = Long Term Goal

Demographics. First, students recorded demographic information on the measure. This information included gender (students circled “Male” or “Female”), ethnicity (students circled “Asian,” “African American,” “Hispanic,” “Caucasian,” or “Other”), grade level, and age. Students also indicated whether or not they were enrolled in an English for Speakers of Other Languages (ESOL) course in school at the time of the study. Students classified as ESOL did not speak English as their first language. Next, students responded to whether they had also their current mathematics course last year (i.e., whether or not they were repeating the course; students will circle “Yes” or “No” in response to each question). These questions were included because the school in which the participants were enrolled had a large percentage of minority students (approximately 81%; source not cited for confidentiality), and students may have been repeating either geometry or Algebra 2 because they were both required courses for graduation (Virginia Department of Education, 2016).

Teacher. Students provided the name of their mathematics teacher at the time of the study. The purpose of this question was to try to account for as many confounding variables as possible regarding the questions about expectancy–value factors. Although the students were reminded that they should answer the items on the basis of the course content and not the teacher, it was still likely that the teacher would have had some influence on their motivational beliefs about the subject. By obtaining this information, I was able to conduct analysis to determine if there were significant differences in expectancy–value factors or mathematics performance among teachers who were teaching the same subject. The data regarding the participants’ teachers are displayed in

the descriptive statistics, and the differences between teachers were tested in the preliminary data analysis of this study.

Short-term goals (Brown & Warren, 2009). Brown and Warren (2009) asked participants to record a numerical goal for a task, which was then classified as their short-term (i.e., proximal) goal. The present study followed the same procedure: students were asked to record a numerical value for their goal for the SOL and the classroom grade for the mathematics course they were taking at the time of the study, resulting in two items for this scale. In the context of this study, short-term goals refer to students' goals in the course in which they were enrolled at the time of the study. These data were part of the overall expectancy–value model and were included in the hierarchical regression model to answer the first and second research questions. Brown and Warren did not measure reliability of their proximal goal scale because it was a single item, but established content validity on the basis of the definition of their constructs and their research questions.

Prior mathematics achievement. Next, students were asked to record their prior achievement in their previous mathematics classes. In the context of this study, prior achievement consists of previous SOL scores and previous final course grades. Because students self-reported these items and may not have accurately remembered their exact scores or grades from previous years, I cross-checked their information with data in the county grade system.

Students in a geometry class at the time of the study were asked to record their prior achievement in Algebra 1, while students in Algebra 2 at the time of the study were

asked to record their prior achievement in both Algebra 1 and geometry. The purpose of including both previous courses in the scale for Algebra 2 students was to determine whether prior achievement in one of the two previous courses was a stronger predictor of achievement in Algebra 2. Thus, both variables were used separately in the data analysis.

Expectation of success (Wigfield & Eccles, 2000). Students were then asked to respond to two questions measuring their expectancy of success in their current mathematics course. These items have been consistently used in studies conducted by Eccles and Wigfield, two of the pioneers of expectancy–value theory. The reliability of these items in the original article was not reported, but in a study that used the items, Trautwein and colleagues (2012) reported a reliability of .92.

Subjective task value (Gaspard, Dicke, Flunger, Schreier, et al., 2015). The purpose of this scale was to measure students' beliefs about the value, importance, and interest of their particular mathematics subject. Students were asked to respond to 37 questions measuring all four aspects of subjective task value—attainment value, intrinsic value, utility value, and cost—in the model of expectancy–value theory. This scale also measures several subscales of each of these four variables, which are outlined below. The reliability of the original scale, which had 37 items, was measured by the reliability value ρ (rho) for each construct. Rho was used as an alternative to Cronbach's alpha to account for correlated errors among the factors (Raykov, 2009). The reliability of each subscale in the original study ranged from $\rho = .52$ (utility for school) to $\rho = .94$ (intrinsic value).

A brief reminder was included before these and other Likert scale items asking students to answer each question on the basis of the *subject* addressed in the question and

not on the basis of the teacher of that particular subject. This explanation was provided in an effort to ensure the true internal beliefs of students about each mathematics subject were measured and to minimize the influence of an external factor (e.g., teacher) when responding. For each expectancy–value item, the responses were answered on a 6-point Likert scale. The response choices were as follows: *strongly disagree*, *disagree*, *slightly disagree*, *slightly agree*, *agree*, and *strongly agree*. The possible responses did not include a *neutral* or *neither* option because of the concept of forced choice. Dimitrov (2014) has stated that participants may feel more inclined to choose a neutral response if presented the option, but excluding this possibility forces participants to choose some level of agreement or disagreement. Thus, the responses in the present study followed this format.

A majority of the measure consisted of items measuring the four main aspects of subjective task value (attainment value, intrinsic value, utility value, and cost), as well as several subsets of each variable. These items were retrieved from the Gaspard, Dicke, Flunger, Brisson, et al. (2015) subjective task value scale. The 11 variables included in this scale, including the subsets of the four main variables, are: intrinsic, importance of achievement, personal importance, utility for school, utility for daily life, social utility, utility for job, general utility for future life, effort required, emotional cost, and opportunity cost.

Intrinsic value. The first subjective task value variable measured was intrinsic value. Intrinsic value is one of the four main variables within subjective task value, which is the theoretical foundation of the present study. The purpose of including this variable

was to measure students' personal interest in the course in which they were enrolled at the time of the study (i.e., geometry or Algebra 2). There were no subsets within intrinsic value that were measured in this subscale. This variable was measured by using four items (e.g., "geometry [or Algebra 2] is fun to me"). In the original study that used this subscale, Gaspard, Dicke, Flunger, Schreier, et al. (2015) reported a reliability of $\rho = .94$, which was the highest of all 11 constructs. In the present study, the reliability of intrinsic value was $\alpha = .93$.

Attainment value. The second subjective task value variable measured was attainment value. Attainment value is also one of the four main variables of subjective task value, which the foundational theory used in the present study. Overall, the purpose of the attainment value items was to measure how students viewed the importance of performing well in school. This variable was measured by using 10 items (e.g., "Performing well in geometry [or Algebra 2] is important to me"). Overall, attainment value had a reliability of $\alpha = .81$ in the present study. Within attainment value, two subconstructs were used. Importance of achievement (e.g., "Good grades in geometry [or Algebra 2] are very important to me") focused more on the performance in mathematics class and achieving good grades. This subset contains four items and had a reliability of $\rho = .88$ in the original study, and a reliability of $\alpha = .80$ in the present study. Personal importance (e.g., "Geometry [or Algebra 2] is very important to me personally"), focused more on how meaningful mathematics was to the individual. The subscale contains six items, two of which were negatively worded and, therefore, reverse coded before analyses were conducted. Personal importance had a reliability of $\rho = .83$ in the original

study. In the present study, personal importance had a reliability coefficient of $\alpha = .56$, which is one of the lowest of all subscales. As a result, any analyses conducted with this subscale should be considered with caution.

Utility value. The third subjective task value variable that was measured was utility value. Utility value, which is another main component of subjective task value, measured to what extent students see the subject as useful. In the scale, 12 items were used to measure utility value (e.g., “Understanding geometry [or Algebra 2] has many benefits in my daily life”). Overall, utility value had a reliability of $\alpha = .90$ in the present study. Within utility value, five subconstructs were measured. First, utility for school (e.g., “Being good at geometry [or Algebra 2] pays off, because it is simply needed at school”) asked students about to what extent they believed the content would be useful in future schooling. This subset has two items and had a reliability of $\rho = .52$, which is the lowest of all 11 constructs as reported by Gaspard, Dicke, Flunger, Schreier, et al. (2015). In the present study, utility for school had a reliability coefficient of $\alpha = .51$, which was the lowest of all subscales in subjective task value.

Second, utility for daily life (e.g., “Understanding geometry [or Algebra 2] has many benefits in my daily life”) asked students how useful they felt the subject would be in their everyday lives. This subset has three items, and Gaspard, Dicke, Flunger, Schreier, et al. (2015) reported a reliability of $\rho = .83$, while the present study reported a reliability of $\alpha = .81$. Third, social utility (e.g., “I can impress other with my intimate knowledge in geometry [or Algebra 2]”) relates to how much students felt the content would help them in a social context. This subset has three items and had a reliability of ρ

= .76 in the original study. The present study yielded a reliability coefficient of $\alpha = .78$. Fourth, utility for job (e.g., “Good grades in geometry [or Algebra 2] can be of great value to me later on”) measured how useful a student felt that the material in a certain course would be in their future career. This subset has two items and had a reliability of $\rho = .68$ in the study from which it was retrieved (Gaspard et al., 2015b) and a reliability of $\alpha = .59$ in the present study. Finally, general utility for future life (e.g., “I will often need geometry [or Algebra 2] in my life”) measured how much students felt that they would use that particular course in the future. This subconstruct was different from utility for daily life because it does not assume that the content will be used every day, but rather in the future. This subset has two items and had a reliability of $\rho = .79$ in the Gaspard, Dicke, Flunger, Schreier, et al. (2015) study. The present study found a reliability of $\alpha = .81$ for this subscale.

Cost. The fourth and final subjective task value variable measured in the present study was cost. Cost measured the effort they put into a task or course and the strain they undergo for that task or course (Eccles & Wigfield, 1992, 1995). This variable was the last of the four primary variables in subjective task value, which falls under expectancy–value theory, the theoretical framework of the present study. Cost was measured by using 11 total items (e.g., “Geometry [or Algebra 2] is a real burden to me”). Overall, cost had a reliability of $\alpha = .94$ in the present study. Three subconstructs of cost were measured. First, effort required (e.g., “Doing geometry [or Algebra 2] is exhausting to me”) refers to the act of actually completing tasks in mathematics. This subset has four items with a reliability of $\rho = .90$ in the original study, but a reliability of $\alpha = .92$ in the present study.

Second, emotional cost (e.g., “Doing geometry [or Algebra 2] makes me really nervous”) measured to what extent students’ emotions were stimulated. This subset contains four items and had a reliability of $\rho = .87$ in the Gaspard et al. (2015b) study. The present study found a reliability of $\alpha = .86$ for emotional cost. Third, opportunity cost (e.g., “I have to give up a lot to do well in geometry [or Algebra 2]”) refers to the amount of other activities that a student feels he or she has to surrender to be successful at a task or course. This subset contains three items, had a reliability of $\rho = .83$ in the previous study (Gaspard, Dicke, Flunger, Schreier, et al., 2015), and had a reliability of $\alpha = .89$ in the present study.

Goals (Smith & Fouad, 1999). The purpose of this scale was to measure students’ long-term goals as they relate to a particular subject. These three items measured long-term goals by measuring students’ career goals related to a particular mathematics domain. There were no additional subscales in this measure. The three items in this scale were: “I am determined to use my mathematics knowledge in my future career”; “I intend to enter a career that will use mathematics”; and “I plan to take more mathematics courses in college than will be required of me.” In these three items, “mathematics” was replaced by either “geometry” or “Algebra 2” depending on which class the participant was enrolled in. The reliability of these items in the original study was $\alpha = .87$, and the reliability of these items in the present study is $\alpha = .84$.

TIMSS self-concept (Marsh et al., 2013). Four items measured students’ academic self-concept in their current course. These academic self-concept items were a subscale from the Trends in International Mathematics and Science Study 2007 scale.

These items were measured by using the same Likert-scale choices as used for the other items. An example of an item in this measure was “I usually do well in geometry” (or Algebra 2, depending on the student’s current course). The original items used the word “mathematics” rather than a specific subject; therefore, I adjusted the items to fit the specific course that students were taking. Two of the four items were negatively worded and thus were reverse coded before data were analyzed. The reliability of this subscale in the Marsh et al. (2013) study was $\alpha = .55$, but the reliability in the present study for these items is $\alpha = .91$.

Stereotype endorsements (Schmader et al., 2004). The purpose of these three items was to measure students’ beliefs about gender stereotypes in either geometry or Algebra 2. The Likert scale choices described above were used for these three items. The items measuring gender stereotype beliefs asked students to rate their beliefs on the following statements: “It is possible that men have more math ability than do women”; “In general, men may be better than women at math”; and “I don’t think that there are any real gender differences in mathematics ability.” The last of those three questions was negatively worded, so it was reverse coded during the data analysis. Additionally, the word “mathematics” was replaced with “geometry” for the geometry students and “Algebra 2” for the Algebra 2 students. The items had a reliability of $\alpha = .88$ in the original study in $\alpha = .79$ in the present study.

Race stereotype bias items (Cromley et al., 2013). Finally, five Likert-scale items were included with the purpose of measuring students’ cultural stereotype beliefs about their own culture in their current mathematics course. The items were modified to

fit the context of the present study. For instance, the item “I believe that my ability to perform well on chem/bio tests is affected by my race” from the original study was modified to “I believe that my ability to perform well in geometry (or Algebra 2) is affected by my ethnicity.” This scale was appropriate for the present study because it measured students’ beliefs about their mathematics ability as it related to their ethnicity; this was particularly relevant for the sample, which was very culturally diverse. The items had a reliability of $\alpha = .86$ in both the Cromley et al. (2013) study and the present study.

Overall, the geometry measure had a total of 65 items and the Algebra 2 measure had a total of 67 items. All items in the geometry measure can be found in Appendix D, and those for the Algebra 2 measure can be found in Appendix E.

Procedures

Institutional Review Board (IRB) approval was received before students were contacted about the study. Appendix A contains the IRB approval letter, Appendix B contains the parental consent form, and Appendix C contains the student assent form. To obtain assent from students and consent from the students’ parents or guardians, I spoke with all classes about the purpose of this study, the measure being used, the students’ optional participation in this study, and the confidential data being collected.

Additionally, I emphasized that the results of the survey would not affect their classroom grade. Students were then given the consent and assent forms, and they were instructed to read and sign the assent forms if they agreed to be a part of the study and have their parents read and sign the consent forms if the parents agreed to their participation. Once

the forms had been read and signed, the students were instructed to return both forms to their teacher. The signed forms were kept in a secure file cabinet in my classroom until the study was completed.

Participants took a pencil-and-paper measure in which they self-reported the levels of their expectancy–value beliefs for their current mathematics course. The measure consists of the 54 Likert-scale items described previously, with five questions pertaining to demographics, one asking the name of their current mathematics teacher, one asking if the student was repeating the current course, two questions in which students stated their goals for the course, two questions in which students stated their expected SOL score and classroom grade, and two to four questions in which students stated their prior achievement in previous mathematics courses. The entire measure took students approximately 15 to 20 minutes to complete. Students were asked to put their student ID number, but not their name, on the measure. A teacher other than the students' own mathematics teacher was in the room while the measure was administered to ensure confidentiality.

Once students had completed the measure, I entered the data into a Microsoft Excel file. I also cross-checked the self-reported prior achievement grades and SOL scores using a county grade program. Finally, at the end of the school year, another teacher and I obtained the students' SOL scores and course grades for geometry and Algebra 2 using their reported student ID numbers. If a student took their current course SOL more than once (due to failing the first attempt), I recorded the higher of the two scores.

Additionally, for current course classroom grades, I used the average of the students' scores in each of the four quarters of the course. I did not include the students' final exam grades in the current course classroom grade because toward the end of the school year, the school at which this study was conducted implemented a policy in which students could use a passing SOL score in lieu of their final exam. Including this value would have been using the students' SOL scores in more than one part of this study's analysis. Furthermore, including only the four quarters in the analysis provided a more accurate depiction of a year-long effort without accounting for a single exam.

After these data had been obtained and recorded, the students' ID numbers were replaced with unidentifiable ID numbers. As an incentive, all students participating in the study were entered into a raffle to win one of five \$20 Target gift cards. Each of the teachers whose students participated in the study also received a \$20 Target gift card.

Research Design and Data Analysis

The design of this quantitative study was a correlational and predictive study because no intervention was administered to any students, but rather I simply collected data through surveys. Table 5 shows both research questions with the corresponding measure and type of analysis performed to answer each question.

Table 5

Data Analyses

Research question	Measures/ Instruments	Data analysis (quantitative)
1. To what extent do expectancy–value beliefs predict achievement on high-stakes mathematics assessments and classroom grades?	Survey measuring expectancy–value variables for the student’s current mathematics course, classroom grades, and SOL scores.	Several hierarchical multiple regression analyses, in which different expectancy–value variables at different levels.
2. Is there a main effect of type of mathematics course (e.g., geometry, Algebra 2), main effect of gender, and an interaction effect between gender and type of mathematics course on expectancy–value factors (i.e., cultural milieu, child’s perception, stable child, previous achievement, child’s goals and general self-schemata, child’s interpretations of experience, expectation of success, subjective task value)?	Survey measuring expectancy–value variables for the student’s current mathematics course, classroom grades, and SOL scores.	2×2 factorial MANOVA, describing differences in expectancy–value factors, classroom grades, and SOL scores by gender and mathematics course.

All data analyses were conducted by using the computer programs Microsoft Excel or SPSS. Before any analysis was calculated, prior course classroom grades were converted to a numerical score to allow for quantitative analysis. For example, a grade of D was coded as a 1, a grade of D+ was coded as a 2, and so on until the highest grade, which was an A, was coded as a 10. If students reported a grade of F, then a numeric code of 0 was recorded. I was only able to obtain the overall letter grade from a student's previous course; therefore, this overall letter grade was used. For the course the student was taking at the time of the study, I was able to obtain the numeric value of the grades from four quarters and calculate the average, which was the value used for the coding. Likewise, the Likert scale items were also coded numerically. *Strongly disagree* was coded as 1, *disagree* was coded as 2, *slightly disagree* was coded as 3, *slightly agree* was coded as 4, *agree* was coded as 5, and *strongly agree* was coded as 6.

Preliminary data analysis. Preliminary quantitative analysis was conducted before the research questions were addressed. First, descriptive statistics were conducted on all data. For example, the mean and standard deviation were calculated for all continuous variables in the study, including SOL scores for each course, classroom grade for each course, and the scores of all constructs and subconstructs. Second, Pearson's correlation coefficients were calculated for all variables. It was important to make sure that the variables were correlated to some extent so that further analysis could be conducted (Johnson & Christensen, 2014). However, it was also important to determine if the variables had correlations that were too strong, which would interfere with analyses. Ideally, the correlation coefficients would be less than .80 so as to avoid multicollinearity

(Shieh & Fouladi, 2003). Each of these analyses were conducted separately for geometry and Algebra 2 results so that the groups could be compared.

First research question. The first research question asks the following: To what extent do expectancy–value beliefs predict achievement on high-stakes assessments and classroom grades? This question was addressed through several hierarchical multiple regression models. The first hierarchical multiple regression model was run to determine what expectancy–value variables predict SOL scores for geometry. At each level, a different variable or set of variables measured in the survey was added, and Geometry SOL scores were used as the dependent variable. At the first level, demographic information, including age, grade, gender, ethnicity, and ESOL status, was included. Several dummy variables were created so that ethnicity could be included in the regression models; this approach allowed the model to determine if the presence of a certain ethnicity significantly predicted the SOL score. This method follows the precedent of multiple similar studies in which a hierarchical approach was used (Chow, Eccles, & Salmela-Aro, 2012; Hendy, Schorschinsky, & Wade, 2014). At the second level, data for prior achievement, gender stereotype beliefs, cultural stereotype beliefs, self-concept, expectancy, and long-term goals were added to the model. Finally, in the third level, the items from all four subjective task value variables and their subconstructs were added. Both Chow et al. (2012) and Andersen and Ward (2013) added subjective task value items at the last level. This same hierarchical procedure was repeated with the Geometry SOL scores, geometry classroom grades, Algebra 2 SOL scores, and Algebra 2 classroom grades as the dependent variables, resulting in four separate regression models.

The purpose of analyzing the results in this hierarchical process was to determine the effect size for a variable (or set of variables), as well as the change in effect size when each new variable (or set of variables) was added. This approach allowed the results to show how much variance a variable (or set of variables) explained over and above what was already included in the regression model (Warner, 2013).

Second research question. The second research question asks the following: Is there a main effect of type of mathematics course (e.g., geometry, Algebra 2), main effect of gender, and interaction effect between gender and type of mathematics course on expectancy–value factors (e.g., cultural milieu, child’s perception, stable child, previous achievement, child’s goals and general self-schemata, child’s interpretations of experience, expectation of success, subjective task value)? This entire question was addressed by running a 2×2 factorial MANOVA test. These two questions were combined into one type of analysis so that one MANOVA test could be run instead of multiple analysis of variance (ANOVA) tests. Running multiple ANOVA tests increases the possibility of Type I errors in the results, and also does not account for the correlations among the variables that were not run in the same ANOVA tests (Miller, 2014; Warner, 2013). In this 2×2 factorial MANOVA, the dependent variables were expectancy–value factors defined by the Eccles et al. (1983) model, individual SOL scores, and individual classroom grades. The data were separated by the independent variables, which were gender (male and female) and specific mathematics course (geometry and Algebra 2). This factorial MANOVA determined if there were significant differences in the main effects of independent variables, gender and mathematics course.

The factorial MANOVA also measured four interaction effects: independent variables versus gender, independent variables versus mathematics course, gender versus mathematics course, and independent variables versus gender versus mathematics course. Any significant interaction effects were explored further to determine specific differences based on all other variables.

Anticipated Results

First research question. In the present study, it was predicted that grade level, self-concept, long-term goals, and prior achievement would all significantly predict classroom grades for both geometry and Algebra 2. In terms of grade level, those students who were taking geometry or Algebra 2 earlier in their high school careers were likely on an honors or fast track before high school and had already been identified as high achieving students. Therefore, it was predicted that students later in their high school careers will have lower achievement than those students earlier in their high school careers. Self-concept is well known to be an indicator of academic achievement even within expectancy–value literature (Eccles, 2009; Eccles & Wigfield, 2002; Guo, Parker, et al., 2015b), and so it was expected that self-concept would significantly predict classroom grades. Additionally, self-concept has been shown to be significantly related to mathematics standardized test scores (Marsh et al., 2005), and thus self-concept was also anticipated to significantly predict SOL scores for both geometry and Algebra 2.

Although it was expected that prior achievement would significantly predict achievement in all regression models, I predicted that prior achievement would be a stronger predictor for Algebra 2 than for geometry. I made this prediction on the basis of

the standards set by the state and county: Much of the Algebra 2 curriculum was repeated from the Algebra 1 material, and therefore students would have already been exposed to some material covered in Algebra 2 (Virginia Department of Education, 2016). On the other hand, not only was a majority of the material in geometry new to students, but geometry and algebra require different cognitive skills (Battista, 2007; Kaput, 1998), and there was less overlap between Algebra 1 and geometry than there was between Algebra 1 and Algebra 2.

While I anticipated that long-term goals would significantly predict classroom grades and SOL scores for both geometry and Algebra 2, I also anticipated that geometry students would report higher levels of career goals than Algebra 2 students. This reasoning was a response to the complexity of the Algebra 2 material. In the state of Virginia, the Algebra 2 curriculum consists of many complex concepts, such as rational and logarithmic functions. The visual nature of geometry, on the other hand, allows students to see how the mathematics could be applied to their lives and future careers. Thus, it was anticipated that geometry students would have higher long-term goal levels than Algebra 2 students.

In addition to these constructs, I predicted that subjective task value variables would significantly predict classroom grades. This hypothesis was consistent with the Farrington et al. (2012) article on noncognitive (e.g., motivational) constructs. Farrington and colleagues also stated that these psychological factors were not strong predictors of standardized test scores. Therefore, it was hypothesized that most subjective task value variables would not significantly predict standardized test scores. However, the exception

to this hypothesis is that attainment value would predict test scores. This hypothesis stems from the idea that attainment value is related to performance goals (Bong, 2001), and thus students with a strong goal to perform well on a test may also have a high attainment value.

When items and factors are differentiated by SOL score and classroom grade, it was hypothesized that personal interest, attainment value, and utility value would predict classroom grades but not standardized test scores. Malka and Covington (2005) have claimed that students who are interested and see value in material perform better in a classroom environment in which assignments are graded; this claim is supported by Farrington and colleagues (2012), who add that these types of beliefs do not predict standardized test performance. However, for cost, I hypothesized that cost would neither predict classroom grades nor standardized test scores. This stance is based on the claim of Gaspard, Dicke, Flunger, Brisson, et al. (2015) that most aspects of students' cost beliefs did not predict students' classroom performance.

Second research question. In terms of specific mathematics course, it was predicted that there would be significant differences in geometry and Algebra 2 SOL scores. Specifically, Algebra 2 SOL scores would be significantly higher than Geometry SOL scores. This hypothesis was based on the previously reported SOL scores in the school from which the sample was drawn (source not cited for confidentiality).

I also predicted that there would be no significant differences in short-term goals (i.e., goals in the current course), long-term goals, gender stereotype beliefs, or self-concept between geometry and Algebra 2. The reason for this prediction is that both

geometry and Algebra 2 are required courses to graduate high school, and the population for each class would be similar. However, I predicted there would be several interaction effects between these variables. For instance, it was predicted that short- and long-term goals would be significantly correlated because according to the Eccles and colleagues (1983) model of expectancy–value theory, both variables fall under the same category of general self-schemata.

In terms of subjective task value, I expected that most beliefs would be significantly lower for Algebra 2 than for geometry. Particularly, utility value would be higher for geometry than for Algebra 2; this hypothesis was made on the basis of the complexity of the topics in Algebra 2 (e.g., logarithms, rational functions), and the lack of time for teachers to incorporate real-world applications into the lessons. The visual nature of the geometry material (Battista, 2007; Clements & Battista, 1992) also enables students to see more application for the geometry content than for the Algebra 2 content, which is why it was anticipated that students would see more value in geometry. I expected there to be no significant differences in classroom grades based on specific mathematics course because there is no current literature suggesting that there would be a difference.

Finally, I hypothesized gender differences within several aspects of this study. First, I predicted that certain expectancy–value variables would differ significantly between males and females. For example, Gaspard, Dicke, Flunger, Brisson, et al. (2015) and Gaspard, Dicke, Flunger, Schreier, et al. (2015) have found that certain aspects of utility value and cost showed significant differences by gender; thus, it was expected that

these results would remain consistent. Females may also report lower utility beliefs due to the perceived barrier that exists for them in pursuing STEM-related careers (Fouad et al., 2010). Second, I anticipated significant differences in average classroom grades and SOL scores in some courses. Kimura (2000) has stated that that females often performed better than males in a classroom setting but worse on mathematics aptitude tests.

However, research has shown that in certain populations, males perform better in geometry classes than females (Ma, 1995). Therefore, in terms of classroom grades, I predicted that females would receive higher grades than males across all courses, but in terms of SOL scores, males would perform significantly better on the Geometry SOL. Third, I hypothesized that gender stereotype beliefs would differ significantly between males and females. According to Schmader et al. (2004), females reported significantly less belief in the idea that men outperform females in mathematics, so I expected the same result in the present study.

I did anticipate that there would, however, be some aspects of the study that showed no significant differences between males and females. For instance, I expected there to be no difference in personal interest by gender, which would be consistent with the study conducted by Marsh and colleagues (2005). Gaspard, Dicke, Flunger, Brisson, et al. (2015) and Gaspard, Dicke, Flunger, Schreier, et al. (2015) have also found no differences by gender in some subjective task value factors, such as utility for school and opportunity cost. Therefore, I predicted that this finding would remain consistent in the present study. Finally, it has been found that there is no difference in algebra achievement by gender (Engelhard, 1990; Ganley & Vasilyeva, 2014; Ma, 1995). Therefore, it was

hypothesized that there would be no difference in Algebra 2 SOL score between males and females.

Chapter Four

Purpose

The purpose of the study was to determine if there were differences in expectancy–value factors, classroom achievement, and standardized test achievement by mathematics course and gender. The following research questions guided the analysis outlined in this chapter:

1. To what extent do expectancy–value beliefs predict achievement on high-stakes mathematics assessments and classroom grades?
2. Is there a main effect of type of mathematics course (e.g., geometry, Algebra 2), main effect of gender, and an interaction effect between gender and type of mathematics course on expectancy–value factors (i.e., cultural milieu, child’s perception, stable child, previous achievement, child’s goals and general self-schemata, child’s interpretations of experience, expectation of success, subjective task value)?

Data Collection

As mentioned previously, students were informed about the study and given consent and assent forms to sign and return to their teacher. Students who had both forms signed returned them to their mathematics teacher. At a date that was convenient for each

teacher whose students were participating in the study, students completed the paper-and-pencil survey and returned it to their teacher. Once students had completed the survey, the results were entered into a Microsoft Excel spreadsheet. Of the 247 students enrolled in a regular geometry class, 193 geometry students participated in the study, resulting in a 78.14% response rate for geometry. Of the 221 students enrolled in a regular Algebra 2 class, 147 Algebra 2 students participated in the study, resulting in a 66.52% response rate for Algebra 2. Combined, 340 students out of a possible 468 students participated, resulting in an overall response rate of 72.65%.

Next, accessing a grade system of the school district, I used the student ID numbers that students provided on the survey to look up their SOL scores and their classroom grades in their Algebra 1 classes and, if applicable, their geometry classes. These data were also recorded into the Microsoft Excel spreadsheet. Of the 193 geometry students who participated, 90.67% had available Algebra 1 classroom grades, and 93.78% had available Algebra 1 SOL scores. Of the 147 Algebra 2 students who participated, 89.12% had available Algebra 1 classroom grades, 88.44% had available Algebra 1 SOL scores, 89.12% had available geometry classroom grades, and 94.55% had available Geometry SOL scores. The missing data were likely the result of students who had transferred into the school from another state or country. Students who transferred in from another state would not have taken the SOL assessment, given that it is a statewide exam. Students who transfer from another country often take a test to determine their mathematics placement, rather than having grades transferred from their home country.

At the end of the school year, geometry and Algebra 2 teachers provided the SOL scores and final classroom grades for all students who participated in the study. Only student ID numbers, not names, were provided so that I was able to match the data with each study participant. A total of 191 out of 193 geometry students (98.96%) and 136 out of 147 Algebra 2 students (92.52%) had a final classroom grade. Not all students had a final classroom grade to report because some students were no longer enrolled in the class from which data were being collected. Of the 193 geometry students who participated in the study, 184 (95.34%) took the Geometry SOL. Of the 147 Algebra 2 students who participated in the study, 140 (95.24%) took the Algebra 2 SOL. Some students may not have taken the SOL in their current class because they had taken and passed the SOL last year, they were no longer in the class, or they simply chose not to come to the test. The test scores of students who had taken and passed the SOL the previous year were not included in this study because their teacher and beliefs about the course might have been different from what they were the previous year. Additionally, there was one student who took a paper-and-pencil version of the Geometry SOL. That student's SOL score was not used in the analysis because the score was not reported in a timely manner and because his testing procedure differed from that of the other students.

Once all data were collected and entered into the Microsoft Excel spreadsheet, student ID numbers were deleted and replaced with an unidentifiable study ID number. Additionally, teachers' names were replaced with an unidentifiable teacher code number. The data were then transferred to a spreadsheet on SPSS.

Data Cleaning

Univariate outliers. Univariate outliers were identified by testing the normality of each continuous variable. After the first calculation of the normality statistics for the variables, it was determined that gender stereotype and expectancy variables reported very high levels of skewness and kurtosis for both courses, suggesting that the data for these variables was not normally distributed. This finding was due to the large number of students answering at one extreme or another: Many students reported low levels of gender stereotype (i.e., *strongly disagree* or *disagree*), whereas many students reported high levels of expectancy (i.e., *agree* or *strongly agree*). As a result, I examined the probability–probability (P-P) plots for each variable and determined that, on the basis of the shape of the plot, there were univariate outliers for each variable. In the geometry data, I removed one entry with a very high gender stereotype score and three entries with very low expectancy scores. In the Algebra 2 data, I removed one entry with a very high gender stereotype score and one entry with a very low expectancy score. After removing these entries, skewness and kurtosis statistics were acceptable, suggesting that the data were at an acceptable level of normality. Table 6 and Table 7 show skewness and kurtosis statistics, respectively, for all continuous variables. Skewness and kurtosis statistics were calculated separately for each course.

Table 6

Skewness Statistics of Continuous Variables for Each Course

Variable	Course			
	Geometry		Algebra 2	
	Statistic	SE	Statistic	SE
Intrinsic value	-.22	.19	-.29	.22
Attainment value	-.60	.19	-.59	.22
Utility value	-.46	.19	-.31	.22
Cost	.28	.19	.13	.22
Self-concept	-.54	.19	-.31	.22
Long-term goals	.36	.19	.17	.22
Expectancy	-.96	.19	-.92	.22
Gender stereotype	1.06	.19	1.01	.22
Cultural stereotype	.99	.19	1.12	.22
Previous course SOL (Algebra 1)	.34	.19	.87	.23
Previous course grade (Algebra 1)	-.34	.19	-.01	.24
Previous course SOL (geometry)	—	—	.51	.23
Previous course grade (geometry)	—	—	-.09	.24
Current class SOL	.62	.18	.23	.23
Current class grade	-.55	.18	-.74	.23

Note. Blank cells indicate variable is not applicable for the given sample.

Table 7

Kurtosis Statistics of Continuous Variables for Each Course

Algebra 2				
Variable	Statistic	SE	Statistic	SE
Intrinsic value	-.75	.36	-.76	.44
Attainment value	.19	.36	.22	.44
Utility value	.02	.36	-.32	.44
Cost	-.65	.36	-.23	.44
Self-concept	-.51	.36	-.52	.44
Long-term goals	-.25	.36	-.31	.44
Expectancy	.77	.36	1.58	.44
Gender stereotype	.50	.36	.40	.44
Cultural stereotype	.45	.36	1.27	.44
Previous course SOL (Algebra 1)	.03	.37	.44	.46
Previous course grade (Algebra 1)	.10	.38	-.67	.47
Previous course SOL (geometry)	—	—	.27	.45
Previous course grade (geometry)	—	—	-.91	.47
Current class SOL	1.07	.37	.04	.46
Current class grade	-.35	.36	.22	.45

Note. Blank cells indicate variable is not applicable for the given sample.

Multivariate outliers. Data were then cleaned by finding multivariate outliers. Multivariate outliers were tested by calculating the Mahalanobis distance on SPSS. The Mahalanobis distance analysis was conducted separately for the geometry data and the Algebra 2 data. A total of 34 multivariate outliers were removed from the data: nine from geometry and 25 from Algebra 2. It was found that many of these outliers were students who answered one choice for every single Likert-scale question and, therefore, had not taken the survey seriously. After removal of the univariate and multivariate outliers, the resulting data contained 300 students—180 geometry and 120 Algebra 2—with which further analyses were conducted.

Self-reported goals and prior achievement. One unanticipated outcome of the survey results was that students' self-reported short-term goals for their current mathematics course did not match a format that allowed for easy analysis. For instance, many students did not report a number value for their SOL goal, or a letter value for their classroom grade goal; rather, they simply wrote "to pass" or "passing" on the survey. This was likely due to the fact that the survey item did not specifically ask for a numeric or letter grade as their response. In my data spreadsheet, I input a 400 for those who reported their goal as "to pass" for the SOL, and a letter grade of D for those who reported their goal as "to pass" for their classroom grade. However, these responses likely did not accurately reflect the students' goals. As a result, I decided to exclude these measures from subsequent analysis. While this step prevented me from including this variable in the analysis, there were other variables that make up the factor of *child's goals and self-schemata* in the Eccles et al. (1983) model (e.g., long-term goals, self-concept),

so I was still able to conduct all of the originally intended analyses by including other variables from this factor.

A similar issue occurred for the questions asking students to self-report their prior achievement. Students often wrote “passed” or “passed advanced” for their previous SOL scores, or wrote “passed” or an estimate between two letter grades (e.g., “A or B”) for their previous classroom grades. While I recorded a numeric value for each question in my data spreadsheet, this likely did not accurately reflect students’ interpretation of experience or affective reactions and memories of their prior achievement, both of which were factors on the Eccles et al. (1983) model of expectancy–value theory. As a result, I decided to exclude these self-reported prior achievement variables from any subsequent analysis.

Research Question Analysis

Research Question 1. The first research question asks the following: To what extent do expectancy–value beliefs predict achievement on high-stakes mathematics assessments and classroom grades? In order to answer this question, several hierarchical regression models were calculated. As mentioned previously in Chapter 3, the order in which variables were added was chosen on the basis of previous studies (Andersen & Ward, 2013; Chow et al., 2012; Hendy et al., 2014). The first level contained age, grade, gender, ethnicity, and ESOL status. The second level contained expectancy, long-term goals, self-concept, prior achievement (all previous SOL scores and final classroom grades), gender stereotype beliefs, and cultural stereotype beliefs. The third level contained utility value, attainment value, intrinsic value, and cost.

To include ethnicity, I made several dummy variables for each ethnicity. By doing so, the model indicated if the “presence” of that particular ethnicity significantly predicted the dependent variable. However, a regression model cannot include all dummy variables as well as the constant that SPSS automatically includes in the model (Suits, 1957). I chose to include the constant and remove the dummy variable that was created for the “other” ethnicity category because “other” is a vague term that could refer to a myriad of different ethnicities and would likely not have given any valuable information in regards to predicting SOL scores and grades.

Descriptive statistics. Descriptive statistics were run for the survey data, as well as for the prior mathematics achievement and achievement in students’ current mathematics course. All descriptive statistics reflect the data after outliers were removed. Table 8 shows the number and percentage of males and females in each course who participated in the study. Table 9 shows the number and percentage of each reported ethnicity in each course. Table 10 shows the number and percentage of ESOL and non-ESOL students in each course.

Table 8

Frequencies of Gender in Geometry and Algebra 2 Samples

Course				
Gender	Geometry		Algebra 2	
	Number	Percent	Number	Percent
Male	98	54.40	63	52.50
Female	82	45.60	57	47.50
Total	180	100	120	100

Table 9

Frequencies of Ethnicity in Geometry and Algebra 2 Samples

Ethnicity	Course			
	Geometry		Algebra 2	
	Number	Percent	Number	Percent
African American	32	17.78	17	14.17
Asian	37	20.56	29	24.17
Caucasian	26	14.44	14	11.66
Hispanic	65	36.11	43	35.83
Other	20	11.11	17	14.17
Total	180	100	120	100

Table 10

Frequencies of ESOL Students in Geometry and Algebra 2 Samples

Course				
Geometry			Algebra 2	
ESOL status	Number	Percent	Number	Percent
Non-ESOL	168	93.33	116	96.67
ESOL	12	6.67	4	3.33
Total	180	100	120	100

Mean and standard deviation. The mean and standard deviation were found for each continuous variable for each mathematics course separately. Table 11 shows the mean and standard deviation of each variable measured on a Likert scale in the survey, as well as the prior achievement variable and current course achievement variables. The values given for each expectancy–value variable reflect the average of each survey response for that particular variable. Responses on the Likert scale items were numerically coded, as mentioned in Chapter 3: *strongly disagree* as 1, *disagree* as 2, *slightly disagree* as 3, *slightly agree* as 4, *agree* as 5, and *strongly agree* as 6. The values for prior classroom grades reflect the numeric conversion outlined in Table 3 because

only letter grades were available to me, whereas the values for current course classroom grade were measured on a 100-point scale because that information was available to me.

Correlation coefficients. Next, Pearson correlation coefficients were calculated by using SPSS. Table 12 shows the correlation of all continuous variables in the geometry sample, and Table 13 shows the correlation of all continuous variables in the Algebra 2 sample.

Table 11

Comparison of Means and Standard Deviations for Expectancy–Value Variables, Prior Achievement, and Current Course Achievement in Geometry and Algebra 2

Variable (number of items)	Course			
	Geometry		Algebra 2	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Intrinsic value (4)	3.40	1.24	3.36	1.27
Attainment value (10)	3.69	0.86	3.56	0.90
Utility value (12)	3.75	0.94	3.61	0.90
Cost (11)	3.18	1.22	3.41	1.02
Self-concept (4)	3.96	1.26	3.74	1.21
Long-term goals (3)	2.89	1.16	3.07	1.18
Expectancy (2)	4.86	0.90	4.76	0.93
Gender stereotype (3)	1.72	0.81	1.60	0.68
Cultural stereotype (5)	2.01	1.02	1.88	0.83
Prior Algebra 1 SOL (1)	438.05	28.24	435.13	31.69
Prior Algebra 1 grade (1)	6.23	2.14	6.08	2.11
Prior Geometry SOL (1)	—	—	442.50	40.06
Prior geometry grade (1)	—	—	5.31	2.46
Current class SOL (1)	443.89	41.08	462.65	55.23
Current class grade (1)	78.85	10.45	80.18	9.03

Note. Blank cells indicate variable is not applicable for the given sample.

Table 12

Pearson Correlation Coefficients among Continuous Variables in Geometry Sample

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1. IV	—												
2. AV	.64**	—											
3. UV	.57**	.81**	—										
4. C	-.69**	-.44**	-.44**	—									
5. SC	.70**	.42**	.42**	-.81**	—								
6. LTG	.52**	.60**	.67**	-.43**	.41**	—							
7. EX	.45**	.58**	.54**	-.41**	.45**	.36**	—						
8. GS	-.01	.01	.11	.03	.02	.16*	-.01	—					
9. CS	-.05	.10	.14	.25**	-.26**	.17*	-.08	.30**	—				
10. PC SOL (A1)	.23**	.24**	.26**	-.33**	.41**	.27**	.19*	.08	-.13	—			
11. PC grade (A1)	.15	.24**	.26**	-.30**	.27**	.18*	.16*	.02	-.05	.48**	—		
12. CC SOL	.30**	.20**	.21**	-.40**	.50**	.30**	.22**	.02	-.17*	.54**	.33**	—	
13. CC grade	.44**	.39**	.33**	-.45**	.57**	.30**	.34**	-.01	-.13	.45**	.46**	.61**	—

Note. IV = intrinsic value; AV = attainment value; UV = utility value; C = cost; SC = self-concept; LTG = long-term goals; EX = expectancy; GS = gender stereotype; CS = cultural stereotype; PC = previous course; A1 = Algebra 1; CC = current course.

* $p < .05$. ** $p < .01$.

Table 13

Pearson Correlation Coefficients among Continuous Variables in Algebra 2 Sample

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. IV	—														
2. AV	.70**	—													
3. UV	.64**	.81**	—												
4. C	-.64**	-.33**	-.32**	—											
5. SC	.70**	.39**	.39**	-.77**	—										
6. LTG	.49**	.58**	.65**	-.24**	.35**	—									
7. EX	.48**	.56**	.54**	-.27**	.33**	.37**	—								
8. GS	-.02	-.11	-.05	.13	-.08	-.01	-.27**	—							
9. CS	-.10	-.10	-.10	.23*	-.10	.01	-.14	.35**	—						
10. PC SOL (A1)	.29**	.10	.07	-.36**	.49**	.15	-.01	.00	-.22*	—					
11. PC grade (A1)	.33**	.22*	.24*	-.38**	.38**	.27**	.09	-.19	-.17	.32**	—				
12. PC SOL (Geo)	.22*	.02	.11	-.33**	.40**	.11	-.05	.12	-.10	.65**	.14	—			
13. PC grade (Geo)	.28**	.19*	.11	-.29**	.41**	.18	.15	-.02	-.22*	.48**	.26**	.45**	—		
14. CC SOL	.36**	.21*	.17	-.44**	.54**	.23*	.15	.05	-.13	.62**	.32**	.61**	.60**	—	
15. CC grade	.36**	.20*	.20*	-.47**	.54**	.23*	.22*	-.12	-.19*	.31**	.38**	.33**	.65**	.66**	—

Note. IV = intrinsic value; AV = attainment value; UV = utility value; C = cost; SC = self-concept; LTG = long-term goals; EX = expectancy; GS = gender stereotype; CS = cultural stereotype; PC = previous course; A1 = Algebra 1; Geo = Geometry; CC = current course. * $p < .05$. ** $p < .01$.

The correlations among the variables indicated multicollinearity between some variables. In both the geometry and Algebra 2 samples, attainment value and utility value had a Pearson correlation coefficient greater than .80. Although the correlations between these variables were larger than desired, I decided to keep attainment value and utility value as separate constructs for several reasons. First, Wigfield (1994) established that attainment value, intrinsic value, and utility value, three of the four components of subjective task value, were all distinct constructs and measured separate beliefs of students in all grade levels. Second, despite finding multicollinearity among subjective task value variables, Trautwein and colleagues (2012) conducted analyses without combining variables, even when one correlation coefficient was as high as .97. As a result, following the precedents set in the literature, attainment value and utility value remained separate variables in this study.

Additionally, in the geometry sample, self-concept and cost were correlated at a Pearson coefficient of $-.81$. This result was expected on the basis of the two variables cross-loading in the confirmatory factor analysis, as well as the claim of Eccles and Wigfield (2002) that self-schemata and subjective task value share a strong relationship. Furthermore, Pajares and Miller (1994) also found strong multicollinearity between mathematics self-concept and mathematics anxiety (i.e., cost). Given that the Pearson correlation coefficient between self-concept and cost did not indicate multicollinearity in the Algebra 2 sample, subsequent analyses were conducted with the two variables remaining distinct. This step allowed for an equivalent comparison between the results of the geometry and Algebra 2 samples. Nevertheless, the multicollinearity between these

variables and between attainment value and utility value was considered when the results of the analyses of this study were interpreted.

Some differences were found between the Pearson correlation coefficients of the geometry sample and the Pearson correlation coefficients of the Algebra 2 sample. First, in the geometry sample, gender stereotype was found to be statistically significantly correlated with long-term goals ($r = .16, p < .05$), but this correlation was not significant in the Algebra 2 sample. Second, in the Algebra 2 sample, gender stereotype was found to be statistically significantly correlated with expectancy ($r = -.27, p < .01$), but this correlation was not significant in the geometry sample. As mentioned previously, many students reported low levels of gender stereotype, which may have affected these results. Nevertheless, these results suggest that those students in geometry who reported stronger gender stereotype beliefs reported more intent to use geometry in the long-term, whereas students in Algebra 2 who reported stronger gender stereotype beliefs reported lower expectations of succeeding in their current mathematics course. Further analysis conducted regarding gender is discussed later in this chapter, including whether these significant findings vary by gender.

Second, correlation coefficients involving cultural stereotype showed some differences between the two samples. In the geometry sample, cultural stereotype was significantly correlated with self-concept ($r = -.26, p < .01$); specifically, those who reported lower levels of cultural stereotype beliefs had higher levels of geometry self-concept beliefs. This correlation, however, was not significant in the Algebra 2 sample. Additionally, cultural stereotype and long-term goals were also significantly correlated in

the geometry sample ($r = .16, p < .05$) but not the Algebra 2 sample. This finding suggests that students who reported higher levels of cultural stereotype beliefs also reported stronger goals to use the geometry content in the long-term. Again, many students reported very low levels of cultural stereotype beliefs for both samples, and the slight skewness of these data may have had an impact on the correlation values.

Third, there were many differences in significant correlations between the two samples regarding prior achievement on the Algebra 1 SOL. In the geometry sample, both attainment value ($r = .24, p < .01$) and utility value ($r = .26, p < .01$) in geometry were found to be positively, statistically, significantly correlated with prior Algebra 1 SOL achievement, whereas attainment value and utility value in Algebra 2 were not statistically significantly correlated with prior Algebra 1 SOL achievement. Furthermore, long-term goals ($r = .27, p < .01$) and expectancy ($r = .19, p < .05$) in geometry were also both found to be significantly correlated with prior Algebra 1 SOL achievement. The only continuous variable that was significantly correlated with prior Algebra 1 achievement in the Algebra 2 sample but not the geometry sample was cultural stereotype ($r = -.22, p < .05$). These differences suggest that prior achievement in Algebra 1 influences expectancy–value beliefs more so for geometry than for Algebra 2. This conclusion makes sense in the context of the study because students in geometry took Algebra 1 only one year before their current class, whereas students in Algebra 2 took Algebra 1 two years before their current class. Additionally, those in Algebra 2 who had a high prior Algebra 1 SOL achievement were less likely to hold beliefs about cultural stereotypes in Algebra 2, but the same was not true for those in geometry.

The correlation coefficient for prior Algebra 1 classroom grades was similar for the geometry and Algebra 2 samples. For both samples, prior Algebra 1 classroom grade achievement was statistically significantly with all continuous variables except intrinsic value, gender stereotype, and cultural stereotype. For both samples, all significant correlations were positive except for the correlation between prior Algebra 1 classroom grade achievement and cost.

In the geometry sample, the only variable that was not significantly correlated with the current course SOL score was gender stereotype beliefs. In the Algebra 2 sample, several variables were not statistically significantly correlated with the current course SOL score: utility value, expectancy, gender stereotype beliefs, and cultural stereotype beliefs. All other correlations among variables were statistically significant for both the geometry and Algebra 2 samples. Therefore, the only differences between the two samples were that in the geometry sample, the current course SOL was significantly correlated with utility value, expectancy, and cultural stereotype beliefs, but this was not the case in the Algebra 2 sample.

Finally, in terms of current course classroom grade, the geometry grade was significantly correlated with all other variables except cultural stereotype and gender stereotype. Of the correlations that were significant, the only negative correlation coefficient with the geometry classroom grade was cost ($r = -.45$). Similar results were found in the Algebra 2 classroom grade data; the only exception was that cultural stereotype was significantly correlated with the Algebra 2 classroom grade. Specifically, students with lower levels of cultural stereotype beliefs scored higher Algebra 2

classroom grades. Cost was also negatively correlated with Algebra 2 classroom grades, whereas all other significant correlation coefficients were positive.

Geometry SOL scores. The first regression model predicted Geometry SOL scores based on expectancy–value constructs listed previously. Table 14 shows the unstandardized coefficients, standard error of the unstandardized coefficients, and standardized coefficients for each variable in the model as well as the change in R^2 for each level of the model. The rationale for the level at which each variable was included in the model can be found in Chapter 3.

Table 14

Hierarchical Regression Analysis for Variables Predicting Geometry SOL Scores

Variable	Level 1			Level 2			Level 3		
	B	SE	β	B	SE	β	B	SE	β
Age	2.08	5.88	-.16	4.05	4.40	.10	3.83	4.74	.10
Grade level	-19.32	7.20	-.32**	-11.47	6.41	-.19	-11.93	6.56	-.20
African American	-17.22	11.06	-.17	-23.14	9.38	-.23*	-23.04	9.74	-.23*
Asian	1.22	10.79	.01	-12.55	9.38	-.13	-13.31	9.53	-.14
Hispanic	-5.93	10.13	-.07	-12.24	8.76	-.15	-12.48	8.93	-.15
Caucasian	16.83	11.71	.15	-.82	10.38	-.01	-1.74	10.57	-.02
ESOL status	-10.49	15.23	-.06	2.22	13.71	.01	4.68	14.23	.03
Gender	-12.47	5.88	-.16*	-9.43	5.31	-.12	-9.20	5.44	-.12
Algebra 1 SOL				.49	.11	.36**	.48	.11	.35**
Algebra 1 grade				1.52	1.38	.08	1.62	1.42	.09
Self-concept				1.75	.67	.23*	2.58	1.00	.34*
Expectancy				-.91	1.63	-.04	-.76	1.89	-.04
Long-term goals				.60	.86	.05	.76	1.07	.07
Gender stereotype				.52	1.11	.03	.35	1.14	.02
Cultural stereotype				-.53	.56	-.07	-.55	.58	-.07
Intrinsic value							-.48	.95	-.06
Utility value							.22	.43	.07
Attainment value							-.22	.60	-.05
Cost							.29	.36	.10
Change in R^2			.20**			.27**			.01

* $p < .05$. ** $p < .01$.

The first level of this hierarchical model was significant, $R^2 = .20$, $F(8, 147) = 4.50$, $p < .001$. The two variables that significantly predict Geometry SOL scores were grade ($\beta = -.32$, $t = -2.68$, $p < .01$) and gender ($\beta = -.16$, $t = -2.12$, $p < .05$). Specifically, the negative standardized coefficient of grade indicated that the model predicted that students in lower grade levels would earn higher Geometry SOL scores. Similarly, the standardized coefficient of gender was negative. Given that the coding for gender was “0” for male and “1” for female, the model predicted that male students would earn higher Geometry SOL scores. The equation for this model is as follows:

$$\hat{Y} = 607.71 - 12.47\alpha + 2.08\beta - 23.04\gamma - 17.22\delta - 5.93\varepsilon + 16.83\zeta - 10.49\eta - 19.32\theta, \quad (1)$$

where \hat{Y} = Geometry SOL score, α = gender (0 for male, 1 for female), β = age, γ = African American status (0 for no, 1 for yes), δ = Asian status, ε = Hispanic status, ζ = Caucasian status, η = ESOL status, and θ = grade level.

The change in R^2 value for the second level of this hierarchical regression model was significant, $\Delta R^2 = .27$, $F(7, 140) = 9.86$, $p < .001$. At this second level, grade and gender were no longer significant predictors of Geometry SOL performance. Rather, the three significant predictors at this level were African American status ($\beta = -.23$, $t = -2.47$, $p < .05$), Algebra 1 SOL prior achievement ($\beta = .36$, $t = 4.55$, $p < .001$), and self-concept ($\beta = .23$, $t = 2.59$, $p < .05$). For Algebra 1 SOL prior achievement and self-concept, both standardized coefficients were positive, meaning that those students with

higher levels of Algebra 1 SOL prior achievement and higher self-reported levels of self-concept were predicted to have higher Geometry SOL scores. On the other hand, the standardized coefficient in this model for African American status was negative, meaning that African American students were predicted to have lower Geometry SOL scores than other students. The equation for this model is as follows:

$$\begin{aligned}\hat{Y} = & 262.71 - 9.43\alpha + 4.05\beta - 23.14\gamma - 12.55\delta - 12.24\epsilon - 0.82\zeta + 2.22\eta - 11.47\theta \\ & + 0.49\iota + 1.52\kappa + 1.75\lambda - 0.91\mu + 0.52\nu - 0.53\xi + 0.60o,\end{aligned}\quad (2)$$

where \hat{Y} = Geometry SOL score, α = gender (0 for male, 1 for female), β = age, γ = African American status (0 for no, 1 for yes), δ = Asian status, ϵ = Hispanic status, ζ = Caucasian status, η = ESOL status, θ = grade level, ι = Algebra 1 SOL score, κ = Algebra 1 classroom grade, λ = self-concept score, μ = expectancy score, ν = gender stereotype score, ξ = cultural stereotype score, and o = long-term goal score.

At the first level of the model, African American status was not significant, but in the second level, African American status became a significant predictor of Geometry SOL scores. This phenomenon is indicative of a suppressor effect. A suppressor variable is one whose inclusion in a regression model increases another variable's influence on the dependent variable (Conger, 1974; Horst, 1941; Smith, Ager, & Williams, 1992). This suppression effect seems to be the result of a relationship between African American status and one or more variables added at the second level of this model. Upon further analysis, I determined that Algebra 1 SOL prior achievement, Algebra 1 classroom grade

prior achievement, and self-concept all had a suppressor effect on African American status. While it is difficult to interpret this effect, it may have arisen from overlapping error variances among the variables (Conger, 1974; Warner, 2013). Further investigation is needed to interpret the complex relationship among these predictors.

On the third level of this model, the change in R^2 for the model was not significant, $\Delta R^2 = .01$, $F(4, 136) = .43$, $p > .05$. This finding indicates that the variables added at this level (i.e., intrinsic value, utility value, attainment value, and cost) did not significantly add to the predictivity of the model. In this level, the same three variables as in the previous level significantly predicted Geometry SOL scores: African American status ($\beta = -.23$, $t = -2.37$, $p < .05$), Algebra 1 SOL prior achievement ($\beta = .35$, $t = 4.32$, $p < .001$), and self-concept ($\beta = .34$, $t = 2.58$, $p < .05$). The equation for this model is as follows:

$$\begin{aligned}\hat{Y} = & 256.30 - 9.20\alpha + 3.83\beta - 23.04\gamma - 13.31\delta - 12.48\varepsilon - 1.74\zeta + 4.68\eta - 11.93\theta \\ & + 0.478 + 1.62\kappa + 2.58\lambda - 0.76\mu + 0.35\nu - 0.55\xi + 0.76\omicron - 0.48\pi + 0.22\rho - 0.22\sigma \\ & + 0.29\tau,\end{aligned}\tag{3}$$

where \hat{Y} = Geometry SOL score, α = gender (0 for male, 1 for female), β = age, γ = African American status (0 for no, 1 for yes), δ = Asian status, ε = Hispanic status, ζ = Caucasian status, η = ESOL status, θ = grade level, ι = Algebra 1 SOL score, κ = Algebra 1 classroom grade, λ = self-concept score, μ = expectancy score, ν = gender stereotype

score, ξ = cultural stereotype score, ω = long-term goal score, π = intrinsic value score, ρ = utility value score, σ = attainment value score, and τ = cost score.

Geometry classroom grades. The next hierarchical regression determined which variables significantly predict geometry classroom grades. Table 15 displays the unstandardized coefficients, standard error of the unstandardized coefficients, and standardized coefficients of each variable in the model, as well as the change in R^2 value for each level of the hierarchical model.

Table 15

Hierarchical Regression Analysis for Variables Predicting Geometry Classroom Grades

Variable	Level 1			Level 2			Level 3		
	B	SE	β	B	SE	β	B	SE	β
Age	-.56	1.32	-.05	.10	1.10	.01	.46	1.16	.04
Grade level	-5.18	1.85	-.32**	-3.36	1.57	-.21*	-3.71	1.58	-.23*
African American	-2.25	2.94	-.08	-4.63	2.40	-.17	-5.04	2.45	-.18*
Asian	4.63	2.87	.18	-.12	2.40	-.01	-.20	2.40	-.01
Hispanic	-2.42	2.68	-.11	-4.45	2.23	-.20*	-4.56	2.24	-.21*
Caucasian	1.36	3.05	.05	-3.50	2.60	-.12	3.33	2.60	-.11
ESOL status	4.46	4.01	.09	6.96	3.48	.15*	6.74	3.54	.14
Gender	-.17	1.55	-.01	.63	1.34	.03	.40	1.35	.02
Algebra 1 SOL				.06	.03	.15*	.05	.03	.14
Algebra 1 grade				1.00	.35	.20**	1.12	.35	.23**
Self-concept				.82	.17	.39**	1.05	.25	.51**
Expectancy				.40	.40	.07	.18	.46	.03
Long-term goals				-.16	.22	-.05	-.16	.27	-.05
Gender stereotype				-.08	.28	-.02	-.01	.28	-.01
Cultural stereotype				-.05	.15	-.02	-.11	.15	-.05
Intrinsic value							.09	.24	.04
Utility value							-.12	.11	-.13
Attainment value							.23	.15	.19
Cost							.15	.09	.19
Change in R^2		.22**			.30**			.02	

* $p < .05$. ** $p < .01$

The first level of the model predicting geometry classroom grades was significant, $R^2 = .22$, $F(8, 151) = 5.25$, $p < .001$. The only variable that significantly predicted geometry classroom grades at this level was grade level ($\beta = -.32$, $t = -2.80$, $p < .01$). The negative standardized coefficient indicates that students at lower grade levels were predicted to have higher geometry classroom grades. The equation for this model is as follows:

$$\hat{Y} = 137.39 - 0.17\alpha - 0.56\beta - 2.25\gamma + 4.63\delta - 2.42\varepsilon + 1.36\zeta + 4.46\eta - 5.18\theta, \quad (4)$$

where \hat{Y} = geometry classroom grade, α = gender (0 for male, 1 for female), β = age, γ = African American status (0 for no, 1 for yes), δ = Asian status, ε = Hispanic status, ζ = Caucasian status, η = ESOL status, and θ = grade level.

At the second level, the model and the change in R^2 were both significant, $\Delta R^2 = .30$, $F(7, 144) = 12.43$, $p < .001$. Six variables were significant predictors of geometry classroom grades at this level: Hispanic status ($\beta = -.20$, $t = -1.99$, $p < .05$), ESOL status ($\beta = .15$, $t = 2.00$, $p < .05$), grade level ($\beta = -.21$, $t = -2.13$, $p < .05$), Algebra 1 SOL prior achievement ($\beta = .15$, $t = 2.02$, $p < .05$), Algebra 1 classroom grade prior achievement ($\beta = .20$, $t = 2.87$, $p < .01$), and self-concept ($\beta = .39$, $t = 4.86$, $p < .001$). For Hispanic status, the standardized coefficient was negative, indicating that the model predicted Hispanic students would earn significantly lower geometry classroom grades than students who are not Hispanic. On the other hand, for ESOL status, the standardized coefficient was positive, indicating that students enrolled in an ESOL class at the time of the study were

predicted to earn higher geometry classroom grades than those who are not ESOL students. As mentioned previously, statistics involving ESOL status should be taken lightly, given that so few students in this study reported being enrolled in an ESOL course. The negative standardized coefficient for grade level indicated that students in lower grade levels were predicted to earn higher geometry classroom grades. The equation for this model is as follows:

$$\hat{Y} = 67.23 + 0.63\alpha + 0.10\beta - 4.63\gamma - 0.12\delta - 4.45\varepsilon - 3.50\zeta + 6.96\eta - 3.36\theta + 0.06\iota + 1.00\kappa + 0.82\lambda + 0.40\mu - 0.08\nu - 0.05\xi - 0.16\omicron, \quad (5)$$

where \hat{Y} = geometry classroom grade, α = gender (0 for male, 1 for female), β = age, γ = African American status (0 for no, 1 for yes), δ = Asian status, ε = Hispanic status, ζ = Caucasian status, η = ESOL status, θ = grade level, ι = Algebra 1 SOL score, κ = Algebra 1 classroom grade, λ = self-concept score, μ = expectancy score, ν = gender stereotype score, ξ = cultural stereotype score, and \omicron = long-term goal score.

Similar to the model predicting Geometry SOL scores, a suppression effect occurred in the model predicting geometry classroom grades; that is, this model contained two variables (specifically, Hispanic status and ESOL status) that were not significant predictors at the first level, but became significant predictors at the second level. As mentioned previously, the interaction among these variables and the suppressor variables (i.e., the variables causing one or more other variables to increase in predictability) is difficult to interpret (Conger, 1974; Smith et al., 1992) and beyond the

scope of this study. Further research is needed to determine the exact relationships among these variables.

Finally, for the third level of this model, the change in R^2 was not significant, $\Delta R^2 = .02$, $F(4, 140) = 1.61$, $p > .05$. None of the four variables introduced at this level (e.g., utility value, attainment value, intrinsic value, and cost) were found to be significant predictors of geometry classroom grades. At this level, five variables were significant predictors of geometry classroom grades: African American status ($\beta = -.18$, $t = -2.06$, $p < .05$), Hispanic status ($\beta = -.21$, $t = -2.03$, $p < .05$), grade level ($\beta = -.23$, $t = -2.35$, $p < .05$), Algebra 1 classroom grade prior achievement ($\beta = .23$, $t = 3.17$, $p < .01$), and self-concept ($\beta = .51$, $t = 4.17$, $p < .001$). The equation for this model is as follows:

$$\begin{aligned}\hat{Y} = & 55.78 + 0.40\alpha + 0.46\beta - 5.04\gamma - 0.20\delta - 4.56\varepsilon - 3.71\zeta + 6.74\eta - 3.71\theta + \\ & 0.05\iota + 1.12\kappa + 1.05\lambda + 0.18\mu - 0.01\nu - 0.11\xi - 0.16\omicron + 0.09\pi - 0.12\rho - 0.23\sigma + \\ & 0.15\tau,\end{aligned}\tag{6}$$

where \hat{Y} = geometry classroom grade α = gender (0 for male, 1 for female), β = age, γ = African American status (0 for no, 1 for yes), δ = Asian status, ε = Hispanic status, ζ = Caucasian status, η = ESOL status, θ = grade level, ι = Algebra 1 SOL score, κ = Algebra 1 classroom grade, λ = self-concept score, μ = expectancy score, ν = gender stereotype score, ξ = cultural stereotype score, \omicron = long-term goal score, π = intrinsic value score, ρ = utility value score, σ = attainment value score, and τ = cost score.

While none of the variables added at the third level were significant predictors, several changes occurred at this level. For example, Algebra 1 SOL prior achievement and ESOL status were no longer significant predictors of geometry classroom grade at this level. Additionally, Hispanic status became a significant predictor of geometry classroom grades even though it was not so at the second level, indicating the occurrence of another suppressor effect.

Algebra 2 SOL scores. Algebra 2 SOL scores were used as the dependent variable in the third hierarchical regression model. Table 16 shows the model information for the variables predicting Algebra 2 SOL scores.

The first level of this hierarchical model was significant, $R^2 = .40$, $F(8, 81) = 6.74$, $p < .001$. There were two significant predictors of Algebra 2 SOL scores at this level: grade level ($\beta = -.64$, $t = -4.15$, $p < .001$) and ESOL status ($\beta = .20$, $t = 2.08$, $p < .05$). In terms of grades, the negative standardized coefficient indicates that the model predicted students in lower grades would score higher on their Algebra 2 SOL. On the other hand, the ESOL status variable was dichotomous, simply indicating whether a student was enrolled in an ESOL class at the time of the study (e.g., 0 for no, 1 for yes). The positive standardized coefficient for ESOL status in this model suggests that students who were enrolled in an ESOL course at the time of the study were predicted to have higher Algebra 2 SOL scores. However, as I mentioned earlier, these results should be taken lightly given the very small number of ESOL students who participated in this study. Additionally, the high standard error value for ESOL status in this model supports this recommendation. The equation for this model is as follows:

$$\hat{Y} = 844.99 + 14.29\alpha + 5.27\beta + 0.67\gamma + 18.86\delta + 22.22\varepsilon + 34.72\zeta + 76.83\eta - 47.13\theta, \quad (7)$$

where \hat{Y} = Algebra 2 SOL scores, α = gender (0 for male, 1 for female), β = age, γ = African American status (0 for no, 1 for yes), δ = Asian status, ε = Hispanic status, ζ = Caucasian status, η = ESOL status, and θ = grade level.

At the second level of this model, the change in R^2 was significant, $\Delta R^2 = .25$, $F(9, 72) = 5.87$, $p < .001$. Grade level remained a significant predictor of Algebra 2 SOL scores ($\beta = -.37$, $t = -2.75$, $p < .01$), whereas ESOL status became nonsignificant ($\beta = .13$, $t = 1.64$, $p > .05$). The two additional variables that were significant predictors of Algebra 2 SOL scores were Geometry SOL prior achievement ($\beta = .24$, $t = 2.35$, $p < .05$) and geometry classroom grade prior achievement ($\beta = .24$, $t = 2.36$, $p < .05$). Both of these standardized coefficients were positive, meaning that it was predicted that students with higher levels of prior achievement in Geometry SOL and geometry classroom grades would score higher on the Algebra 2 SOL. The equation for this model is as follows:

$$\hat{Y} = 311.65 - 1.69\alpha + 6.25\beta - 11.54\gamma + 8.72\delta + 20.77\varepsilon + 9.38\zeta + 50.78\eta - 27.44\theta + 0.19\iota + 3.95\kappa + 0.34\varphi + 5.65\chi + 0.95\lambda + 2.44\mu + 2.73\nu - 1.09\xi - 0.12\omicron, \quad (8)$$

where \hat{Y} = Algebra 2 SOL scores, α = gender (0 for male, 1 for female), β = age, γ = African American status (0 for no, 1 for yes), δ = Asian status, ε = Hispanic status, ζ = Caucasian status, η = ESOL status, θ = grade level, ι = Algebra 1 SOL score, κ = Algebra 1 classroom grade, ϕ = Geometry SOL score, χ = geometry classroom grade, λ = self-concept score, μ = expectancy score, ν = gender stereotype score, ξ = cultural stereotype score, and ω = long-term goal score.

Finally, the third level of the model did not have a significant change in R^2 , $\Delta R^2 = .01$, $F(4, 68) = .26$, $p > .05$. As a result, none of the variables added at this level (i.e., intrinsic value, utility value, attainment value, and cost) were significant predictors of Algebra 2 SOL scores over and above the variables already in the model. Grade level ($\beta = -.40$, $t = -2.78$, $p < .01$), Geometry SOL prior achievement ($\beta = .24$, $t = 2.20$, $p < .05$), and Geometry classroom grade prior achievement ($\beta = .23$, $t = 2.20$, $p < .05$) remained significant predictors of Algebra 2 SOL scores. The equation for this model is as follows:

$$\begin{aligned}\hat{Y} = & 356.57 - 2.50\alpha + 6.80\beta - 11.13\gamma + 10.54\delta + 21.21\varepsilon + 11.32\zeta + 54.04\eta - \\ & 29.48\theta + 0.19\iota + 3.55\kappa + 0.34\phi + 5.51\chi - 0.47\lambda + 1.36\mu + 2.41\nu - 1.03\xi - 0.19\omega + \\ & 0.80\pi + 0.13\rho + 0.10\sigma - 0.43\tau,\end{aligned}\tag{9}$$

where \hat{Y} = Algebra 2 SOL scores, α = gender (0 for male, 1 for female), β = age, γ = African American status (0 for no, 1 for yes), δ = Asian status, ε = Hispanic status, ζ = Caucasian status, η = ESOL status, θ = grade level, ι = Algebra 1 SOL score, κ = Algebra 1 classroom grade, ϕ = Geometry SOL score, χ = geometry classroom grade, λ = self-

concept score, μ = expectancy score, v = gender stereotype score, ξ = cultural stereotype score, o = long-term goal score, π = intrinsic value score, ρ = utility value score, σ = attainment value score, and τ = cost score.

Table 16

Hierarchical Regression Analysis for Variables Predicting Algebra 2 SOL Scores

Variable	Level 1			Level 2			Level 3		
	B	SE	β	B	SE	β	B	SE	β
Age	5.27	8.23	.11	6.25	6.84	.13	6.80	7.04	.14
Grade level	-47.13	11.36	-.64**	-27.44	9.98	-.37**	-29.48	10.62	-.40**
African American	.67	18.21	.01	-11.54	15.08	-.07	-11.13	16.34	-.07
Asian	18.86	15.70	.15	8.72	13.32	.07	10.54	13.85	.08
Hispanic	22.22	15.31	.18	20.77	13.29	.17	21.21	14.10	.18
Caucasian	34.72	19.36	.19	9.38	16.38	.05	11.32	17.32	.06
ESOL status	76.83	36.87	.20*	50.78	31.01	.13	54.04	32.00	.14
Gender	14.29	10.06	.13	-1.69	9.20	-.02	-2.50	9.68	-.02
Algebra 1 SOL				.19	.20	.10	.19	.21	.10
Algebra 1 grade				3.95	2.40	.15	3.55	2.51	.13
Geometry SOL				.34	.15	.24*	.34	.15	.24*
Geometry grade				5.65	2.40	.24*	5.51	2.50	.23*
Self-concept				.95	1.09	.08	-.47	1.94	-.04
Expectancy				2.44	2.76	.08	1.36	3.08	.04
Long-term goals				.12	1.44	.01	-.19	1.76	-.01
Gender stereotype				2.73	2.35	.09	2.41	2.46	.08
Cultural stereotype				-1.09	1.17	-.08	-1.03	1.21	-.07
Intrinsic value							.80	1.82	.07
Utility value							.13	.74	.03
Attainment value							.10	.90	.02
Cost							-.43	.64	-.08

Table 16, continued

Hierarchical Regression Analysis for Variables Predicting Algebra 2 SOL Scores

	Level 1	Level 2	Level 3
Change in R^2	.40**	.25**	.01

* $p < .05$. ** $p < .01$.

Algebra 2 classroom grades. Finally, the fourth regression model determined factors that significantly predict Algebra 2 classroom grades. Table 17 shows the coefficients of the variables predicting Algebra 2 classroom grades and the change in R^2 for each level of the model.

The first level of the model predicting Algebra 2 classroom grades was significant, $R^2 = .38$, $F(8, 84) = 6.35$, $p < .001$. The three variables that were found to be significant predictors of Algebra 2 classroom grades were Caucasian status ($\beta = .22$, $t = 2.03$, $p < .05$), grade level ($\beta = -.50$, $t = -3.21$, $p < .01$), and gender ($\beta = .28$, $t = 3.12$, $p < .01$). For Caucasian status, the standardized coefficient was positive, indicating that the model predicted that Caucasian students would earn higher Algebra 2 classroom grades. For grade level, the standardized coefficient was negative, meaning that students in lower grades were predicted to earn higher Algebra 2 classroom grades. For gender, the standardized coefficient was positive. Because 0 was used for males, and 1 was used for

females, the positive coefficient indicated that females were predicted to have higher Algebra 2 classroom grades. The equation for this model is as follows:

$$\hat{Y} = 120.80 + 4.87\alpha + 0.93\beta + 0.28\gamma + 4.18\delta - 0.83\varepsilon + 6.02\zeta + 4.99\eta - 5.70\theta, (10)$$

where \hat{Y} = Algebra 2 classroom grade, α = gender (0 for male, 1 for female), β = age, γ = African American status (0 for no, 1 for yes), δ = Asian status, ε = Hispanic status, ζ = Caucasian status, η = ESOL status, and θ = grade level.

The second level of the model predicting Algebra 2 classroom grades was significant, and the change in R^2 was also significant, $\Delta R^2 = .28$, $F(9, 75) = 6.67$, $p < .001$. Grade level ($\beta = -.32$, $t = -2.43$, $p < .05$), Algebra 1 SOL prior achievement ($\beta = -.30$, $t = -2.74$, $p < .01$), Algebra 1 classroom grade prior achievement ($\beta = .26$, $t = 3.05$, $p < .01$), geometry classroom grade prior achievement ($\beta = .46$, $t = 4.65$, $p < .001$), and self-concept ($\beta = .30$, $t = 3.27$, $p < .01$) were all found to be significant predictors for Algebra 2 classroom grades. One odd finding at this level was that Algebra 1 SOL prior achievement had a negative standardized coefficient, meaning that students who scored lower on their Algebra 1 SOL were predicted to earn higher Algebra 2 classroom grades. All other continuous variables (e.g., Algebra 1 classroom grade prior achievement, geometry classroom grade prior achievement, and self-concept) had positive standardized coefficients, meaning that they all positively significantly predicted Algebra 2 classroom grades. The equation for this model is as follows:

$$\hat{Y} = 114.38 + 1.93\alpha + 0.57\beta - 0.36\gamma + 1.57\delta + 0.69\varepsilon + 2.69\zeta - 4.25\eta - 3.67\theta - 0.09\iota + 1.09\kappa + 0.01\varphi + 1.70\chi + 0.54\lambda + 0.56\mu + 0.22\nu - 0.03\xi - 0.16o, \quad (11)$$

where \hat{Y} = Algebra 2 classroom grade, α = gender (0 for male, 1 for female), β = age, γ = African American status (0 for no, 1 for yes), δ = Asian status, ε = Hispanic status, ζ = Caucasian status, η = ESOL status, θ = grade level, ι = Algebra 1 SOL score, κ = Algebra 1 classroom grade, φ = Geometry SOL score, χ = geometry classroom grade, λ = self-concept score, μ = expectancy score, ν = gender stereotype score, ξ = cultural stereotype score, and o = long-term goal score.

Finally, the third level of this model did not show a significant change in R^2 value, $\Delta R^2 = .01$, $F(4, 71) = .37$, $p > .05$. As with all other models, the subjective task value variables were not found to be significant. All five variables that were significant in the second level of the model were also significant at the third level. These variables include grade level ($\beta = -.33$, $t = -2.33$, $p < .05$), Algebra 1 SOL prior achievement ($\beta = -.31$, $t = -2.71$, $p < .01$), Algebra 1 classroom grade prior achievement ($\beta = .26$, $t = 2.93$, $p < .01$), geometry classroom grade prior achievement ($\beta = .48$, $t = 4.65$, $p < .001$), and self-concept ($\beta = .31$, $t = 2.00$, $p < .05$). The equation for this model is as follows:

$$\hat{Y} = 118.84 + 1.87\alpha + 0.52\beta + 0.35\gamma + 1.69\delta + 1.09\varepsilon + 2.54\zeta - 4.26\eta - 3.71\theta - 0.09\iota + 1.10\kappa - 0.01\varphi + 1.77\chi + 0.56\lambda + 0.71\mu + 0.24\nu - 0.05\xi - 0.04o + 0.01\pi + 0.03\rho - 0.14\sigma - 0.01\tau, \quad (12)$$

where \hat{Y} = Algebra 2 classroom grade, α = gender (0 for male, 1 for female), β = age, γ = African American status (0 for no, 1 for yes), δ = Asian status, ε = Hispanic status, ζ = Caucasian status, η = ESOL status, θ = grade level, ι = Algebra 1 SOL score, κ = Algebra 1 classroom grade, φ = Geometry SOL score, χ = geometry classroom grade, λ = self-concept score, μ = expectancy score, ν = gender stereotype score, ξ = cultural stereotype score, ω = long-term goal score, π = intrinsic value score, ρ = utility value score, σ = attainment value score, and τ = cost score.

Table 17

Hierarchical Regression Analysis for Variables Predicting Algebra 2 Classroom Grades

Variable	Level 1			Level 2			Level 3		
	B	SE	β	B	SE	β	B	SE	β
Age	.93	1.29	.12	.57	1.05	.07	.52	1.07	.07
Grade level	-5.70	1.78	-.50**	-3.67	1.51	-.32*	-3.71	1.59	-.33*
African American	.28	2.89	.01	-.36	2.34	-.01	.35	2.52	.01
Asian	4.18	2.48	.21	1.57	2.07	.08	1.69	2.14	.09
Hispanic	-.83	2.39	-.04	.69	2.05	.04	1.09	2.17	.06
Caucasian	6.02	2.96	.22*	2.69	2.43	.10	2.54	2.59	.09
ESOL status	4.99	5.83	.08	-4.25	4.80	-.07	-4.26	4.94	-.07
Gender	4.87	1.56	.28**	1.93	1.39	.11	1.87	1.44	.11
Algebra 1 SOL				-.09	.03	-.30**	-.09	.03	-.31**
Algebra 1 grade				1.09	.36	.26**	1.10	.38	.26**
Geometry SOL				.01	.02	.01	-.01	.02	-.01
Geometry grade				1.70	.37	.46**	1.77	.38	.48**
Self-concept				.54	.17	.30**	.56	.28	.31*
Expectancy				.56	.40	.12	.71	.45	.15
Long-term goals				-.16	.21	-.06	-.04	.27	-.02
Gender Stereotype				.22	.36	.05	.24	.37	.05
Cultural stereotype				-.03	.17	-.01	-.05	.18	-.03
Intrinsic value							.01	.27	.00
Utility value							.03	.11	.03
Attainment value							-.14	.14	-.14
Cost							-.01	.10	-.01

Table 17, continued

Hierarchical Regression Analysis for Variables Predicting Algebra 2 Classroom Grades

	Level 1	Level 2	Level 3
Change in R^2	.40**	.25**	.01

* $p < .05$. ** $p < .01$.

Comparison of hierarchical regression models. Similarities and differences exist among all hierarchical regression models generated in the analysis of the present study. Comparing and contrasting these models will shed light on how expectancy–value variables predict each mathematics achievement variable differently.

Comparison of Geometry SOL and geometry classroom grade models. The models predicting Geometry SOL scores and geometry classroom grades have some similarities. First, self-concept was found to be a significant predictor for both Geometry SOL scores and classroom grades. Second, students in lower grade levels were significantly predicted to have higher SOL scores and classroom grades in geometry. Third, African American status was found to be a significant predictor of both Geometry SOL scores and geometry classroom grades; specifically, African American students were predicted to have significantly lower SOL scores and classroom grades. However, for both models, a suppressor effect occurred that made African American status change from nonsignificant to significant.

These two models also have some differences. For instance, Algebra 1 SOL prior achievement was a significant predictor of Geometry SOL score, but not of geometry classroom grades. On the other hand, prior achievement as reflected in Algebra 1 classroom grade was a significant predictor of geometry classroom grades, but not of Geometry SOL scores. Next, Hispanic status was a significant predictor of geometry classroom grades, but not of Geometry SOL scores. Again, it is important to keep in mind that Hispanic status became significant due to a suppressor variable in the model.

Comparison of Geometry SOL and Algebra 2 SOL models. The models predicting Geometry SOL scores and Algebra 2 SOL scores have some similarities. First, in both models, it was found that grade level significantly predicted SOL scores; specifically, students in lower grades were found to score significantly higher than students in upper grades. An explanation is that students taking these courses early in high school typically might have been eligible for honors courses. However, the sample in this study was obtained from on-level courses. Therefore, it is possible that younger students in these on-level courses had skills that placed them in honors-level courses, but they chose to take the on-level course instead.

A second similarity between these two models was that neither model found any subjective task value variable to be a significant predictor of SOL scores. Guo, Marsh, et al. (2015) found that subjective task value variables were predictors of mathematics achievement, a finding which seems to oppose the finding in the present study. On the other hand, Farrington and colleagues (2012) indicated that motivational constructs did not impact standardized test as much as they impacted classroom grades. Further

comparisons are needed of SOL achievement and classroom grades to determine the extent to which this literature is supported.

Third, prior achievement was a significant predictor of both models. For geometry, Algebra 1 SOL prior achievement significantly predicted Geometry SOL scores, and for Algebra 2, both Geometry SOL and geometry classroom grade prior achievement both predicted Algebra 2 SOL scores. However, the type and extent of prior achievement differs between the two models. For geometry, previous Algebra 1 SOL achievement predicted current course SOL achievement, whereas for Algebra 2, both SOL and classroom grades predicted Algebra 2 SOL achievement. Neither Algebra 1 SOL nor Algebra 1 classroom grade prior achievement predicted Algebra 2 SOL scores. This was a surprising find, given the amount of overlap between the two curricula.

Another difference between the two models was the influence of self-concept. Self-concept was a significant predictor of Geometry SOL achievement but not of Algebra 2 SOL achievement. While self-concept may have predicted achievement in Algebra 2 SOL, it did not do so over and above the other significant predictors.

Comparison of Algebra 2 SOL and Algebra 2 classroom grade models. The models predicting Algebra 2 SOL scores and Algebra 2 classroom grades show some similarities. First, grade level was a significant predictor for both dependent variables. Specifically, students in lower grade levels were found to score higher in each category. Second, geometry classroom grade prior achievement significantly predicted Algebra 2 SOL scores and classroom grades. It was predicted that students who scored higher in

their previous geometry course would achieve higher Algebra 2 classroom grades and Algebra 2 SOL scores.

On the other hand, the models show some differences in terms of predictor variables. In the Algebra 2 SOL model, Geometry SOL prior achievement was a significant predictor, but not in the Algebra 2 classroom grade model. In the Algebra 2 classroom grade model, Algebra 1 prior achievement (both SOL and classroom grade) and self-concept were significant predictors but not in the Algebra 2 SOL model. However, Algebra 1 SOL prior achievement was negatively correlated with Algebra 2 classroom grades, which is a finding that should be taken lightly.

Comparison of all hierarchical regression models. Of the four models calculated in this study, some comparisons can be made for all of them. For example, each model found that at least one type of prior achievement was a significant predictor. Although this specific prior achievement variable varied by model, this study has found the importance of this factor in mathematics achievement. Next, three out of the four models found that self-concept predicted mathematics achievement. The only dependent variable that self-concept was not found to predict was the Algebra 2 SOL score. Furthermore, the third level of each model, which was the one at which each subjective task value variable was added, did not add any significant predictability to the model. As a result, intrinsic value, utility value, attainment value, and cost were not predictors for any mathematics achievement variable.

Research Question 2. The second research question asks: Is there a main effect of type of mathematics course (i.e., geometry, Algebra 2), main effect of gender, and

interaction effect between gender and type of mathematics course on expectancy–value factors (e.g., cultural milieu, child’s perception, stable child, previous achievement, child’s goals and general self-schemata, child’s interpretations of experience, expectation of success, subjective task value)? This question was answered by running a 2×2 factorial MANOVA. The same descriptive statistics described earlier in this chapter, represented in Table 11, Table 12, and Table 13, all apply to the second research question as well. As mentioned previously, rather than using each individual expectancy–value variable collected in the study, I grouped them into factors outlined by the Eccles et al. (1983) model.

For all MANOVA calculations, SPSS reported partial η^2 as the effect size. According to Miles and Shevlin (2001), a partial η^2 value of .01 or less is considered small, a partial η^2 value of 0.06 is considered medium, and a partial η^2 value of 0.14 or more is considered large. Partial η^2 is calculated by using the following equation:

$$\text{partial } \eta^2 = \frac{SS_{\text{effect}}}{(SS_{\text{effect}} + SS_{\text{error}})} , \quad (13)$$

where SS_{effect} represents the sum of squares of the effect of the variable, and SS_{error} represents the sum of squares of the error variance.

Factors. Cultural milieu contains gender role stereotypes, cultural stereotypes, and family demographics. Specific demographics, such as ethnicity, were analyzed in the preliminary analysis section of this study, and were not included with this research question. Therefore, cultural stereotype and gender stereotype questions were included in this factor. Because the child’s perception factor contained items similar to those of the cultural milieu factor (e.g., gender roles), they were not analyzed as two separate factors.

The survey used in this study contained three questions measuring gender stereotype beliefs and five questions measuring cultural stereotype beliefs. To include both of these in the same factor without having one variable outweigh the other, I found the average value of the response for the gender stereotype questions and added it to the average value of the response for the cultural stereotype questions. This new value was used as the Cultural Milieu factor.

The stable child factor contains aptitudes of child and siblings, child gender, and birth order. Gender was used as a fixed factor in this 2×2 factorial MANOVA. The other two items within this factor were not collected in this study. As a result, stable child was not used as a separate factor in this study.

Next, previous achievement, in the context of this study, contains previous SOL scores and classroom grades. For students in a geometry class at the time of this study, these were an Algebra 1 SOL score and an Algebra 1 classroom grade. For students in an Algebra 2 class at the time of this study, these were an Algebra 1 SOL score, an Algebra 1 classroom grade, a Geometry SOL score, and a geometry classroom grade. Classroom grades were converted to a numerical value by using a 10-point scale (see Table 4 for conversions), whereas SOL scores were based on a scale with a maximum score of 600, but no set minimum score. Given the inability to accurately convert either value to the same scale as the other value, I included an average value of prior SOL scores and an average value of prior classroom grades separately in the factorial MANOVA. For students enrolled in a geometry class at the time of the study, I only used prior achievement in Algebra 1. For students enrolled in an Algebra 2 class at the time of the

study, I used an average of prior achievement from Algebra 1 and geometry. If any values were missing, I only used the values that had been completed.

According to the Eccles et al. (1983) model, child's goals and self-schemata contain personal and social identities, short-term goals, long-term goals, ideal self, and self-concept. On the basis of the items collected in this study, long-term goals and self-concept was included in this factor. The survey used in this study contained three questions measuring long-term goals and four questions measuring self-concept. To include both of these in the same factor without having one variable outweigh the other, I found the average value of the response for the long-term goals, and added it to the average value of the response for the self-concept. This new value was used as the child's goals and self-schemata factor.

Child's interpretation of experience was another factor in the Eccles et al. (1983) model of expectancy-value theory. Originally, I had intended to include students' self-reported prior achievement (i.e., SOL scores and classroom grades) for this factor. However, as mentioned previously in this chapter, I experienced unexpected responses on the survey that did not accurately reflect students' prior achievement or were not easily interpretable in any analysis. Therefore, unfortunately, child's interpretation of experience was not included in the second research question analysis.

Next, expectation of success was included as a factor in the analysis of the second research question. Only one variable, expectancy, was included within this factor. No additional changes needed to be made to include this factor in the factorial MANOVA.

Finally, subjective task value includes interest (i.e., intrinsic value), attainment value, utility value, and relative cost. The survey used in this study contained four questions measuring intrinsic value, 12 questions measuring utility value, 10 questions measuring attainment value, and 11 questions measuring cost. To include all of these in the same factor without having one variable outweigh the other, I found the average value of the response for each variable and added them together. This new value was used as the subjective task value factor.

Results of factorial MANOVA. Table 18 shows the results of the 2×2 factorial MANOVA test. Box's tests for equality of covariance was found to be insignificant, $F(63, 117214.52) = 1.09, p > .05$. Levene's test of equality of error variances found to be nonsignificant for all dependent variables, indicating that the error variances of each dependent variable were equal across all groups (Warner, 2013). Wilks's lambda was found to be significant for current course, $\Lambda = 0.95, F(6, 256) = 2.13, p = .05$, partial $\eta^2 = .05$, with an effect size considered just below medium. Wilks's lambda was also found to be significant for gender, $\Lambda = 0.90, F(6, 256) = 4.88, p < .001$, partial $\eta^2 = .10$, with an effect size between medium and large. However, Wilks's lambda was found to be not significant for the interaction between current course and gender, $\Lambda = 0.98, F(6, 256) = 1.02, p > .05$, partial $\eta^2 = .02$, and the effect size was found to be small.

Table 18

Multivariate Test of Gender and Current Course on Expectancy–Value Factors

	Wilks's Lambda	F	Hypothesis <i>df</i>	Error <i>df</i>	<i>p</i>	Partial η^2
Course	.95	2.13	6	256	.05	.05
Gender	.90	4.88	6	256	.00	.10
Course * Gender	.98	1.02	6	256	.41	.02

Main effect of current course. Table 19 shows the results of the between-subjects effects of the 2×2 factorial MANOVA test. The test of between-subjects effects determined that the only dependent variable that was significantly different by current course was average prior classroom grade: $F(1) = 6.41$, $p = .01$, partial $\eta^2 = .02$. The effect size for this calculation is considered small (Miles & Shevlin, 2001). Comparing the mean differences of the two courses yielded the result that students in geometry had higher prior classroom grades than students in Algebra 2. Because this variable consists only of Algebra 1 grades for geometry students but of both Algebra 1 and geometry grades for Algebra 2 students, I conducted post-hoc analysis using the Algebra 2 sample to determine which prior classroom grade was higher. Further analysis determined that within the Algebra 2 sample, Algebra 1 prior classroom grade ($\bar{x} = 6.08$) had a significantly larger mean than geometry prior classroom grade ($\bar{x} = 5.31$). Therefore,

within the Algebra 2 sample, geometry prior classroom grades were significantly lower than Algebra 1 prior classroom grades.

Table 19

Between-Subjects Effects of Current Course and Gender on Expectancy–Value Factors

Factor	F	<i>p</i>	Partial η^2
Course			
Cultural milieu	1.08	.30	.004
Goals & self-schemata	.15	.70	.001
Expectancy	.45	.51	.002
Subjective task value	.01	.92	.000
Prior SOL scores	.13	.71	.001
Prior classroom grades	6.41	.01	.024
Gender			
Cultural milieu	4.77	.03	.018
Goals & self-schemata	2.18	.14	.008
Expectancy	2.59	.11	.010
Subjective task value	.08	.78	.000
Prior SOL scores	.55	.46	.002
Prior classroom grades	8.89	.01	.033
Course * Gender			
Cultural milieu	2.22	.14	.008
Goals & self-schemata	2.61	.11	.010
Expectancy	.01	.97	.000
Subjective task value	.88	.35	.003
Prior SOL scores	.01	.92	.000
Prior classroom grades	.87	.35	.003

Main effect of gender. The test of between-subjects effects showed that the factors that were significantly different by gender were cultural milieu: $F(1) = 4.77, p < .05$, partial $\eta^2 = .02$; and prior classroom grades: $F(1) = 8.89, p < .01$, partial $\eta^2 = .03$; but both had a relatively small effect size value. In terms of prior classroom grades, males ($\bar{x} = 5.66$) had a significantly lower average classroom grade than females ($\bar{x} = 6.41$).

In terms of cultural milieu, a pairwise comparison showed that males reported higher levels for this factor. Because the cultural milieu factor consists of more than one variable (e.g., cultural stereotype and gender stereotype), I decided to run a follow-up analysis to determine which variable or variables significantly differed by gender. Specifically, I ran a one-way MANOVA test with gender as the fixed factor and gender stereotype and cultural stereotype as the dependent variables. For this one-way MANOVA, Box's tests for equality of covariance was found to be insignificant: $F(3, 51454897.32) = 1.31, p > .05$. However, Levene's test of equality of error variances found that error variances were not equal across the gender stereotype responses, $F(1, 298) = 4.42, p < .05$. Therefore, results regarding this variable must be considered with caution.

Wilks's lambda for this one-way MANOVA was found to be significant for gender with a small to medium effect size, $\Lambda = 0.97, F(2, 297) = 5.33, p < .01$, partial $\eta^2 = .04$. The test of between-subjects effects determined that gender stereotype was significantly different by gender, $F(1) = 5.53, p < .01$. Specifically, males were more in agreement with the gender stereotype questions on the survey. Based on the way that the gender stereotype questions were worded on the survey (e.g., "In general, men may be

better than women at Geometry [or Algebra 2]”), men had a stronger belief that females do not perform as well in mathematics than men. However, on the basis of the previous results regarding the main effect of current course, this belief did not differ by mathematics course. Cultural stereotype was not significantly different by gender, $F(1) = 2.81, p > .05$.

Interaction effect of current course and gender. In addition to the main effects of gender and current course, the interaction effect between these two variables was tested. Wilks’s Lambda was found to be not significant for this interaction with a small effect size, $\Lambda = 0.98, F(6, 256) = 1.02, p > .05$, partial $\eta^2 = .02$. This finding indicated that the impact of one fixed factor (e.g., gender or current course) did not depend on the other fixed factor. Because this interaction effect was not significant, no follow-up tests were performed.

Chapter Five

Restatement of Purpose

The purpose of this study was to determine if expectancy–value factors predicted classroom grades and standardized test scores differently for algebra and geometry. Additionally, the purpose of the study was to determine if responses for expectancy–value variables were significantly different by gender or mathematics course. The statistical analyses outlined in Chapter 4 addressed these questions; Chapter 5 presents a discussion of the results of these analyses and compares and contrasts them with the literature in the field.

Discussion of Findings

First research question. The first research question asked: To what extent do expectancy–value beliefs predict achievement on high-stakes mathematics assessments and classroom grades? To answer this question, I conducted four separate hierarchical multiple regression models: one for Geometry SOL scores, one for geometry classroom grades, one for Algebra 2 SOL scores, and one for Algebra 2 classroom grades.

Descriptive statistics. Preliminary analyses were conducted to provide details about descriptive statistics. First, in the confirmatory factor analysis and the Pearson correlation coefficients, it was found that cost and self-concept cross-loaded onto the same factor. This suggested that, even though each variable was in a different factor in

the expectancy–value theory model (Eccles et al., 1983), there is a significant amount of similarity between these two motivational constructs. In terms of the present study, this multicollinearity was considered when data were interpreted and new models representing motivation in algebra and geometry were constructed separately. Although subsequent analyses were conducted with these two variables separately, it should be noted that Pajares and Miller (1994) also found self-concept and mathematics anxiety (i.e., cost) to be more strongly correlated than normal. Furthermore, in the preliminary analysis, I found multicollinearity between attainment value and utility value. Although this discovery posed an issue for the validity of the study, it mirrored the finding in the study by Trautwein and colleagues (2012). In both situations, the variables are within the same expectancy–value theory model (Eccles et al., 1983), and Eccles and Wigfield (2002) have stated that all variables and factors within the model are strongly correlated with one another. Therefore, the findings of these preliminary analyses are not surprising and support the literature regarding these variables.

Geometry SOL scores. For the model predicting Geometry SOL scores, two variables predicted achievement at the first level of the model but not at the second or third level: grade level and gender. In terms of grade level, it was predicted that students in lower grades would get higher Geometry SOL scores. This was a surprising finding given that Pajares and Miller (1994) found that students in higher grade levels performed better on mathematical tasks. However, the claim of Burger and Shaughnessy (1986) may explain this finding. According to their research, students who are exposed to geometric concepts in the van Hiele levels at an earlier age are able to move through these levels

more quickly than those students who were exposed to geometric concepts later in life. Additionally, the sample of the present study comprised students in on-level courses. It is also my proposition, based on the school population and my experience, that students who are taking geometry in earlier grades may have either taken an honors mathematics course previously or have skills that would have qualified them to take an honors mathematics course. Both of these explanations make it understandable that students in lower grade levels received better scores on the Geometry SOL than students in higher grade levels.

In terms of gender, it was found at the first level of the model, which predicted Geometry SOL scores on the basis of expectancy–value variables, that males were expected to score higher on the Geometry SOL than females. Liu and Wilson’s (2009) work supports the finding of this study; they found that males performed better on standardized tests than females. Specifically, for geometry, Pattison and Grieve (1984) stated that males typically performed better on tasks that involve spatial reasoning, whereas females performed better on tasks that involved logical thinking. On the basis of the curriculum in the present study (Virginia Department of Education, 2016), it appears that a majority of the material in the geometry course and standardized test involves spatial reasoning rather than logical reasoning. Therefore, the Geometry SOL lends itself to males performing better. However, it is important to keep in mind that gender was only a significant predictor at the first level of the model. This fact suggests that the predictability of gender on Geometry SOL is fully mediated by another predictor variable introduced at a later level.

Three variables predicted Geometry SOL scores at the third and final level of this model: Algebra 1 SOL prior achievement, self-concept, and African American status. The Algebra 1 SOL prior achievement variable supports a finding in a study by Marsh and Yeung (1998) in which they stated that student achievement was similar on tasks that were similar (e.g., grades, tests). It follows that students who did well on the Algebra 1 SOL would also perform well on the Geometry SOL. In terms of self-concept, many researchers have found that self-concept positively significantly predicts mathematics achievement (Marsh, 1989; Marsh et al., 2005, 2013; Pajares & Miller, 1994) and, therefore, it is no surprise that this finding was replicated in the present study. Finally, African American status negatively predicted Geometry SOL scores; that is, African American students were predicted to have significantly lower scores than other ethnicities. Steele and Aronson (1995) not only defined cultural stereotype in their study, but they also said that students in an ethnic minority would score lower on academic tasks because they believed in this stereotype, whether the belief was stated explicitly or not. The findings in the present study support this claim, although no other group composed of ethnic minority students (e.g., Hispanic) had any significant effects on Geometry SOL scores. Further research is needed to determine the differences that caused African American status, but not Hispanic status, to be a significant predictor.

Geometry classroom grades. Next, I discuss the results of the geometry classroom grades regression model and how they relate to the literature. Two forms of prior achievement were found to be predictors of geometry classroom grades: Algebra 1 SOL scores and Algebra 1 classroom grades. The Algebra 1 SOL was only a significant

predictor at the second level of the model, whereas the Algebra 1 classroom grade was a significant predictor at both the second and third levels of the model. As mentioned previously, Marsh and Yeung (1998) stated that achievement in a task predicted achievement in a similar type of task. The authors urged researchers to “consider school grades and test scores as separate constructs” (p. 729). Their finding supports the outcome found in this model; at the third level, geometry classroom grades were predicted by Algebra 1 classroom grades, but not by the Algebra 1 SOL score.

At the third level of this model, three other variables also predicted geometry classroom grades: grade level, African American status, and self-concept. Self-concept and African American status were both also predictors of Geometry SOL scores. I believe that the same literature supports the notion that these two variables are significant predictors of geometry classroom grades as well. In particular, for self-concept, Marsh and colleagues (2005) stated that self-concept was more highly correlated with classroom grades than with standardized test scores. It is well documented that African American students often do not perform as well academically as students of other ethnicities (Darensbourg & Blake, 2013; Matthews, Kizzie, Rowley, & Cortina, 2010; Yeung & Pfeiffer, 2009), and thus the finding in the present study supports findings in the literature. In terms of grade level, as I mentioned previously, it is my belief that students who take geometry in lower grade levels are likely students who have the skills to perform well in honors mathematics courses but who chose to take on-level geometry. Although this idea seems to contradict the notion stated by Pajares and Miller (1994) that students in higher grade levels typically perform better in mathematics than students in

lower grade levels, Smith (1996) stated that certain factors, such as prior achievement, predict mathematics achievement differently for students who took early algebra courses before high school. This statement suggests that students in lower grade levels may have differences in cognitive or noncognitive factors that impacts their mathematics achievement.

Algebra 2 SOL scores. Next, the model predicting Algebra 2 SOL scores was examined. First, ESOL status positively predicted Algebra 2 SOL scores at the first level, but not afterwards. This is an interesting finding given the literature on English proficiency and performance on standardized tests. Martiniello (2009) states that students with limited English proficiency did not perform well on standardized tests because they may not understand what is being asked. Furthermore Guglielmi (2012) found that English proficiency was not a mediator between academic achievement and other academic beliefs, such as self-concept. Again, the Algebra 2 sample had very few ESOL students (four), so this finding may not have much validity.

In this model, the three variables that significantly predicted Algebra 2 SOL scores at the third level were grade level, Geometry SOL prior achievement, and geometry classroom grade prior achievement. Grade level negatively predicted Algebra 2 SOL achievement; that is, students at a lower grade level were expected to score higher on this standardized test. I believe that explanation for why students at lower grade levels got better geometry classroom grades than students at higher grade levels holds true for this model as well. Geometry SOL scores and geometry classroom grades are both measures of prior mathematics achievement. Marsh and Yeung (1998) stated that similar

types of tasks yielded similar achievement results, which supports the idea that Geometry SOL scores predict Algebra 2 SOL scores. Conversely, geometry classroom grades predicting Algebra 2 SOL scores seems to contradict this same claim by Marsh and Yeung. However, it is important to remember that, while distinct, geometry and Algebra 2 both fall within the same overall subject of mathematics. It has been proposed in many foundational studies in expectancy–value theory that achievement in tasks within one subject predict achievement in future tasks within that same subject (Eccles & Wigfield, 2002). Although they are different types of tasks, the fact that they are in the same domain supports the relationship between the two variables.

On a similar note, two other variables that did not predict Algebra 2 SOL scores are Algebra 1 classroom grades and Algebra 1 SOL scores. This is an unexpected result due to the large amount of overlap in the Algebra 1 and Algebra 2 curricula (Virginia Department of Education, 2016). One possible explanation for this finding is the cognitive development of students over time. Susac, Bubic, Vrbanc, and Planinic (2014) have stated that students develop algebraic skills over time, and a “turning point” in students’ cognitive abilities typically comes at age 15 or 16. So, although much of the content is the same, students in Algebra 2 may have developed the skills to perform well in the curriculum that they did not have at an earlier age in Algebra 1.

This is the only model of the four in which self-concept did not significantly predict mathematics achievement. While this finding is an outlier within the study, Marsh and colleagues (2005) have claimed that self-concept was more strongly correlated with classroom grades than with standardized tests. In terms of this specific sample, the

diploma requirements of the county at which the present study took place may have also influenced this finding. Passing the Algebra 2 SOL is not a graduation requirement, as long as students have passed either the Algebra 1 or Geometry SOL. Because many students who take this course are seniors, it is possible that numerous students, even those with strong mathematics skills, may put little effort into performing well on this test and, therefore, the score may not accurately reflect students' typical motivation or mathematical ability. Another possible explanation is that many students who take the Algebra 2 SOL have also taken the Algebra 1 SOL or the Geometry SOL or both. As a result, they may have become familiar with the format of the test and learned to perform well even without having mastered the content of the test.

Algebra 2 classroom grades. The last model that was run to address this research question predicted Algebra 2 classroom grades. Two variables predicted Algebra 2 classroom grades at the first level, but not at the second or third levels: gender and Caucasian status. Kimura (2000) wrote that females are usually found to have higher classroom grades than males, which supports the finding in the present study. Additionally, because the first level of this model states that Caucasian students are predicted to achieve higher classroom grades than other ethnic groups, the claim of Steele and Aronson's (1995) claim that minority students do not perform as well as Caucasian students holds true, as mentioned previously. However, given that these two variables were significant at the first level but not the second or third levels, it is possible that other variables that became significant later in the model fully mediated the relationships between these variables and Algebra 2 classroom grades.

The five variables that predicted Algebra 2 classroom grades at the third level were grade level, self-concept, Algebra 1 SOL prior achievement, Algebra 1 classroom grade prior achievement, and geometry classroom grade prior achievement. In terms of prior achievement, both forms of Algebra 1 prior achievement are likely significant due to the large overlap of the two curricula (Virginia Department of Education, 2016). Similarly, prior achievement reflected in the geometry classroom grade is an expected predictor because it is a similar type of task (i.e., both are measures of classroom grades), as detailed by Marsh and Yeung (1998). As explained previously, self-concept has been found to be a significant predictor of mathematics achievement, particularly of classroom grades, in many studies (Marsh, 1989; Marsh et al., 2005, 2013; Pajares & Miller, 1994), so this finding was also expected. Finally, once again, students in lower grade levels were predicted to have higher Algebra 2 classroom grades. I believe this prediction can also be explained by students in lower grade levels with the mathematical ability to be in honors courses who have chosen to enroll in an on-level course instead. Furthermore, Smith (1996) stated that prior achievement is more predictive for students who took early algebra before high school. It is assumed that students who took early algebra before high school, which is earlier than usual, were placed there because they have strong mathematical skills. As a result, I believe that students who took algebra early in their academic careers have an advantage in terms of classroom grade achievement over students who follow the traditional timing.

Subjective task value. One of the most surprising findings of this entire research question is that none of the variables in the subjective task value factor (e.g., attainment

value, utility value, intrinsic value, and cost) significantly predicted any of the four mathematics achievement variables. Previous studies that included all variables stated that each variable distinctly predicted mathematics achievement (Eccles & Wigfield, 1995; Gaspard, Dicke, Flunger, Brisson, et al., 2015; Gaspard, Dicke, Flunger, Schreier, et al., 2015; Wigfield & Eccles, 2000, 2002). Furthermore, Eccles and colleagues (1983) included subjective task value in the expectancy–value theory model as a unique factor that distinctly measures academic achievement. The finding of the present study is even more surprising given that in the preliminary study, all four subjective task value variables were significantly correlated with all forms of mathematics achievement. My belief is that although each variable was a significant predictor by itself, each variable was fully mediated by another variable in the expectancy–value theory model (Eccles et al., 1983). As I mentioned in the Gaps in the Literature section in Chapter 2 few studies incorporate all expectancy–value factors and variables as detailed by Eccles and colleagues (1983). For instance, Nagy and colleagues (2006) included intrinsic value, self-concept, and prior achievement in their model, but no other expectancy–value variables. Gaspard, Dicke, Flunger, Brisson, et al. (2015) measured the effects of the four subjective task value variables, including subsets of each variable, but did not include other factors in the Eccles et al. (1983) model. In addition, Marsh and colleagues (2005) found reciprocal effects of mathematics self-concept and intrinsic value. We also know that, in the present study and in previous studies, that all subjective task value variables are all highly correlated (Eccles et al., 1983; Eccles & Wigfield, 2002; Marsh et al., 2005). Therefore, it is my suggestion that the predictability of subjective task value

variables was fully mediated by one or more expectancy–value variables (e.g., self-concept, prior achievement) in the Eccles et al. (1983) model.

Second research question. Finally, the second research question asked: Is there a main effect of type of mathematics course (e.g., geometry, Algebra 2), main effect of gender, and interaction effect between gender and type of mathematics course on expectancy–value factors (e.g., cultural milieu, child’s perception, stable child, previous achievement, child’s goals and general self-schemata, child’s interpretations of experience, expectation of success, subjective task value)? The results of the analyses used to answer this three-part question were compared with the literature on the subject.

Main effect of course. First, only one expectancy–value factor was significantly different between the geometry and Algebra 2 samples: prior classroom grades. Specifically, students in the geometry sample had a higher average prior classroom grade average than students in the Algebra 2 sample. By conducting further analysis, I determined that in the Algebra 2 sample, students had higher Algebra 1 classroom prior achievement than geometry classroom prior achievement. In the context of this sample, I believe that the content in geometry is more complex and difficult than that of Algebra 1; much of the curriculum in geometry incorporates some of the most difficult concepts in Algebra 1 (e.g., factoring) and asks students to apply it to other new concepts (e.g., three-dimensional shapes). This work can be difficult for students who have not necessarily mastered these Algebra 1 concepts, causing them to fall behind in the course very quickly. As a result, I believe that the content of each course contributes to this particular finding.

Main effect of gender. Second, the two expectancy–value factors that were significantly different by gender were prior classroom grades and cultural milieu. In terms of prior classroom achievement, females had a significantly higher average than males. This is supported by Kimura’s claim (2000) that females typically earn higher classroom grades than males. This significant difference was found for the combined samples of geometry and Algebra 2, rather than for only one subject, which makes it a more noteworthy result. Furthermore, there were no differences found for prior SOL scores by gender, which is supported by the literature (Hoffman & Spataru, 2008; Liu & Wilson, 2009). Both of these results indicate that gender influences classroom grades and standardized test scores differently.

Given that the factor cultural milieu contains several variables, I ran a follow-up test to determine which variable (or variables) contributed to the significant difference by gender. I determined that gender stereotype was the only variable within the cultural milieu factor that was significantly different by gender. Specifically, females reported stronger beliefs that they do not perform as well in mathematics as males. This finding is not surprising, given the extensive literature on gender stereotype beliefs. Nosek et al. (2002) reported that women felt they did not perform as well in mathematics tasks as men. According to the authors, this feeling is both implicit and explicit; the fact that gender stereotype questions were on the survey may have introduced an explicit stereotype belief to females. In addition to stereotype threat, there is the concept of implicit stereotype lift, which is the notion that males believe that they are superior in

mathematics (Franceschini et al., 2014; Walton & Cohen, 2003). These articles also support the gender differences found in the present study.

One factor that was not significantly different by gender was subjective task value. Skouras (2014) found the same result; he concluded that there was no difference in “attitude toward mathematics” by gender. By his definition, this term corresponds to intrinsic value and utility value. However, several other articles did find significant differences in all four variables by gender (Gaspard, Dicke, Flunger, Brisson, et al., 2015; Guo, Marsh, et al., 2015; Guo, Parker, et al., 2015). There are several explanations for this inconsistency in the literature. First, many studies only looked at parts of the expectancy–value theory model (Eccles et al., 1983). For example, Gaspard, Dicke, Flunger, Brisson, et al. (2015) only measured the extent to which the subjective task value factor is different by gender. The present study expanded on these studies by looking at the entire model. Second, many studies did not specify the type of mathematics used in the mathematics achievement measure. The present study not only specified the mathematics topic but also provided differences between the impact of algebra and geometry. It is my hope that the results of the present study will contribute to the contradicting findings regarding subjective task value and gender.

Interaction effect between course and gender. Finally, there was no interaction effect between course and gender in the factorial MANOVA results. Simply put, this means that the relationship between course and gender are not dependent on one another. This finding was expected because only one factor was significantly different by course. Although other analyses within this study found differences in what affects achievement

in each mathematics course, as well as differences in how gender impacts mathematics achievement, it is important to note that each difference is not significantly related.

Proposed Models

Although the Eccles et al. (1983) model was the foundational and theoretical framework of the present study, expectancy–value theory only considers entire subjects and not specific domains within a single subject. On the basis of educational psychology literature, mathematics literature, and the results of the present study, I propose two distinct models—one for geometry and one for algebra—that describe the relationships among expectancy–value factors for both of these mathematics subjects.

Geometry. Figure 2 shows the proposed model of expectancy–value factors on standardized test and classroom grade achievement in geometry. The solid lines represent relationships that were significant at the final level of a regression model; the dashed lines represent relationships that were significant at early levels of a regression model but became insignificant. According to the model, gender has a significant relationship with gender stereotype, as supported by the finding in response to the second research question. Ethnicity has a significant relationship with cultural stereotype, as supported by the findings in the preliminary analyses. The literature supports the notion that subjective task value mediates the relationship between gender stereotype and mathematics achievement (Plante et al., 2013), and the relationship between cultural stereotype and expectancy–value variables has been demonstrated (Andersen & Ward, 2013; Else-Quest et al., 2013; Watt et al., 2012), which is why there are arrows from both stereotype variables toward the subjective task value factor.

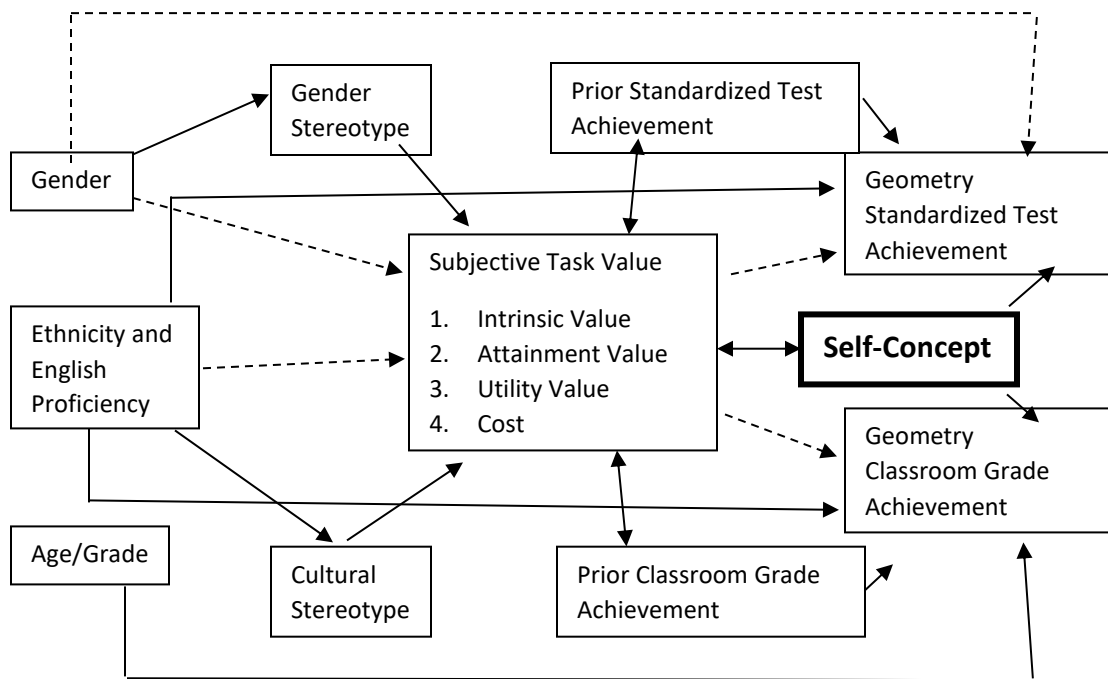


Figure 2. Proposed expectancy–value factor model for achievement in the geometry classroom and on geometry tests.

There are two-way arrows between subjective task value and both prior achievement factors, as well as between subjective task value and self-concept. As mentioned previously, subjective task value incorporates intrinsic value, utility value, attainment value, and cost. According to Marsh and colleagues (2005), there are reciprocal effects of subjective task value and self-concept, meaning that factors impact one another. I also included the two-way arrows between prior achievement and

subjective task value because several pieces of literature have indicated that prior mathematics achievement has a strong influence on subjective task value variables, particularly attainment value (Trautwein et al., 2012; Watt et al., 2012). In other words, when students perform well, their task value beliefs increase, and when students have high task value beliefs, they tend to perform better in mathematics tasks (Trautwein et al., 2012). Therefore, although subjective task value was not found to be significant in analysis carried out to respond to the first research question, it had very high correlations with other variables in the model, and much of the literature supports its inclusion in a model representing mathematics achievement.

At the end of the model, there are two measures of achievement: geometry standardized test achievement and geometry classroom grade achievement. On the basis of the results of the first research question, ethnicity/English proficiency, prior standardized test achievement, and self-concept each point to geometry standardized test achievement with a solid arrow. Dashed arrows point to that box as well because the two variables that were significant at the first level of the model became insignificant after other variables were added. It is suggested that future studies determine if there is a full mediation of other variables, such as self-concept and prior achievement, on geometry standardized test achievement.

I also included a dashed line between subjective task value and the two geometry achievement variables. Although this factor was not a significant predictor of either achievement variable, much of the literature on this topic, as well as the results of the preliminary analyses, suggests strong correlations between all four subjective task value

variables and mathematics achievement (Eccles & Wigfield, 1995; Gaspard, Dicke, Flunger, Brisson, et al., 2015; Gaspard, Dicke, Flunger, Schreier, et al., 2015; Wigfield & Eccles, 2000, 2002). Therefore, as I mentioned previously, I believe there is a relationship between subjective task value and mathematics achievement that is fully mediated by self-concept and prior achievement. Further research is needed to determine if that mediation exists. Finally, I did not include long-term goals or expectancy within this model despite the fact that they are included in the same factor as self-concept on the Eccles et al. (1983) model. The reason for this exclusion is that I found no indication of any significant findings involving these variables in the analysis for either research question or in the preliminary analyses. Therefore, I believe that it has minimal impact on geometry achievement, particularly within this sample.

Algebra. Figure 3 shows the proposed model of expectancy–value factors on standardized test and classroom grade achievement in algebra. Again, the solid lines represent significant relationships at the last level of a regression model, and the dashed lines represent relationships in earlier levels of a regression model. This model follows much of the same format as the geometry model, with some differences in arrows. The boxes at the end, which all other variables attempt to predict, are algebra standardized test achievement and algebra classroom grade achievement.

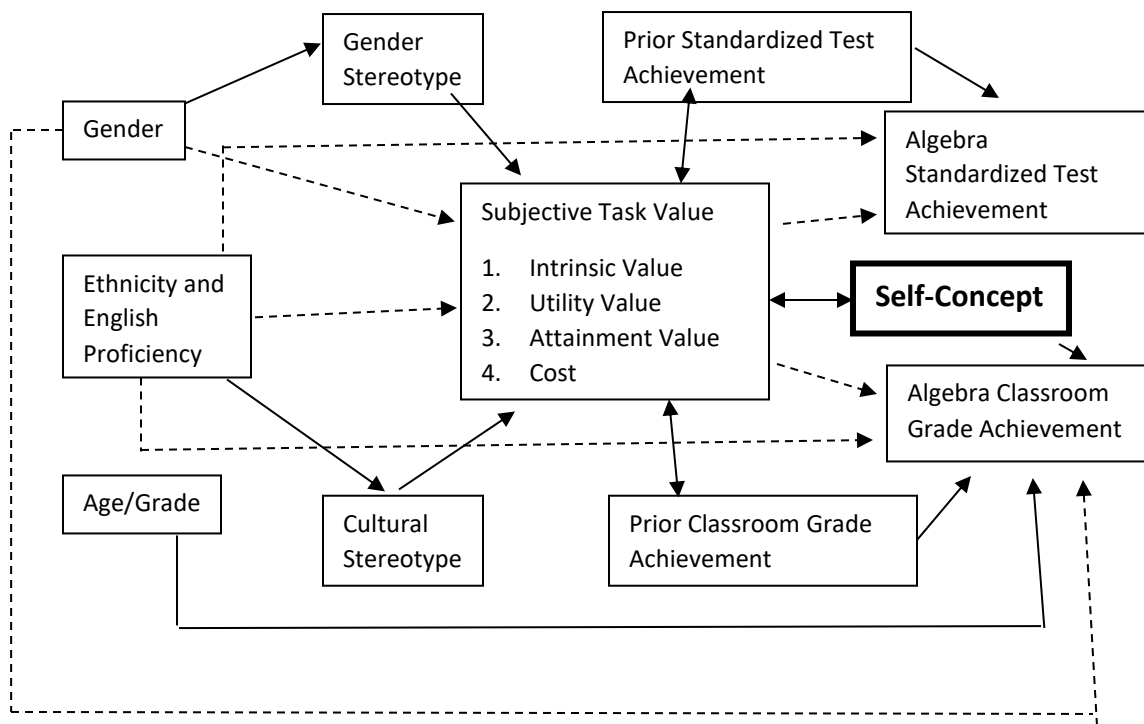


Figure 3. Proposed expectancy–value factor model for achievement in the algebra classroom and on algebra tests.

Arrows pointing to and away from the subjective task value box are the same as those in the geometry model, given that the literature does not distinguish between specific mathematics subjects. Furthermore, the preliminary and second research question analyses do not offer any substantial differences besides those between certain ethnicities and prior classroom grade achievement, neither of which warrant a change in the model.

Additionally, the same variables that were excluded from the previous model—long-term goals and expectancy—were also excluded for the reasons described previously. I also decided to keep the self-concept box bolded, even though it did not significantly predict algebra standardized test achievement, because I believe that, on the basis of the literature and other findings in the present study, it is one of the most important expectancy–value variables in predicting mathematics achievement.

This model differs from the geometry model as follows: the factors and variables point to (i.e., predict) algebra achievement. The three solid lines that have a significant relationship with algebra standardized test achievement are prior standardized test achievement, prior classroom grade achievement, and age/grade after all variables were included in the regression models. These arrows were drawn on the basis of the three factors that were found to be significant predictors of Algebra 2 SOL scores in response to the first research question. There is also a dashed arrow pointing from ethnicity and English proficiency to algebra standardized test achievement because ESOL status predicted Algebra 2 SOL scores at the first level of the hierarchical regression model, but not afterwards, meaning that another variable possibly mediated the effect of ethnicity on this particular dependent variable. A dashed arrow also points from subjective task value, which includes intrinsic value, utility value, attainment value, and cost, to algebra standardized test achievement because, as I mentioned previously, I believe its effect is mediated by prior achievement. Additional research is needed to test these mediation claims.

Finally, algebra classroom grade achievement has four solid arrows pointing to it from prior achievement as reflected in standardized tests, prior achievement as reflected in classroom grades, self-concept, and age/grade. These four were chosen on the basis of the results of the hierarchical regression model used in responding to the first research question. Similar to the algebra standardized test achievement factor, both subjective task value and ethnicity and English proficiency have relationships with algebra classroom grade achievement. Caucasian status was significant at the first level of the regression model predicting Algebra 2 classroom grades, but not after, indicating an indirect effect mediated by one or more other variables. Lastly, subjective task value also has a dashed line pointing to algebra classroom grade achievement on the basis of literature that has found a strong relationship between task value and mathematics achievement in the classroom (Eccles & Wigfield, 1995; Gaspard, Dicke, Flunger, Brisson, et al., 2015; Gaspard, Dicke, Flunger, Schreier, et al., 2015; Wigfield & Eccles, 2000, 2002).

Implications

After the discussion of the results of this study, as well as the connections to the literature, it is important to understand the implications of this study. Understanding how this study can be applied to both a research and classroom setting will open new path for future studies, as well as allow for improvement in teaching methods, resulting in more student success.

Research implications. As mentioned previously, earlier studies have only used portions of the expectancy–value theory model introduced by Eccles and colleagues (1983). As a result, many previous studies did not investigate the entire picture of how

motivational factors impact mathematics achievement. The present study has used the entire model, allowing a larger percentage of variance of mathematics achievement to be explained by variables within expectancy–value theory. I recommend that future studies use all the variables in the model, including the variables that could not be included in this study (e.g., short-term goals), to lead to a better understanding of motivation as it relates to mathematics achievement.

Because the entire expectancy–value theory model (Eccles et al., 1983) was considered in the present study, it was possible to look at the distinctions between the effects of motivational factors on algebra and geometry. These differences were not seen in the literature, primarily because studies that investigated expectancy–value factors only looked them within the larger subject of mathematics. The present study found differences in the effects of motivational factors on algebra and geometry, which is a new finding in the educational psychology field. Additionally, this study also determined which expectancy–value factors influence standardized test scores and classroom grades for each course. My hope is that this study will be a starting point for future research to explore further differences between achievement in different types of algebra and geometry tasks.

In Chapter 1 of this study, I mentioned that expectancy–value theory was a domain-specific theory, meaning that beliefs about one subject (i.e., mathematics, social studies) do not impact the beliefs about another subject (Eccles & Wigfield, 1992, 1995; Wigfield & Eccles, 2000). Little research had been done to examine differences in expectancy–value beliefs within one subject (e.g., mathematics). One of the main

purposes of the present study was to expand the research in this way, zooming in the lens of the theory to look at two distinct courses within mathematics. I expect that the results of this study will encourage researchers to further investigate differences in expectancy–value factors by mathematics course.

From a mathematics education standpoint, the results of the present study also support an increase in research in mathematics identity. Cobb, Gresalfi, and Hodge (2009) suggested that due to this phenomenon, some students of minority succeed in mathematics while others do not. Cribbs, Hazari, Sonnert, and Sadler (2015) developed a model to represent mathematical identity that include interest, competence, recognition, and performance. The results of the present study are relevant to the topic of mathematical identity because it was shown that ethnicity status and self-concept were both shown to be significant predictors of mathematical achievement. It is my suggestion that an additional model for mathematical identity be developed and tested using the variables found to be significant in the present study.

Not only does these implications pertain to mathematics, but they can also be applied to other subjects. For instance, further research can investigate the differences in expectancy–value factors by science area, such as chemistry, biology, or physics. Understanding the dynamics of each specific domain (e.g., geometry, algebra) will help lead to an understanding of how student motivation, prior experience, and cultural and gender stereotype beliefs impact student achievement in both the classroom and standardized tests. It is my hope that studies similar to the present study will be

conducted for all academic subjects to lead to comprehension of how expectancy–value theory works in all academic areas.

Classroom and school system implications. In addition to implications in the research field, the present study provides many implications valuable to the classroom setting. First and foremost, this study provides valuable information to teachers on how to help students succeed. In my view, instilling motivation is as important as teaching the actual mathematics material. For instance, self-concept was a significant predictor of mathematics achievement in many of the models in the present study. As a result, teachers have the responsibility to instill confidence in students as they learn by praising their effort and progress. This, in turn, will give students a better self-concept of their mathematics ability and increase achievement.

Additionally, according to the proposed models in Figure 2 and Figure 3, subjective task value (i.e., intrinsic value, utility value, attainment value, and cost) and self-concept impact one another. Teachers can use this relationship between factors to build students' self-concept. For instance, when students find mathematics interesting (i.e., intrinsic value) and see how mathematics is useful in their lives (i.e., utility value), their self-concept is influenced, and, as a direct consequence, mathematics achievement improves. This responsibility not only falls on teachers but also on those who create the curriculum for mathematics courses. Based on my teaching experience, I have found that the high school curriculum is packed with as much material as possible, without leaving any time for real-world applications. I believe that learning too much content without being able to apply it can decrease intrinsic value and utility value, and increase cost.

Furthermore, the content itself has an influence on student motivation as well. As mentioned in Chapter Two, Middleton (2013) stated that students have reported less motivation when variables are introduced in courses before Algebra 1. Curriculum makers should consider these and other studies when determining what students will learn and when they will learn it. Therefore, it is my belief that both teachers and those creating mathematics curricula must consider student motivation and value in school.

Another implication for teachers is the anticipation of student achievement and proactively working with students to increase their potential. Prior achievement has been found to predict achievement, but different forms of prior achievement predict achievement on different tasks. For example, Algebra 1 SOL predicts Geometry SOL success, but Algebra 1 classroom grades do not. If geometry teachers want to identify students who may be at risk of failing the Geometry SOL, they should be aware that students' prior Algebra 1 SOL scores are more of an indication of success than their prior Algebra 1 classroom grades. This logic can be applied to all four mathematics tasks tested in the present study, allowing teachers to place students in courses of the appropriate level and identify at-risk students who may need more practice and preparation to succeed.

Future directions. In addition to implications, this study also encourages future directions for research to take. First, as mentioned previously, I proposed that several mediation effects occurred among the variables. For example, I suggested that the predictability of subjective task variables was mediated by other variables in the model, due to the large amount of previous literature that claimed that subjective task value

variables predicted mathematics achievement. However, a hierarchical regression test does not test mediation among variables. Further research is needed to determine what mediation effect, if any, exist among these variables, and what the differences are among the four mathematics achievement variables used in the present study.

Second, two models were proposed in this study to explain the relationship among expectancy–value variables and mathematics achievement, as well as to highlight the differences in these variables between algebra and geometry. Figure 2 and Figure 3, included earlier in this chapter, show the proposed models that were created based on the statistical analyses in the present study, previous expectancy–value literature, and the Eccles et al. (1983) model of expectancy–value theory. However, testing the validity of these models is beyond the scope of this study. Further research, using structural equation model analysis, is needed to determine if these models are appropriate representations of mathematics achievement.

Limitations

This study has several limitations. One is the validity of a self-report measure. It is important to consider the validity of each measure when collecting data. In particular, the measure of interest should be carefully examined. Tracey (2012) claimed that single interest scales contain two types of error: systematic error and general factor variance. Furthermore, the scales used in the present study did not take into account bias that can influence students' interest. For example, interest is often correlated with students' mathematics scores, which can cause a problem with validity (Tracey, 2012). Thus, it is

important to analyze the results of all the self-reported items to determine if any of these problems can compromise the research questions.

Another limitation of this study is the fact that the analysis was conducted using a cross-sectional sample. In order to best measure students' beliefs about geometry and Algebra 2, students must be enrolled in the course. There is no current literature that suggests that there is any validity to measuring students' beliefs about a course after it has been completed. Therefore, two different sets of students participated in the study, and none of those students reported their answers for both courses. This is a limitation because I could not directly compare students' beliefs about the two courses, but rather the average of the two separate groups. I suggest that this study be replicated in the future as a longitudinal study, in which the same students are surveyed at the end of their geometry course, and then a year later at the end of their Algebra 2 course.

Next, the participant selection of this study is that of a sample of convenience. The students who made up the sample used in this study attended the school where I taught at the time of the study. This link can create bias in the research because of a personal connection to me, as well as a potential conflict of interest. Additionally, some of the responses to the self-report measure might be the result of socially desirable responding; that is, students' answers might be what they thought the teacher or I would want to hear, rather than an accurate representation of their motivational beliefs. This problem can be avoided by replicating the study with students who do not attend the school where the researcher teaches.

One additional limitation of this study is the fact that students have had different teachers for each of the courses being measured. Although it is possible that some students may have had the same teachers for each class as other students, the assumption is that both courses being evaluated were taught by a variety of teachers with a variety of teaching styles. An effort was made in the beginning of the measure to encourage students to answer questions on the basis of the subject alone, but research has shown that the teacher can impact students' motivation (den Brok, Levy, Brekelmans, & Wubbels, 2005; Maulana, Opdenakker, & Bosker, 2014; Opdenakker, Maulana, & den Brok, 2012). Additionally, a preliminary analysis conducted to determine if there were significant differences in responses and mathematics performance by teacher gave no results indicating a strong rationale to remove any responses on the basis of teacher. Nevertheless, this outside influence must be considered when conducting analysis and discussing results in a study such as this one.

Another limitation of this study is the responses to some of the items on the survey. As mentioned previously, the questions asking about goals and expectations of current course SOL and classroom grades were excluded from the analysis because many responses were in the incorrect format. As a result, the analysis for the second research question (i.e., the 2×2 factorial MANOVA) included fewer variables than intended. In a future study including the same intended variables, these questions should be reworded so that they can be included in the analysis; this improvement may provide new insight into the main and interaction effects of expectancy–value factors on gender and mathematics course.

Finally, a limitation of this study concerns the way that the SOL was used in the school where the study was carried out. As mentioned in the beginning of Chapter 4, a few weeks before students were set to take the SOL test for their current course, the school at which the study was conducted announced that if students passed their SOL, they could use that grade in lieu of taking a final exam. This change caused several issues for the present study. First, this incentive may have changed students' motivation levels for the SOL; instead of the SOL counting solely as a graduation requirement, it could be used as a grade if they did well, which would give them more incentive to perform well. Second, prior achievement data were collected before this incentive went into effect, which means that students' motivation in regards to grades and SOL scores may have evolved. It is suggested that this study be repeated in a school that does not have this policy in place so that results can be compared with this or other schools' data.

Conclusion

The present study focused on expectancy–value theory, gender, mathematics achievement, and specific mathematics course. Although algebra and geometry fall within the same subject of mathematics, this study found that different motivational factors impact achievement in the two domains differently. Furthermore, the results of this study suggest that achievement in standardized tests and classroom grades are also influenced by different motivational factors. Using the expectancy–value theory model (Eccles et al., 1983) in its entirety revealed more information about how noncognitive factors affect achievement in algebra and geometry differently.

It is my hope that this study, on the basis of these findings, will spark new research in expectancy–value theory by specific subjects or topics within a content area. Significant findings in this study provide a path for researchers to conduct extensions to this study, as well as a path for teachers and school staff to provide the best opportunity for high school students to succeed in their required mathematics courses. I am confident that the fields of educational psychology and secondary mathematics will benefit from the findings of this study and the precedents set in this research.

Appendix A

IRB Approval Letter



Office of Research Integrity and Assurance

Research Hall, 4400 University Drive, MS 6D5, Fairfax, Virginia 22030
Phone: 703-993-5445; Fax: 703-993-9590

DATE: January 30, 2017

TO: Erin Peters-Burton
FROM: George Mason University IRB

Project Title: [904399-1] Expectancy-Value Constructs, Gender, and Achievement: Is There a Difference by Math Course?

SUBMISSION TYPE: New Project

ACTION: APPROVED
APPROVAL DATE: January 30, 2017
EXPIRATION DATE: January 29, 2018
REVIEW TYPE: Expedited Review

REVIEW TYPE: Expedited review categories #5 & 7

Thank you for your submission of New Project materials for this project. The George Mason University IRB has APPROVED your submission. This submission has received Expedited Review based on applicable federal regulations.

Please remember that all research must be conducted as described in the submitted materials.

Please remember that informed consent is a process beginning with a description of the project and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the project via a dialogue between the researcher and research participant. Federal regulations require that each participant receives a copy of the consent document.

Please note that any revision to previously approved materials must be approved by the IRB prior to initiation. Please use the appropriate revision forms for this procedure.

All UNANTICIPATED PROBLEMS involving risks to subjects or others and SERIOUS and UNEXPECTED adverse events must be reported promptly to the Office of Research Integrity & Assurance (ORIA). Please use the appropriate reporting forms for this procedure. All FDA and sponsor reporting requirements should also be followed (if applicable).

All NON-COMPLIANCE issues or COMPLAINTS regarding this project must be reported promptly to the ORIA.

The anniversary date of this study is January 29, 2018. This project requires continuing review by this committee on an annual basis. You may not collect data beyond this date without prior IRB approval. A continuing review form must be completed and submitted to the ORIA at least 30 days prior to the

anniversary date or upon completion of this project. Prior to the anniversary date, the ORIA will send you a reminder regarding continuing review procedures.

Please note that all research records must be retained for a minimum of five years, or as described in your submission, after the completion of the project.

If you have any questions, please contact Katie Brooks at (703) 993-4121 or kbrook14@gmu.edu. Please include your project title and reference number in all correspondence with this committee.

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within George Mason University IRB's records.

Appendix B

IRB Parental Consent Form

Expectancy-Value Constructs, Gender, and Achievement: Is There a Difference by Math Course?

INFORMED CONSENT FORM

RESEARCH PROCEDURES

This research is being conducted to help understand the relationship between motivation and achievement in different math courses (Algebra and Geometry). If your child agrees to participate, he/she will be asked to complete a survey measuring his/her feelings towards their current mathematics course. The results of this survey, as well as their SOL score and final classroom grade, will be collected for analysis. The survey will take approximately fifteen minutes to complete. Your child's responses on the survey will not affect his/her grade or standing in their current mathematics class.

RISKS

There are no foreseeable risks for participating in this research.

BENEFITS

There are no benefits to you or the participants other than to further research in motivation and achievement in the field of mathematics.

CONFIDENTIALITY

The data in this study will be confidential. Once data is collected, student ID numbers will be deleted and identities will be protected. No names will be used for any purpose. Your child's teacher will not see their name attached to the survey in any way, and another teacher will oversee the data collection process. Only the researchers will have access to the data collected. The information collected will not be reported on an individual basis, but rather as a large group of data.

PARTICIPATION

Participation is voluntary; you child may withdraw from the study any time and for any reason. If he/she decides not to participate or withdraws from the study, there is no penalty or loss of benefits to which he/she is otherwise entitled. There are no costs to you or any other party. If your child participates, he/she will be entered into a raffle to win one of five \$20 Target gift cards.

ALTERNATIVES TO PARTICIPATION

If your child chooses not to participate in the study, he/she will not complete a survey. This will not impact his/her grade in any way.

CONTACT

This research is being conducted by Michael Mazzeella at George Mason University. He may be reached at 703-642-4327 for questions or to report a research-related problem. The faculty advisor for this study is Dr. Erin Peters-Burton. She may be reached at 703-993-9695. You may contact the George Mason University Office of Research Integrity & Assurance at 703-993-4121 if you have questions or comments regarding your child's rights as a participant in the research. This research has been reviewed according to George Mason University procedures governing participation in this research.

CONSENT: I have read this form and agree to allow my child to participate in this study.

Signature of Parent/Guardian

Date of Signature

Child's Name

Appendix C

Student Assent Form

Expectancy-Value Constructs, Gender, and Achievement: Is There a Difference by Math Course?

ASSENT FORM

RESEARCH PROCEDURES

The reason for this research is to find out if your motivation impacts your achievement in Geometry or Algebra differently. If you agree to take part in this study, you will be asked to fill out a survey about your feelings about your current math course. Your SOL score and final classroom grade in your current math course will also be recorded. The survey will take about 15 minutes. Your responses on the survey will not count towards your grade or affect your standing in the class in any way.

RISKS AND BENEFITS

There are no risks to you if you take part in this study. This information will help teachers understand how to best help students in Geometry and Algebra courses.

CONFIDENTIALITY

Once all the data is collected, I will delete your student ID number so that nobody will be able to identify you. Your name will not be recorded into the data at all. Also, another teacher will oversee the data collection process, so they will not be able to identify your survey, SOL score, or classroom grade. Your responses and scores will not be individually reported; only the overall results of all students will be reported. Only the researchers will have access to the data.

PARTICIPATION

If you participate in this study, you will be entered into a raffle to win one of five \$20 Target gift cards. There will be no negative consequences if you decide that you would not like to answer the helping questions, or if you would not like your scores to be used in the study. You may choose to stop participating at any time with no risks or consequences.

CONTACT

My name is Mike Mazzarella, and I am studying to get a PhD in Educational Psychology at George Mason University. This research has been reviewed according to George Mason University procedures governing your participation in this research. You can call me at 703-642-4327 if you have any questions about this study. You may contact the George Mason University Office of Research Integrity & Assurance at 703-993-4121 if you have questions or comments regarding your rights as a participant in the research.

CONSENT: I have read this form and I agree to be part of this study.

Name of Student

Date

Signature of Student



Project Number: 804389-1
Date Approved: 1/30/17
Approval Expiration Date: 1/29/18

IRB: For Official Use Only

Page 1 of 1

Appendix D

Geometry Measure

Student ID _____
SURVEY

DO NOT PUT YOUR NAME ON THIS

1. Circle your gender: Male Female
2. Circle your ethnicity: African-American Asian Hispanic Caucasian Other
3. Are you currently enrolled in an ESOL class? Yes No
4. Circle your current grade: 9 10 11 12
5. Write your age: _____
6. Did you take Geometry last year? Yes No
7. Write the name of your current Geometry teacher:

8. Write your goal for the Geometry SOL:

9. Write your goal for your final Geometry grade:

10. Write what you expect to get on the Geometry SOL (this may be different than your goal)

11. Write what you expect to get for your final Geometry grade (this may be different than your goal) _____
12. Write your SOL score from Algebra 1 (if you don't remember, give an estimate):

13. Write your final course grade from Algebra 1 (if you don't remember, give an estimate):

For the remaining questions, please answer honestly regarding the feelings about your current math class. Your responses will remain anonymous and will not affect your grade. Remember, you are answering the question based on the subject, and not about the teacher.

For questions 14 – 67, circle the appropriate response about your feelings about Geometry.

14. Geometry is fun to me.

Strongly Disagree Disagree Slightly Disagree Slightly Agree Agree Strongly Agree

15. It is important to me to be good in Geometry.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
16. I care a lot about remembering the things we learn in Geometry.					
Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
17. It is worth making an effort in Geometry, because it saved me a lot of trouble at school in the next years.					
Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
18. Understanding Geometry has many benefits in my daily life.					
Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
19. Being well versed in Geometry will go down well with my classmates.					
Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
20. Good grades in Geometry can be of great value to me later on.					
Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
21. Geometry contents will help me in my life.					
Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
22. Doing Geometry is exhausting to me.					
Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
23. I would rather not do Geometry, because it only worries me.					
Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
24. I have to give up other activities that I like to be successful in Geometry.					
Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
25. I usually do well in Geometry.					
Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree

26. I like doing Geometry.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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27. Being good at Geometry means a lot to me.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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28. Geometry is meaningful to me.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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29. Being good at Geometry pays off, because it is simply needed at school.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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30. Geometry comes in handy in everyday life and leisure time.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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31. I can impress others with my knowledge in Geometry.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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32. Learning Geometry is worthwhile, because it improves my job and career chances.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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33. I will often need Geometry in my life.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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34. I often feel completely drained after doing Geometry.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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35. When I deal with Geometry, I got annoyed.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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36. I have to give up a lot to do well in Geometry.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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37. I learn things quickly in Geometry

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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38. I simply like Geometry.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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39. Performing well in Geometry is important to me.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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40. I am really keen on learning a lot in Geometry.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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41. Geometry is directly applicable in everyday life.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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42. If I know a lot of Geometry, I will leave a good impression on my classmates.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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43. Dealing with Geometry drains a lot of my energy.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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44. Geometry is a real burden to me.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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45. I have to sacrifice a lot of free time to be good at Geometry.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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46. Geometry is harder for me than for many of my classmates.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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47. I enjoy dealing with topics in Geometry.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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48. Good grades in Geometry are very important to me.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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49. Geometry is very important to me personally.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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50. Learning Geometry exhausts me.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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51. Doing Geometry makes me really nervous.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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52. To be honest, I don't really care about Geometry.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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53. I am just not good at Geometry.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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54. It is really important for me to know a lot of Geometry.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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55. It is possible that men have more Geometry ability than do women.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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56. In general, men may be better than women at Geometry.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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57. I don't think that there are any real gender differences in Geometry ability.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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58. I am determined to use my Geometry knowledge in my future career.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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59. I intend to enter a career that will use Geometry.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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60. I plan to take more Geometry courses in college than will be required of me.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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61. I believe that my ability to perform well in Geometry is affected by my ethnicity.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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62. I believe that if I perform poorly on a Geometry test, the teacher will attribute my poor performance to my ethnicity.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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63. I believe that if I perform well on a Geometry test, the teacher will attribute my good performance to my ethnicity.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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64. I believe that negative stereotypes about my ethnicity increase my anxiety about Geometry tests.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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65. I believe that positive stereotypes about my ethnicity increase my anxiety about Geometry tests.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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66. I expect to do well in Algebra 2 for the remainder of the year.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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67. I expect to be good at learning something new in Algebra 2.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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Appendix E

Algebra 2 Measure

Student ID _____
SURVEY

DO NOT PUT YOUR NAME ON THIS

1. Circle your gender: Male Female
2. Circle your ethnicity: African-American Asian Hispanic Caucasian Other
3. Are you currently enrolled in an ESOL class? Yes No
4. Circle your current grade: 9 10 11 12
5. Write your age: _____
6. Did you take Algebra 2 last year? Yes No
7. Write the name of your current Algebra 2 teacher:

8. Write your goal for the Algebra 2 SOL:

9. Write your goal for your final Algebra 2 grade:

10. Write what you expect to get on your Algebra 2 SOL (this may be different than your goal):

11. Write what you expect to get for your final Algebra 2 grade (this may be different than your goal): _____
12. Write your SOL score from Algebra 1 (if you don't remember, give an estimate):

13. Write your final course grade from Algebra 1 (if you don't remember, given an estimate):

14. Write your SOL score from Geometry (if you don't remember, give an estimate):

15. Write your final course grade from Geometry (if you don't remember, give an estimate):

For the remaining questions, please answer honestly regarding the feelings about your current math class. Your responses will remain anonymous and will not affect your grade. Remember, you are answering the question based on the subject, and not about the teacher.

For questions 16 – 69, circle the appropriate response about your feelings about Algebra 2.

16. Algebra 2 is fun to me.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
17. It is important to me to be good at Algebra 2.					
Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
18. I care a lot about remembering the things we learned in Algebra 2.					
Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
19. It is worth making an effort in Algebra 2, because it saved me a lot of trouble at school in the next years.					
Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
20. Understanding Algebra 2 has many benefits in my daily life.					
Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
21. Being well versed in Algebra 2 will go down well with my classmates.					
Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
22. Good grades in Algebra 2 can be of great value to me later on.					
Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
23. Algebra 2 contents will help me in my life.					
Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
24. Doing Algebra 2 is exhausting to me.					
Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
25. I would rather not do Algebra 2, because it only worries me.					
Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
26. I have to give up other activities that I like to be successful in Algebra 2.					
Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree

27. I usually do well in Algebra 2.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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28. I like doing Algebra 2.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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29. Being good at Algebra 2 means a lot to me.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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30. Algebra 2 is meaningful to me.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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31. Being good at Algebra 2 pays off, because it is simply needed at school.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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32. Algebra 2 comes in handy in everyday life and leisure time.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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33. I can impress others with my knowledge in Algebra 2.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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34. Learning Algebra 2 is worthwhile, because it improves my job and career chances.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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35. I will often need Algebra 2 in my life.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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36. I often feel completely drained after doing Algebra 2.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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37. When I deal with Algebra 2, I got annoyed.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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38. I have to give up a lot to do well in Algebra 2.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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39. I learn things quickly in Algebra 2

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
----------------------------	----------	-------------------	----------------	-------	----------

40. I simply like Algebra 2.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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41. Performing well in Algebra 2 is important to me.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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42. I am really keen on learning a lot in Algebra 2.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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43. Algebra 2 is directly applicable in everyday life.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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44. If I know a lot of Algebra 2, I will leave a good impression on my classmates.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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45. Dealing with Algebra 2 drains a lot of my energy.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
----------------------------	----------	-------------------	----------------	-------	----------

46. Algebra 2 is a real burden to me.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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47. I have to sacrifice a lot of free time to be good at Algebra 2.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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48. Algebra 2 is harder for me than for many of my classmates.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
----------------------------	----------	-------------------	----------------	-------	----------

49. I enjoy dealing with topics in Algebra 2.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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50. Good grades in Algebra 2 are very important to me.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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51. Algebra 2 is very important to me personally.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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52. Learning Algebra 2 exhausts me.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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53. Doing Algebra 2 makes me really nervous.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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54. To be honest, I don't really care about Algebra 2.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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55. I am just not good at Algebra 2.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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56. It is really important for me to know a lot of Algebra 2.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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57. It is possible that men have more Algebra 2 ability than do women.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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58. In general, men may be better than women at Algebra 2.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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59. I don't think that there are any real gender differences in Algebra 2 ability.

Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
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60. I am determined to use my Algebra 2 knowledge in my future career.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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61. I intend to enter a career that will use Algebra 2.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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62. I plan to take more Algebra 2 courses in college than will be required of me.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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63. I believe that my ability to perform well in Algebra 2 is affected by my ethnicity.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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64. I believe that if I perform poorly on an Algebra 2 test, the teacher will attribute my poor performance to my ethnicity.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
----------------------------	----------	-------------------	----------------	-------	----------

65. I believe that if I perform well on an Algebra 2 test, the teacher will attribute my good performance to my ethnicity.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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66. I believe that negative stereotypes about my ethnicity increase my anxiety about Algebra 2 tests.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
----------------------------	----------	-------------------	----------------	-------	----------

67. I believe that positive stereotypes about my ethnicity increase my anxiety about Algebra 2 tests.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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68. I expect to do well in Algebra 2 for the remainder of the year.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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69. I expect to be good at learning something new in Algebra 2.

Strongly Disagree Agree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly
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Biography

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