EXAMINING THE ASSOCIATION BETWEEN TEACHER PRACTICES AND MATH IDENTITY: ASCERTAINING THE MEDIATING EFFECTS OF EXPECTANCY-VALUE BELIEFS

by

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Significant Black-White disparities in the STEM pipeline and math achievement continue to persist in education. Extant research postulates that math identity is a critical contributor to students' math achievement and subsequent persistence and success in math. Guided by expectancy-value theory and the CLASS-S framework, the present study utilizes quantitative data to examine a mediating mechanism by which teacher practices impact math identity through motivational beliefs (i.e., expectancies, task values, and cost value) and whether this mechanism differs for European American and African American students. Data came from 525 sixth grade students (49% male; 64% European American and 36% African American; 59% free/reduced-price lunch eligible) from ten ethnically and socioeconomically diverse middle schools. The findings suggest that all expectancy-value beliefs, except cost value, mediate the association between teacher practices and math identity. The results also illustrate that specific mediating pathways differ by race, although nonsignificantly. The study's implications for future research and practice were discussed.

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1.0 INTRODUCTION

An academic performance gap in mathematics between African American and European American students –usually referred to as the Black-White achievement gap—has been well documented (Ferguson & Mehta, 2004; Jenck & Phillips, 1998; McGee & Pearman II, 2014). The National Assessment of Educational Progress (2009) reports that only 12% of African American eighth grade males are proficient in math compared to 44% of their European American peers and these disparities are present throughout the STEM pipeline (Civil Rights Data Collection, 2013). This is problematic because math has been cited as the gateway to science, technology, engineering, and mathematics (STEM; Maltese & Tai, 2011). Indeed, African American students, due to lowered performance and participation in mathematics, have limited access to opportunities in STEM. Therefore, increasing African American student performance and motivation in math may be one key to closing the Black-White achievement gap and increased opportunities to participate in STEM fields.

Past research suggests several psychological and contextual factors critical for African American student performance in math. For example, a positive academic identity is a precursor to desirable school outcomes like academic performance (Childs, 2017). Most saliently, the construct of math identity—an individual's sense of self in the math domain (Darragh, 2013)—is important for student performance and persistence in math (Cribbs, Hazari, Sadler, & Sonnert, 2015). In addition, research has demonstrated that students' motivational beliefs are critical contributors to students' performance and positive math identity (Berry, Thunder, & McClain, 2011). One critical contextual factor with important implications for math identity development and math achievement is math teacher practices, such as teacher sensitivity, quality of feedback, and instructional learning formats (Pianta, Hamre, & Allen, 2012). Promoting these teacher practices will likely promote math identity and achievement for African American students.

Lastly, extant research postulates that adolescence is a critical period for influencing students' trajectories of math achievement (Frenzel, Pekrun, Dicke, & Goetz, 2012). Adolescence is a time in which students establish academic identities (Atwater, Wiggins, & Gardner, 1995) and experience declines in math motivation (Anderman & Maher, 1994). Specifically, the transition to middle school—around sixth grade—is an important time to examine student motivation and achievement (Atwater et al., 1995).

In this study, I use Expectancy-Value Theory and the Classroom Assessment Scoring System—Secondary framework to examine the associations between teacher practices, motivational beliefs, and math identity in sixth grade students; I seek to investigate a psychological mechanism by which teacher practices impact math identity through expectancy-value beliefs and explore the significance of these pathways in both European American and African American sixth grade students.

2.0 THEORETICAL FRAMEWORKS

2.1 EXPECTANCY-VALUE THEORY

The expectancy-value theory (EVT) model (Eccles-Parsons, et al, 1983; Wigfield & Cambria, 2010) provides a comprehensive framework for the study of identity based on environmental and psychological factors. This model demonstrates the interrelation of the three components of interest: identity, motivation, and teacher behavior. Two motivation constructs—expectancies and task values—are largely important for students' educational outcomes. *Expectancies* are defined as an individual's beliefs about their performance on a future task (Eccles-Parsons et al., 1983) and *task values* are an individual's evaluation of specific tasks and how qualities of those tasks influence their desire to complete them. Task value is further differentiated into utility value, intrinsic value, attainment value, and cost. *Utility value* is the instrumental value of a task for helping to fulfill goals (Wang & Degol, 2013). *Intrinsic value* is based on the anticipated enjoyment of activity participation (Eccles, 2009). *Attainment value* has been conceptualized as the personal values that an activity or task fulfills (Eccles, 2009). Lastly, *cost* refers to what an individual needs to sacrifice in order to participate in an activity or as a loss of time or energy due to activity participation (Wigfield, Tonks, & Klauda, 2016). Research has shown that the four value components can be empirically differentiated (Guo et al., 2016; Trautwein et al., 2012) though the task value components are moderately or highly correlated. As such, researchers often combine the three positive aspects of value components together (e.g., Kosovich, Hulleman, Barron, & Getty, 2015; Perez, Cromley, & Kaplan, 2014).

Drawing from the EVT framework, personal identities can be conceptualized as a product of motivational beliefs. For instance, an individual's expectations to succeed in math and their valuation of math tasks and math goals predict his/her identification as a math "person" (Eccles, 2009). Indeed, research demonstrates that expectancy-value beliefs predict students' choices of class, activity, and career aspirations in STEM (Eccles, 2009; Eccles & Wang, 2012; Wang & Eccles, 2013). These choices may then inform a student's sense of identity. For instance, an individual may choose to continue with their math coursework if they expect to be successful in math. When a student engages in an activity—in this case, math—they may develop competence in mathematics and their development of math skills will become a part of their sense of self (Eccles, 2009). Taken together, an individual's expectancies and task values—their beliefs about the necessity of, interest in, personal importance of, and beliefs about required effort—may impact a student's identification in math.

Moreover, EVT suggests that experiences in school are linked to the development of both expectancy-value beliefs and identity. Interactions with teachers are crucial for informing students' sense of school-related competence (Eccles & Midgley, 1989) as well as for promoting motivation in students (Wentzel, 2004). With regards to the math domain, teachers may create opportunities for adolescents to participate in STEM-related activities (Eccles et al., 1993). Through their participation, students may glean information about their competence and personal values for math (Wentzel, 2004). Over time, this understanding of their competence, their personal values, and motivation accumulate to inform students' expectancies and task values in the math domain (Wang & Degol, 2013). Thus, teachers may be critical to informing students' beliefs about their competence and task value (e.g. interest) through their curation of classroom experiences (Schunk, Pintrich, & Meece, 2008). Students' positive beliefs about competence in math are integral to expectancies; this in combination with task valuation is likely to encourage continued participation in math and promote identification with math (Eccles & Wigfield, 1995; Marchant, Paulson, & Rohlisberg, 2001).

2.2 CLASSROOM ASSESSMENT SCORING SYSTEM-SECONDARY (CLASS-S) FRAMEWORK

Although extant research suggests student-teacher interaction as a critical component for student learning (Simpkins, Davis-Kean, & Eccles, 2006), research based in EVT has yet to define specific teaching practices that may be integral to promoting positive student learning outcomes; much of the conclusions derive consistently from general assessments of teacher influences such as teacher beliefs, expectations, and attitudes toward students' ability (Wigfield & Cambria, 2010). The CLASS-S framework employs a more specific approach than EVT to examine teacher-student interactions by utilizing specific dimensions to assess the quality of teachers' social and instructional interactions with their students. Extant CLASS-S research emphasizes three teacher practices—teacher sensitivity, quality of feedback, and instructional learning formats—that are particularly important for student learning and development (Pianta et al., 2012). *Teacher sensitivity* refers to the teacher's responsiveness to the academic and social/emotional needs of individual students (Pianta et al., 2012). *Quality of feedback* encompasses teacher-student interactions that transmit information about a student's performance or effort (Pianta et al., 2012). Lastly, *instructional learning formats* are the methods by which a teacher engages students in and facilitates activities to maximize learning opportunities (Pianta et al., 2012). These three practices may critically impact the development of expectancy-value beliefs and identity in math (Berry et al, 2011; Schunk et al., 2008). For example, when teachers provide a variety of novel and interesting learning activities, students are more likely to enjoy learning (Cotton, 2000; Yair, 2000). In conjunction, student interest in learning may increase participation in the curated activities; continued participation in math activities may also indicate a desire to continue to exhibit characteristics integral to one's sense of self (Eccles, 2009).

Below, I use EVT and the CLASS-S framework as guiding frameworks to examine a mediation model by which the three teacher practices influence students' math identity through expectancy-value beliefs in adolescent students.

3.0 LITERATURE REVIEW

3.1 MATH IDENTITY

Learning mathematics involves the development of each student's sense of self in math (Darragh, 2013). A common phrasing that individuals have regarding their identity in a domain is whether they are a "person" of that domain (i.e., "I am (not) a math person") (Anderson, 2007; Yeager & Dweck, 2012). This identification is important because students with positive math identities are more likely to achieve academically at a higher level, persist in mathematics, and pursue a higher education in STEM (Froschl & Sprung, 2016; Maltese & Tai, 2011).

A positive math identity may be particularly important for African American students. A persistent and deleterious societal narrative paints African Americans as mathematically inept (Martin, 2009). Given these negative expectations for performance, research posits that African American students may feel that they do not belong in the math domain (Walton & Cohen, 2011); these negative feelings can influence beliefs about ability and continued persistence in math (Rivera-Batizm, 1992). However, research also demonstrates the malleability of math identity (Berry et al., 2011). Together, these imply that school learning experiences and other psychological beliefs influence African American students' math identity. Drawing from EVT, I conceptualize five motivational beliefs that predict a positive math identity. They are an individual's beliefs that (1) they are good at mathematics, (2) math is useful, (3) math is interesting, (4) math is important to them, and (5) participation in math is worth the effort.

3.2 TEACHER PRACTICES AND MATH IDENTITY

Research has suggested that interactions between teachers and students are the primary mechanism for student academic development and learning (Pianta et al., 2012). Prior research has demonstrated that a teacher's responsiveness, their use of feedback to promote increased in-depth thinking, and their facilitation of activities to maximize learning are all teacher practices that are especially important in the classroom (Butler, 1987; Roeser, Eccles, & Sameroff, 1998; Yair, 2000). Prior qualitative research suggests that these teacher practices may be potentially beneficial for students' math identity development, especially for African American students (Berry et al., 2011).

3.2.1 Teacher Sensitivity

Teacher sensitivity is the level of a teacher's responsiveness to the academic and social/emotional needs of individual students (Pianta et al., 2012). Teachers, by personalizing instruction in response to student needs and difficulties, may promote a sense of belonging in students. A sense of belonging can inform students' identification as math learners (Nasir, 2008). When students feel that they belong, they feel comfortable learning in their environment and their participation in the classroom is likely to increase (Baumeister & Leary, 1995; Ryan & Deci, 2000). As students participate in math, they may begin to see themselves and have others view them as valuable members of the math community (Anderson, 2007). As a consequence of feeling vulnerable and devalued due to their assigned status as academically subordinate, African American students may become alienated from school (Rjosk, Richter, Hockweber, Ludke, &

Stanat, 2015). Therefore, teachers might play an integral role in facilitating African American students' belonging in the math classroom and consequently, their identification as a math learner. Indeed, previous research shows that African American students' relationships and experiences with teachers could help students ascertain who they are relative to mathematics (Anderson, 2007).

3.2.2 Quality Feedback

Teacher quality feedback encompasses a variety of teacher-student interactions in which information about a student's performance or effort is transmitted (Pianta et al., 2012). Through quality feedback, a teacher can promote more in-depth thinking and processing of information by focusing on expanding learning and understanding rather than simply indicating a correct answer (Franke, Kazemi, & Battey, 2007; Pianta et al., 2012). High quality feedback may promote student competence and interest by providing opportunities to connect learning goals and student ability level (Pianta et al, 2012). Research indicates that teachers who explain problems more thoroughly and "push them to the limit" were important for African American students' math identity development (Berry et al., 2011). In other work by Nasir and colleagues (2014), positive student outcomes occur when teachers in a diverse high school switch from the traditional teacher-centered, lecture-based pedagogical style in favor of a pedagogy centered around method demonstration and teacher questioning in math classes. This quasi-experimental work demonstrates that adopting the latter pedagogical style of increased quality feedback results in both a decrease in the math achievement disparity between this case study school and other local high schools as well as the math achievement gap between European American and minority students (Nasir et al., 2014). By improving African American student performance, lowered beliefs about ability and belonging may be alleviated and allow African American students to identify as math learners (Anderson, 2007; Berry et al., 2011).

3.2.3 Instructional Learning Formats

Instructional learning formats are a teacher's methods of engaging students and facilitating activities so that learning opportunities are maximized (Pianta et al., 2012). When teachers provide a variety of novel and interesting learning activities, students are likely to engage in learning (Cotton, 2000; Yair, 2000). Continued pursuit of participation in math activities is considered an indication of the individual's personal identity and their desire to continue to exhibit characteristics integral to their sense of self (Eccles, 2009). Similarly, previous qualitative work indicates that African American adolescent students reported that teachers who made math interesting and fun are a crucial factor to the development of their math identities (Berry et al., 2011).

3.3 EXPECTANCY-VALUE BELIEFS AND MATH IDENTITY

Motivational factors can impact math identity development in students (Master, Cheryan, & Meltzoff, 2016). There are several avenues by which this influence can occur. Eccles (2009) postulates that when an individual feels that math tasks are central to their identity, they will likely prioritize effort (cost) and engagement in those tasks. Secondly, if a student feels that math is important (attainment), participating in the tasks will provide the student opportunities to express or confirm aspects of the self (Eccles, 2009). As a student completes math tasks, this can reflect important personal goals (utility) and provide opportunities to connect these goals to an individual's sense of self (Wigfield et al., 2016). Lastly, as a student persists in math, they will likely show more interest and develop competence; their developed skills will then become a part of their sense of self (Eccles, 2009; Master et al., 2016; Wigfield et al., 2016). Despite the well-established associations between motivation and identity, little research has explicitly examined the particular relation between math motivational beliefs and math identity formation.

3.4 TEACHER PRACTICES AND EXPECTANCY-VALUE BELIEFS

There has been ample evidence for the relations between teaching practices and students' expectancies and task values (Marchant et al., 2001; Wang, 2012; Wigfield et al., 2016). Specifically, teacher sensitivity, quality feedback, and instructional learning formats are particularly important for students' motivation (Pianta et al., 2012, Pianta & Hamre, 2009).

3.4.1 Teacher Sensitivity

Teacher communications can convey both responsiveness and sensitivity to student needs as well as expectations about ability to students (Raphael, Pressley, & Mohan, 2008). Research shows that student appraisals of positive emotional support may result in improved perceived competence and valuation of a task by promoting positive teacher-student relationships (Eccles & Roeser, 2011; Wentzel, 2004). A positive perception of competence is integral to an individual's beliefs of success in a future math task and continued participation in math activities (Eccles & Wigfield, 1995; Marchant et al., 2001). An individual's continued participation reflects valuation of the task (Eccles, 2009) and the evaluation that the effort expended in math is worthwhile (Kukla, 1972).

Studies have also shown that African American students may be particularly receptive to teacher sensitivity (Smokowski, Reynolds, & Bezrucko, 2000). Previous research has demonstrated that teachers have lowered expectations for their disadvantaged and minority students and this may result in fewer positive teacher-student interactions (Chang & Demyan, 2007). However, ethnic minority students specifically highlight the importance of a teachers' responsiveness to individual differences and needs, help with academics, and encouragement (Hayes, Ryan, & Zseller, 1994). When teachers tailor their instruction to more appropriately address minority students' needs and interests, a more motivating climate results (Rjosk et al., 2015). Thus, a teacher's use of sensitivity towards their minority students may result in increased expectancies and task values as well as lowered cost evaluations.

3.4.2 Quality Feedback

High-quality feedback involves specific information about how to get the answer, improving performance, and the relation between students' performance and larger goals (Brophy, 1986; Pianta et al., 2012; Pianta, La Paro, & Hamre, 2008). For middle school students, providing scaffolding and challenging students' thinking produces higher levels of student engagement (Raphael et al., 2008). This may be due to an increase in expectancy-value beliefs. Butler (1987) explains that quality feedback increases interest; this is likely because as students' beliefs about their ability increase, their interest also increases (Eccles, 2009). In addition, when an individual anticipates performing well in math, they are likely to put more effort into their math tasks (Eccles-Parsons et al., 1983).

Furthermore, African American adolescent students report that the teachers who explain thoroughly explain math problems and "push them to the limit" were important for their engagement in mathematics (Berry et al., 2011). In "pushing students to the limit," teachers may also improve students' competence beliefs through scaffolding students to higher-order thinking in math. In addition, as teachers scaffold student learning, they may allow students to connect their learning goals and their current performance; connecting these may increase students' task values of math (Eccles, 2009).

3.4.3 Instructional Learning Formats

An important component of instructional learning formats is the active engagement of students with the inclusion of interesting instruction, projects, and learning modalities (Pianta et al., 2012). Instructionally rich learning environments are related to engagement in math learning in elementary and middle school years (Marks, 2000). For example, working in small groups to work through challenging assignments can promote increased engagement and subsequent learning (Davidson, 1999). This relation between interesting learning formats and heightened engagement and learning may operate through expectancy-value beliefs. First, teacher facilitation of students' participation in tasks that stray from the traditional lecture-based pedagogy in favor of active pedagogical strategies supports greater student enjoyment (intrinsic value) in the tasks (Akey, 2006). In addition, academic performance informs student competence (Wigfield & Cambria, 2010); individuals often engage and participate in tasks to experience competence (White, 1959). Through their engagement, students likely improve in math skills and consequently, increase their enjoyment of the task (Eccles, 2009); therefore, instructional learning formats may have important implications for expectancies and task values.

3.5 RACIAL DIFFERENCES

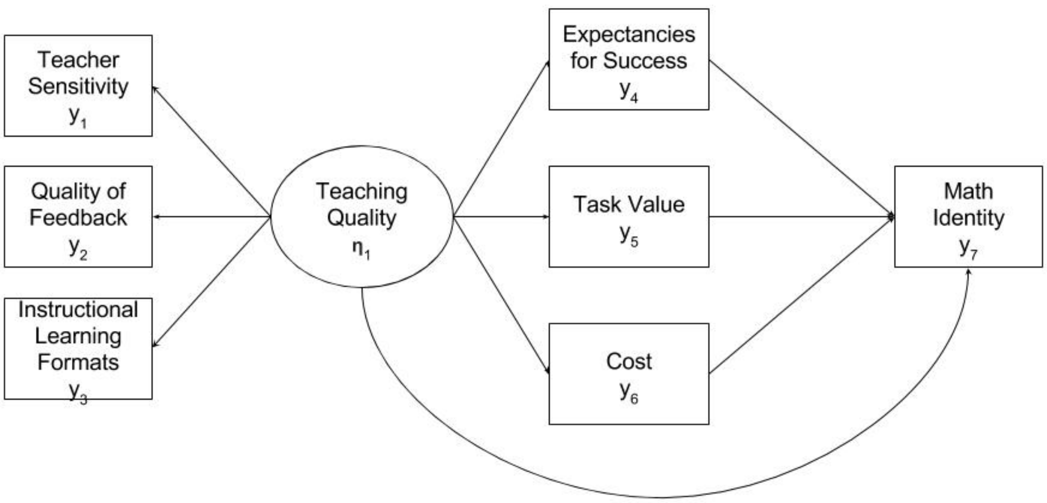
Research suggests that there are significant differences between African American and European American experiences in school (Hakim, 2014; Martin, 2012). For instance, extensive literature demonstrates that teachers hold lower expectations for African American students' academic ability, perceive African Americans as more disruptive, and provide more negative feedback to their African American students (Bennett, 1976; Ross & Jackson, 1991). Indeed, the effect of teacher practices on students' motivation in math and math identity development may vary as a function of students' race (Chang & Demyan, 2007; Nasir, 2008). A wealth of research suggests that African American students strongly prefer learning and achievement opportunities in alignment with their communal culture (Tyler, Boykin, & Walton, 2006); yet teachers tend to adopt a more independent pedagogy aligned with European American culture (Boykin, Tyler, & Miller, 2005). Given that classrooms are not culturally neutral and teachers respond differently to varying cultural behaviors (Tyler et al., 2006), teachers may foster different expectations and vary opportunities for success for students of different races, especially in the case of a mismatch between student-preferred classroom culture and teacher-endorsed classroom culture. Less preferred treatment by teachers could hamper African American students' academic performance and erode students' motivation (Casteel, 1998).

In addition to varying classroom effects for students of different races, motivation factors may also vary between these students. Cost may be especially important for African American students. Due to the pervasive stereotype of inferiority in math, African American students likely have lowered self-perceptions of academic competence (Eccles-Parsons et al., 1983; Okeke, Howard, Kurtz-Costes, & Rowley, 2009). These decreased perceptions may impact their motivation. Academic competence perception is critical for expectancies and task value (Eccles, 2009; Wang & Degol, 2013). These lowered perceptions of competence may impact an individual's beliefs about cost of participating in a domain. Specifically, students' stereotype threat in mathematics (Martin, 2009, 2012) may lead to perceptions that greater effort expenditure will be required to succeed in math (Okeke et al, 2009). Because European American students are not subject to this stigma, it is likely that the association of cost with teaching practices and math identity differ for African American students when compared to their European American cohort. However, little research has examined the moderation effect of students' race when examining associations between teacher practices, motivational beliefs, and math identity. Including race as a moderator would allow researchers to better account for racial differences.

4.0 THE CURRENT STUDY

Although EVT researchers have conceptualized associations between teaching practices, expectancy value beliefs, and academic identities, no research has discerned the potential mediating effect of expectancy-value beliefs in the relation between teacher practices and math identity. Furthermore, despite the importance of students' learning experiences in relation to their math identities, there is very little quantitative research on the identification of specific teaching practices and motivational beliefs that promote or undermine math identity development, especially for African American students. Researchers who have studied students' math identities have predominantly employed qualitative methods. Qualitative research is advantageous in conducting explanatory research as it seeks to gain further understanding of people's experiences of the world; however, these experiences are variable, personal, and subjective, resulting in limited generalizability (Miller, 2013). I will address these gaps in the literature by utilizing the CLASS-S framework to examine specific teaching practices that demonstrate importance for math motivation and identity. With a large racially and socioeconomically diverse sample of sixth graders, I will examine whether a psychological mechanism in which teacher practices (i.e., teacher sensitivity, quality feedback, and instructional learning formats) impact math identity through expectancy-value beliefs (i.e., expectancies, utility value, intrinsic value, attainment value, and cost) (Figure 1). Furthermore, I will ascertain whether these processes operate differently in the context of increased stereotype by examining race as a moderator of the mediated mechanism. Specifically, I seek to answer the questions: (1) do students' expectancy-value beliefs mediate the associations between teaching practices and math identity and (2) does the mediation effect of students' motivational beliefs on the association between teaching practices and math identity vary by race? I hypothesize that expectancy-value beliefs will mediate the associations between teaching quality and math identity and these mediations will differ by race.

Figure 1. Path Analysis Model



5.0 METHODS

5.1 PARTICIPANTS

Participants were middle school students enrolled in the Assessing Youth STEM Engagement and School Engagement Study that was designed to examine the influence of contextual and motivational factors on students' engagement. The sample included 525 sixth graders recruited from ten schools in three school districts in the Mid-Atlantic region of United States. The student sample was approximately 49% male, racially diverse (64% European American and 36% African American), and economically diverse with approximately 59% of the sample qualifying for a free- or reduced-price lunch.

5.2 PROCEDURE

All participants were invited to participate in the study using school-based recruitment during the fall semester of the 2016-2017 school year. First, at each school, the researchers described the study to math teachers and obtained their consent accordingly. The research team, with the assistance of the math teachers, distributed letters about the project to students in their math classes and asked permission for students to participate in the study. Additional informational forms were sent home to describe the study purpose and procedures and provide an opportunity for parents and/or students to opt out of the study (only 2% of students chose to opt out of the study). Students who agreed to participate were given a computer-based survey and completed the math engagement survey during their regular instruction time in school. Research staff was available during survey administration to provide assistance and answer student questions about survey purpose. In addition to student engagement information, the survey also asked students about their math teachers' instructional practices, personal motivational beliefs, and identification as a math learner. Following survey administration, research staff provided students with a small gift for participation.

5.3 MEASURES

5.3.1 Math Identity

Adolescents reported their math identity with four items (e.g., "I am a math person") (Hazari, Sonnert, Sadler, & Shanahan, 2010; Vincent Ruz, Dorph, Binning, & Schunn, 2017). Students answered on a 4-point scale from 1 (NO!) to 4 (YES!) and items were averaged such that higher scores indicated a stronger math identity (Cronbach's $\alpha = .891$).

5.3.2 Relational Connections with Teachers

We examined student perceptions of teacher use of sensitivity, quality feedback, and instructional learning formats. The following scales were adapted from prior work by Downer, Stuhlman, Schweig, Martinez, and Ruzek (2015). All measurements were scaled appropriately so that high scores indicate higher student perceptions of each teacher practice. These three scales demonstrate strong internal consistency (α = 0.800, 0.844, and 0.712, respectively) and comprise the higher-order factor of teaching quality.

The Teacher Sensitivity scale included three items (e.g., “My math teacher helps me when I need help”) that measured the extent to which students perceived responsiveness from their teacher. Responses were measured on a 5-point scale, ranging from 1 (*almost never*) to 5 (*almost always*).

The three-item scale of Quality Feedback assessed students’ beliefs of appropriate scaffolding and intellectual support in their math classes. Students responded to items (e.g., “My math teacher keeps working with me until I understand what we’re doing”) on a 5-point scale from 1 (*almost never*) to 5 (*almost always*).

The Instructional Learning Formats scale utilized two items (e.g., “I do all kinds of interesting activities in math class”) to ascertain student perceptions of teacher facilitation of interesting learning opportunities. For both items, students responded on a 5- point scale from 1 (*almost never*) to 5 (*almost always*).

5.3.3 Math Expectancy-Value Beliefs

Adolescents responded to questions about expectancies, utility value, intrinsic value, attainment value, and cost in math (Trautwein et al., 2012). Sixth graders’ expectancies were assessed with three items (e.g., “I am good at math”). Students responded on a 5-point scale from 1 (*strongly disagree*) and 5 (*strongly agree*). Task value included five items and measured students’ utility value, intrinsic value, and attainment value (e.g. “I will need good math skills for my daily life outside of school;” Wang & Eccles, 2013). These three constructs were averaged together due to high correlations between the three value components (utility value and intrinsic value = 0.263; utility value and attainment value = 0.474; intrinsic value and attainment value = 0.214). Items were rated on a 5-point scale from 1 (*strongly disagree*) to 5 (*strongly agree*). Higher scores for task value indicated higher valuation of mathematics. Lastly, the Cost scale included four items (e.g., I'd have to sacrifice a lot of free time to be good at math") to ascertain student beliefs that effort in math is worthwhile. Items were answered on a 5-point scale from 1 (*strongly disagree*) to 5 (*strongly agree*).

5.3.4 Covariates

Demographic characteristics of the participating adolescents were included in the analyses as covariates. Measures included adolescents' *gender* (0-female, 1-male), *race* (European American and African American), *socioeconomic status* (eligible for free or reduced-lunches), and math achievement. PSSA standardized scores were used as a marker for students' math achievement level.

6.0 DATA ANALYSIS

I conducted the structural equation models with Mplus Version 6 (Muthen & Muthen, 2010). Each of the teaching practices (teacher sensitivity, quality of feedback, and instructional learning formats) was loaded onto the latent factor teaching quality. Across both the path model and multigroup models, all endogenous variables were conditioned on the following observed variables: gender, SES (free lunch), and math achievement. Due to the extreme sensitivity of the χ^2 test to negligible sources of ill fit in large samples, I follow convention and rely upon four alternative fit indices to evaluate model fit. These alternative fit indices are RMSEA, CFI, TLI, and SRMR; acceptable fit statistics are less than .08, from .95 to 1.000, from .95 to 1.000, and less than .05, respectively. In addition, normality assessments demonstrated a lack of kurtosis or skew in the data. Missing data (n = 45) analyses demonstrated that data was missing completely at random for variables of interest: teacher sensitivity, quality of feedback, instructional learning support, expectancies, task value, cost and math identity. Unfortunately, analyses confirmed that data was not missing at random on free lunch eligibility with those missing more likely to be free lunch eligible. To account for this, I controlled for free lunch eligibility by regressing all endogenous variables on this variable. Lastly, I accounted for the clustered nature of the data (students in classrooms) by using CLUSTER command in Mplus.

To address the research questions, I ran a model of the full psychological mechanism to test the mediating effect of expectancies, task value, and cost on teaching quality and math identity. Prior to multigroup analyses, both groups were included in analyses. Each endogenous variable (math identity, expectancies, task value, and cost) was regressed on the covariates (gender, free lunch eligibility and math achievement) and teaching quality. To examine the moderating effect of race, I conducted multigroup analyses. I began by establishing measurement invariance of the latent variable by conducting a series of four models with increasingly stricter invariance—(1) configural invariance, (2) weak or metric factorial invariance, (3) strong or scalar factorial invariance, and (4) strict factorial invariance—between the two groups. Likelihood ratio tests (LRT) were used to determine whether model fit worsens as the latent variable is constrained to equality between both groups. Table 1 demonstrates fit indices and the results of each LRT; the results demonstrate that the model fit does not significantly worsen when the latent variable is constrained to equality between the two models. Therefore, for parsimony, I used the strictest model of factorial invariance. Employing the fourth model listed in Table 1, students were grouped by race and both a fully free model—no constrained pathways—and fully fixed model—all constrained pathways—were conducted and compared to determine whether the model (Figure 1) differed between races. Then, utilizing model constraints, I compared the pathway coefficients between the European American and African American students to determine any significant moderation effects.

Table 1. Fit statistics and results of LRTs for measurement invariance.

Model	χ^2 df	χ^2	χ^2 p-value	$\Delta\chi^2$	$\Delta\chi^2$ df	χ^2 p-value	RMSEA	CFI	TLI	SRMR
Configural	1	1.29	0.256	--	--	--	.033	.999	.997	.027
Metric	2	4.08	0.130	2.789	1	0.095	.063	.996	.988	.038
Scalar	5	8.03	0.155	3.946	3	0.267	.048	.994	.993	.053
Strict	8	12.95	0.114	4.921	3	0.178	.049	.991	.931	.102

7.0 RESULTS

Table 2 shows descriptive statistics for the observed variables across both African American and European American students. No significant differences were reported between African American and European American students, except that African American students were more likely to be eligible for free lunch and receive a “below basic” or “basic” classification for their PSSAs scores.

Table 2. Descriptive statistics for African American and European American students.

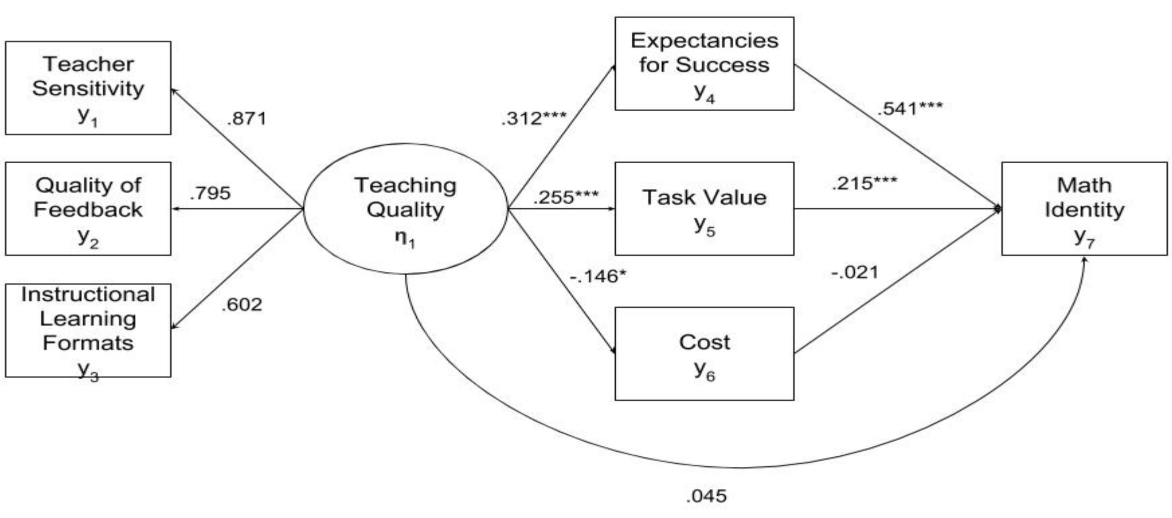
	African American (n = 189) n/mean	European American (n = 336) n/mean	T-Test
Gender			9.101*
Male	130	122	
Female	57	210	
Free Lunch Eligibility			173.785***
Eligibility	150	151	
Non-Eligibility	37	176	
PSSAS			8.251***
High Achievers	31	55	
Low Achievers	121	98	
Teacher Sensitivity	3.705	3.749	0.517
Quality of Feedback	3.987	3.901	2.264
Instructional Learning Formats	3.559	3.481	2.258
Expectancies	3.747	3.467	0.172
Task Value	4.125	4.031	0.124
Cost	2.906	2.722	0.041
Math Identity	2.683	2.798	3.044†

*p < .05, **p < .01, ***p < .001, †trending significance

7.1 PATH ANALYSIS

In this paper, I sought to test a model in which expectancy value beliefs (i.e., expectancies, task value, and cost) mediated the relation between teacher quality and math identity (Figure 1). The results indicated that each expectancy-value belief was significantly predicted by teaching quality in the expected directions. Higher teaching quality was associated with higher expectancies ($\beta = .267$, $SE = .075$, $p < .001$), higher task value ($\beta = .526$, $SE = .029$, $p < .001$), and lower cost ($\beta = -.146$, $SE = .066$, $p = .027$). Furthermore, the associations between math identity and two of the expectancy value beliefs were also significant in the expected directions. Specifically, increased expectancies predicted increased math identity ($\beta = .541$, $SE = .042$, $p < .001$) and higher task value predicted higher math identity ($\beta = .215$, $SE = .051$, $p < .001$). Lastly, the indirect effects were only significant through expectancies ($\beta = .144$, $SE = .032$ $p < .001$) and task value ($\beta = .113$, $SE = .030$ $p < .001$). Figure 2 shows the results of the mediation model.

Figure 2. Results of Mediation Model: Direct Effects.



7.2 MULTIGROUP ANALYSES

As Table 1 demonstrates, there were no significant differences in the latent or observed variables between each of the models; model fit between each of the models did not significantly differ. For parsimony, the last model—strict factorial invariance—was utilized to conduct the path analyses. Table 3 demonstrates the results of the LRTs between these two models; results indicated that there were significant differences in fit between the models. Fit was significantly worse in the model with fully fixed pathways demonstrating that there were significant differences in pathways between races.

Table 3. Fully fixed and fully free model in European American and African American students.

Model	χ^2 df	χ^2	χ^2 p-value	$\Delta\chi^2$	$\Delta\chi^2$ df	χ^2 p-value	RMSEA	CFI	TLI	SRMR
Free	36	52.297	0.0388	--	--	--	.042	.989	.975	.033
Fixed	43	75.515	0.0016	23.218	7	0.0372	.054	.978	.958	.074

For the European American students, the association between teaching quality and math identity was significantly mediated by expectancies (β = .155, *SE* = .045, p = .0001) and task value (β = .101, *SE* = .031, p = .0001). This indicates that a unit increase in teaching quality relates to a 0.134 unit increase in math identity through expectancies and a 0.087 unit math identity increase in task value for European American students. Both the indirect effect of cost on the relation between teaching quality and math identity and the direct effect of teaching quality on math identity were nonsignificant. For African American students, the relation between teaching quality and math identity was also significantly mediated by expectancies (β = .130, *SE* = .039, $p < .0001$) and task value (β = .123, *SE* = .063, $p = .05$). Thus, a unit increase in teaching quality relates to a 0.130 unit increase in math identity through expectancies and a 0.123 unit increase in math identity through task value. The mediating effect of expectancies yielded a larger increase in European American's math identity as a result of higher teaching quality compared to their African American counterparts while the mediating effect of task value resulted in a larger increase in math identity due to increased teaching quality for African American students as compared to the European American peers. Similarly to European American students, the indirect effect of cost on the association between teaching quality and math identity as well as the direct effect of teaching quality on math identity were nonsignificant.

Although analyses revealed different effect sizes between the significant pathways for the association between teaching quality and math identity, follow-up analyses demonstrated that the indirect effects do not differ significantly by race. Specifically, the difference in the indirect effects of expectancies (β = .060, *SE* = 0.062, $p = .332$) and task value (β = -0.026, *SE* = .050, $p = .611$) were not significantly different between African American and European American students.

8.0 DISCUSSION

The development of math identity has received a lot of attention, yet most of the extant studies are qualitative research, thus limiting researchers' ability to generalize the findings. In response, I examined the motivational mechanism by which teaching practices impact math identity by using a sample of approximately 500 sixth graders. Working within the EVT and CLASS-S frameworks, the motivational process by which teaching quality impacts math identity through the expectancy value beliefs of—expectancies, task values, and cost—was ascertained. I also examined the moderating effect of race for this mechanism by comparing African American and European American students. As hypothesized, results demonstrated that adolescent math identity is influenced by teaching practices through expectancy-value beliefs. European American students showed a larger increase in math identity due to their teacher's positive impact on their math expectancies than their African American counterparts; African American students experienced a greater increase in their math identity as a result of a teachers' positive impact on their math task value compared to European American students. However, these racial differences were not statistically significant.

8.1 THE LINKS BETWEEN TEACHING QUALITY, EVT, AND MATH IDENTITY

Consistent with my hypotheses, the results indicated higher teaching quality was associated with higher expectancies and task value as well as lowered cost. Students' perception of higher teaching quality positively related to their beliefs about their ability to succeed in future math tasks and their valuation of math for all students as well as diminished students' perceptions of the cost of participating in math. This furthers the extensive literature based in EVT describing the critical importance of teachers and teaching quality for students' motivation (Marchant et al., 2001; Wang, 2012; Wigfield et al., 2016). According to CLASS-S (Pianta et al., 2012), the specific use of teacher sensitivity, quality of feedback, and instructional learning formats are critical classroom elements for promoting students' math motivation. Indeed, these teaching practices have been found to enhance student academic learning by producing a more responsive and engaging learning environment (Berry, 2008; Berry et al., 2011; Pianta et al., 2012). Improved responsiveness to students' emotional and academic needs, appropriate assistance with math problems, and facilitating interesting learning opportunities likely enhanced students' math competence and interest as well as their beliefs about the usefulness and personal importance of math (Berry et al., 2011; Wentzel, 2004). By doing so, these practices help students feel competent in mathematics and value math.

Furthermore, my findings confirmed that expectancy-value beliefs were positively associated with increased math identity. As students' expectancies and task value increased, students' math identity also increased. Extant research has determined the association between these two constructs but with identity conceptualized as an antecedent to expectancy value beliefs (Perez, Cromley, & Kaplan, 2014). My findings extend this literature and provide evidence that students' expectancy value beliefs also predict students' math identity. A student's expectations for success in math tasks and task value can provide motivation for a student to engage in math tasks (Eccles, 2009; Wigfield et al., 2016). By continuing to engage in this task, they may continue to develop their skills and value; these skills and values may translate into the individual's sense of self (Eccles, 2009; Master et al., 2016).

The mediation analyses show that teaching quality predicts students' math identity through expectancies and task values. This suggests that students' perceptions of higher utilization of the three teaching practices positively related to their beliefs about their ability to succeed in and their valuation of math. These motivational beliefs, in turn, influence math identity. Research has demonstrated that responding to students' needs appropriately can provide improved perceptions of future success and valuation of tasks they engage in which are critical for promoting math identity development (Berry et al., 2011; Eccles & Roeser, 2011). In addition, previous research has suggested that scaffolding students' learning to a higher level and providing interesting learning opportunities may also provide information about students' competence and task valuation, further informing math identity (Berry et al, 2011; Eccles, 2009; Pianta et al., 2012). My results extend these findings by both quantitatively validating qualitative research as well as demonstrating the particular importance of the examined teaching practices and motivational constructs for math identity development.

Contrary to my hypothesis, the direct effect of teaching quality on math identity was not significant. These findings suggest that teaching quality does not directly impact math identity development for sixth grade students. This result seems to largely contradict a wealth of research that demonstrates the importance of teachers for students' academic identity (Eccles- Parsons et al, 1983; Wentzel, 2004; Wigfield et al, 2010). One potential explanation for these null findings may lie in the typical methodology utilized in math identity research. A majority of the research examining math identity is qualitative; it may be the case that previous qualitative findings fail to generalize to a broader population. A second explanation may be the choice of teaching practices that were used to create the latent variable of teaching quality. The CLASS-S framework includes ten additional classroom and teaching components that may be related to teaching quality that were not examined in this study. Although extant research (Berry, 2008; Berry et al, 2011; Nasir et al., 2014, Pianta et al., 2012) has demonstrated the importance of these three practices for motivation, learning, and identity, it may be the case that other practices may be more important for student's math identity development. Self-determination theory (Ryan & Deci, 2001) postulates that promoting student relatedness, autonomy, and competence are important for motivation and learning; thus, other teaching practices that translate to encouraging these student outcomes, such as regard for adolescent perspectives and content understanding, may be more impactful for fostering student math identity development.

8.2 RACIAL DIFFERENCES

My findings indicate that the indirect effect of teaching quality onto math identity through expectancy value beliefs was true for both racial groups. However, analyses confirmed my hypothesis that the size of the indirect effects differs by race. This indicates that this mechanism does not operate equally for both racial groups of students. Both of the significant indirect effect pathways differed between the races. The indirect effect of expectancies had a larger effect size for European American students while the indirect effect of task value's effect size was larger for African American students. These findings suggest that European American students' expectations for math success and African American students' valuation of math tasks increase differently as a result of teaching quality compared to their opposite race peers.

Specifically, this first result indicates that European American students expect to succeed in mathematics as a result of teaching quality and this expectation promotes a greater increase in math identity than their African American counterparts. Extant research suggests that African American students, due to the stigmatization in mathematics, may be less likely to expect to succeed in mathematics (Byrd & Chavous, 2011; Chavous, Rivas-Drake, Smalls, Griffin & Cogburn, 2008). Thus, although the teacher has a positive impact on their expectancies for success, African American students' generally lowered expectations for success in mathematics might explain the smaller effect size of the indirect effect for African American students compared to their peers. Furthermore, other work demonstrates that African American students' beliefs about competence are not related to their performance in school, perhaps as a response to the negative expectations of their performance to protect their self-esteem (Stevenson, Chen, Uttal, 1990). Considering that math identity is strongly related to math achievement (Berry, 2008; Berry et al., 2011; Cribbs et al., 2015), this lack of relation between competence beliefs and achievement for African American students may explain the smaller effect size for this group of students.

Secondly, as a result of teacher's usage of the three teacher practices, African American students' math motivation improves, and this increase promotes a greater increase in math identity than their European American counterparts. Prior work has demonstrated that African Americans might be more impacted by teacher practices in mathematics (Berry et al., 2011; Hayes, Ryan, & Zseller, 1994). Due to their stigmatization in mathematics, students may be more responsive to encouragement, assistance, or feedback from their math teacher (Martin, 2009; Rjosk et al., 2015). In addition, previous literature has showed that task value may be particularly important for African American students' math achievement. According to Long and colleagues (2007), interest was a critical motivation source related to improved academic performance for African American adolescents. The particular importance of interest—a key component of task value—may explain why African American students experience a greater increase in math identity development through task value in response to higher teacher quality than their European American counterparts.

However, as mentioned previously, the differences between African American students and European American students in both pathways described above were not significant. These findings were surprising given the wealth of research implying potential differences between these two groups (Berry et al., 2011; Byrd & Chavous, 2011; Chavous et al., 2008; Hayes et al., 1994). These results suggest that there is no significant difference in how African American and European American students develop their math identity; African American and European American student's math identity development are equally as impacted by teaching quality. It is important to keep in mind that the dataset utilized in this study is relatively heterogeneous in SES and achievement; therefore, significant results may be obscured. Follow-up analyses should utilize a more nationally representative dataset in order to determine whether racial effects are present.

8.3 COST RESULTS

Contrary to my hypotheses, associations between cost and math identity and the indirect effect of teaching quality onto math identity through cost were not significant. The findings suggest that the mechanism by which teaching quality impacts math identity may not include decreasing the cost of participating in mathematics; in other words, a student's perception of required effort for participating in math may not relate to the association between teaching quality and math identity. This contradicts a wealth of research that postulates the importance of cost for participation in mathematics (Eccles-Parsons et al., 1983; Eccles, 2009; Wigfield & Cambria, 2010). Research demonstrates when students are asked about their least motivating class, many students voice that the cost of participating in the course was too high (Flake, Barron, Hulleman, McCoach, & Welsh, 2015). Other empirical findings posit that cost is a critical component of EVT and it independently predicts students' achievement (Conley, 2012; McClelland, Atkinson, Clark, & Lowell, 1953). My results especially go against prior work that indicates that cost may be a particularly important motivational factor for African American students (Andersen & Ward, 2013). Due to the persistent narrative that depicts African American students as inferior in mathematics, African American students tend to perceive greater potential effort expenditure to succeed in math (Martin, 2009, 2012; Okeke et al., 2009). However, it may be the case that this societal stigma might be more salient for students' math identity rather than their interpretation of cost (Walton & Cohen, 2011). Future research should include an analysis of stereotype threat in mathematics when analyzing the development of cost and math identity. Another explanation for my null findings may be in the measure of cost utilized. Several types of cost have been examined in previous literature (Flake et al., 2015). The items used in this study examined mostly task effort—the amount of effort required to participate in math (Flake et al, 2015). Flake and colleagues (2015) found in interviews with older adolescents that the most salient type of cost depended on the student's level of motivation for the class. For those most motivated, task effort was most salient; yet for those who were the least motivated, loss of a valued alternative cost—sacrificing a more desirable activity to participate in the target task—was the most salient. Math is largely known as a difficult subject with low student motivation (Nasir et al., 2014), and it may be the case that many adolescents are not highly motivated and the loss of a valued alternative type of cost would be better suited to understand student cost perceptions. Future research should examine this type of cost with students in mathematics.

8.4 LIMITATIONS, FUTURE DIRECTIONS, AND CONCLUSIONS

While the present study contributes to the literature on the potential mechanisms by which teaching quality can promote math identity through math expectancies and task values in both European American and African American students, there are likely several limitations to my work. First, this study only examines sixth grade students. Adolescence covers a large age range so my generalizability to other grades of students is limited. Future research should examine this psychological mechanism in a broad range of adolescents.

Additionally, for each measure, only student perspectives are considered. It may be concerning that teacher practices included in teacher quality are the measures of student perceptions of each teacher practice. There may be a mismatch between student perceptions of teacher practices and the actual presence of teacher practices in the classroom. Furthermore, there may be monomethod bias—the same individual is reporting for all variables and this may influence the estimated associations between constructs. Future research should utilize multiple reporters (e.g., teacher report) or methods (e.g., classroom observation) to measure teacher practices to eliminate potential sources for perception bias. Lastly, although we controlled for students' prior math achievement, the main psychological constructs (e.g., motivation, math identity) utilized in this study are mainly cross-sectional. Future research should adopt longitudinal methodology; for example, analyzing the development of math identity over time may provide more insight into the mechanisms by which teaching quality impacts math identity.

Despite these limitations, this study expands our understanding of math identity development in middle school students. Teachers are crucial for promoting math identity development; specifically, teachers' use of sensitivity, quality of feedback, and instructional learning formats can impact students' math identity development through their expectancies and task values. This may be especially important for African American students who are typically stigmatized against in mathematics. This improved understanding of the relations between teaching quality, motivation, and math identity is essential. This can inform math teachers' teaching practices to promote math motivation, identity, and achievement, not only for all students but also especially for those stigmatized. Schools seeking to improve math performance, especially in their minority or stereotyped students, should consider professional development seminars to improve the teaching practices of sensitivity, quality of feedback, and instructional learning supports to improve math identity and achievement.

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