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Does student-centered instruction engage students differently? The moderation effect of student ethnicity

Eli Talbert[a,b], Tara Hofkens[a,b], and Ming-Te Wang[a,b]

[a]Department of Psychology, School of Education, University of Pittsburgh, Pittsburgh, Pennsylvania, USA; [b]Tara Hofkens is now at the Curry School of Education, University of Virginia, Charlottesville, Virginia, USA

ABSTRACT

Student-centered instruction is featured in reforms that aim to improve excellence and equity in mathematics education. Although research on stereotype threat suggests that student-centered instruction may have differential effects on racial minority students, the relationship between student-centered mathematics instruction and student engagement remains understudied. This study examined the relationship between student-centered mathematics instruction and adolescents' behavioral, cognitive, emotional, and social engagement in mathematics and whether the relationship differed by ethnicity. The authors used a multilevel path analysis with data from 3,883 sixth- to 12th-grade students (52.1% girls, 38.2% eligible for free/reduced lunch, 66.1% Caucasian, 23.8% African American, 7.2% multiracial, and 2.9% Asian American). The results showed that student-centered instruction was positively related to all dimensions of mathematics engagement. However, the positive association between student-centered mathematics instruction and student engagement was weaker for African American students. This study provides empirical evidence for the benefits of student-centered instruction while suggesting differential effects based on students' ethnicity.

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African American students; mathematics engagement; mathematics instruction; student-centered instruction

Active engagement in mathematics learning during secondary school is essential to student mathematics achievement and aspirations to pursue science, technology, engineering, and mathematics college majors and careers (Wang & Degol, 2014, 2017). However, student engagement in mathematics declines significantly starting in Grade 6 (Wang & Degol, 2014). Racial disparity in mathematics achievement also tends to grow during secondary school (Bacharach, Baumeister, & Furr, 2003), making secondary mathematics a focus of educators and policy makers aiming to improve equity in education opportunities, quality, and outcomes. Recently, student-centered instructional practices have become a central component of instruction that aims to promote student engagement in mathematics (see Common Core State Standards Initiative, 2015). Student-centered instruction emphasizes supporting students in generating their own strategies to solve cognitively challenging tasks and in constructing their own understanding of mathematics concepts (Slavich & Zimbardo, 2012). Theoretically, positioning students with intellectual authority and responsibility for their learning contributes to student mathematics achievement by fostering deep engagement in mathematics coursework (Smith & Stein, 2011; Niemiec & Ryan, 2009).

Despite the increasing prominence of student-centered instruction in mathematics education policy and practice, very little research has been done to examine the relationship between student-centered instructional practice in mathematics and adolescents' engagement in mathematics coursework. In addition, studies have yet to address whether the association between student-centered instruction and student engagement varies by ethnicity. In several education policies, student-centered instructional practices are leveraged as a mechanism for supporting equity in mathematics education. Although student-centered instruction is perceived as providing high-quality opportunities for students to learn (National Council of Teachers of Mathematics, 2014), there is reason to believe that student-centered instruction could have complex effects on how African American students engage in their mathematics coursework. On one hand, student-centered instruction requires students to actively participate in their mathematics courses, which could undermine African American adolescents' engagement by increasing their fear of activating others' negative stereotypes about their mathematics ability (Steele, 1997). On the other hand, student-centered instruction could reduce racial stereotype threat by empowering African American students to engage in their mathematics courses.

To this end, we aim to examine the associations between student-centered mathematics instruction and adolescents' behavioral, emotional, cognitive, and social engagement in mathematics learning during middle and high school and whether the associations vary by student ethnicity.

CONTACT Eli Talbert ejt26@pitt.edu Department of Psychology, School of Education, University of Pittsburgh, Posvar Hall 5926, 230 South Bouquet Street, Pittsburgh, PA 15260, USA.

The study provides empirical evidence about the effects of student-centered mathematics instruction on student engagement and relays critical information about how its implementation relates to the goal of supporting equity in mathematics education. This study also contributes to our understanding of disproportionate experiences and outcomes of African American adolescents in mathematics learning and achievement in secondary school.

Theoretical and empirical framework

Student-centered instruction

Broadly, student-centered instruction refers to an instructional philosophy that aims to position students at the center of inquiry and problem solving (Slavich & Zimbardo, 2012). Many perspectives have given rise to a wide range of terminology for describing a student-centered approach to instruction (Newman, Ridenour, Newman, & DeMarco, 2003), including but not limited to student-activated instruction (e.g., Struyven, Dochy, Janssens, & Gielen, 2006), learner-centered instruction (e.g., Meece, 2003), and student-directed learning (e.g., Zimmerman, 2002). These perspectives share the fundamental view that students become deeply engaged in learning when they construct their own understanding of mathematics concepts by connecting with the material in a variety of ways, such as through discussion, problem-solving, comparing strategies for solving problems, and an in-depth analysis of mathematical ideas (Svinicki, 2011). Teachers support student engagement by scaffolding their effort on open-ended and challenging tasks (Stein, Grover, & Henningsen, 1996), by positioning students as having intellectual authority (Felder & Brent, 1996), and by honoring and respecting students' voices (Meece, 2003).

Student-centered instruction is often contrasted with teacher-centered instruction. Mathematics has a particularly strong tradition of implementing a relatively teacher-centered approach to instruction that emphasizes students' memorization of essential information and procedures (Stein, Kinder, Silbert, & Carnine, 2005) through lecture (Cuban, 2006) and repeated practice (Porter, 1989). The focus is on efficiency and using instructional time efficiently to transfer essential information. Accordingly, little time is allotted for activities that are flexible, open-ended, relate to students' goals or lives, or that validate students as learners, such as opinion sharing or reflecting on what they are learning, which can limit the quality of the opportunities to learn (National Council of Teachers of Mathematics, 2000) and undermine students' engagement in their mathematics coursework (Eccles & Roeser, 2009).

Indeed, student-centered instruction came to the fore in education policy in response to the need for American students to learn the more advanced mathematics skills needed to participate in an increasingly complex society and workplace (Gijselaers, 2000). Student-centered instruction was also motivated by evidence that many American youth fail to meet minimum standards of competency in mathematics (Klein, 2003), a concern still relevant today with only 41% of high school seniors taking the ACT in 2017 meeting the mathematics benchmark (ACT Inc., 2017). For their part, African Americans experience multiple gaps. Not only do they underperform in mathematics relatively to their peers (Lee, 2002), but they also experience a mismatch between effort and the academic outcomes that they attain (Greene, Marti, & McClenney, 2008). At the start of secondary school, minority youth are less engaged and lower achieving than their peers, and these gaps widen over the course of secondary school (Riegle-Crumb & Grodsky, 2010). In response, over the past few decades, student-centered instruction has been featured in a growing number of education policies at the state and local levels. These policies aim to improve achievement and learning of mathematics (Resnick, Stein, & Coon, 2008) and to improve mathematics opportunities and outcomes for minority youth (National Council of Teachers of Mathematics, 2014).

Student-centered instruction and student engagement in mathematics

Despite the increasing prevalence of student-centered mathematics instruction in education policy and practice, its support for equity and excellence in student outcomes has yet to be studied in a large and diverse sample of secondary students. There is some evidence that student-centered mathematics instruction contributes to mathematics outcomes in students overall. Students report higher levels of intrinsic motivation in academic work when their teachers are using student-centered instructional practices (Baeten, Dochy, & Struyven, 2013; Hänze & Berger, 2007). Middle school students report greater enjoyment of mathematics when it is taught with student-centered instructional practices (Noyes, 2012). Student-centered instructional practices have also been shown to increase adolescents' understanding of mathematics concepts and practices (Saragih & Napitupulu, 2015), raise their achievement level in mathematics coursework (Wilson et al., 2002; Ziegler & Yan 2001), and improve their performance on standardized tests (Cornelius-White, 2007; Friedlaender, Burns, Lewis-Charp, Cook-Harvey, & Darling-Hammond, 2014; Lasry, Charles, & Whittaker, 2014; Polly et al., 2013; Tarr et al., 2008).

However, despite the support in education policy and practice for student-centered instruction and some evidence of positive effects, several questions about implementation and effectiveness remain. For example, some teachers are concerned that implementing student-centered instructional practice will undermine their ability to maintain classroom order (Polly, Margerison, & Piel, 2014) and report that, when given challenging and open-ended tasks, students resist working and exhibit negative emotions and behaviors (Felder & Brent, 1996; Garrett, 2008; Lasry et al., 2014; Pedersen & Liu, 2003). For their part, some students also report preferring more structure when learning mathematics (Peters, 2010), and, in some studies, both teachers and students describe a preference for teacher-centered instruction (Brown & Melear, 2006; Hains & Smith, 2012; Liu, Qiao, & Liu, 2006).

These mixed results suggest that additional research is needed to clarify the extent to which student-centered instruction is related to student academic outcomes—particularly with respect to student engagement. Engagement refers to the quality of the involvement in academic coursework (Skinner, Kindermann, Connell, & Wellborn, 2009; Wang & Eccles, 2012) and the energy, purpose, and durability adolescents expend on their participation in their mathematics classes (Skinner & Pitzer, 2012). Engagement is considered multidimensional (Fredricks, Blumenfeld, & Paris, 2004; Wang & Degol, 2014). Mathematics engagement, for example, has been found to consist of four distinct components: behavioral, emotional, cognitive, and social (Wang, Fredricks, Ye, Hofkens, & Linn, 2016). Behavioral engagement in mathematics courses refers to involvement in academic and classroom activities and the presence of positive behavior (Fredricks et al., 2004). Emotional engagement refers to positive interactions with teachers, peers, and classroom activities as well as the student's emotional relationship with the learning material (Voelkl, 1997). Cognitive engagement denotes the student's self-regulated learning, use of deep learning strategies, and ability to use the appropriate strategies to comprehend complex ideas in a mathematics class (Zimmerman, 1990). Finally, social engagement in mathematics reflects the quality of students' social relationships and their willingness to form and maintain relationships while learning (Wang et al., 2016). Each dimension of mathematics engagement has been shown to play an important role in learning mathematics, making each one a vital outcome for understanding the relations between instruction and achievement in mathematics (Wang et al., 2017), particularly among African American students whose mathematics engagement and achievement tends to decline over the course of secondary school (Marks, 2000). Although student-centered instruction targets student learning by providing opportunities for high-quality engagement, the relationship between student-centered instruction and the multiple dimensions of engagement has not been studied.

Differential effects for African American students

Studying the differential effects of student-centered mathematics instruction on African American students' engagement fills a need in our understanding of and ability to improve their mathematics achievement. Some evidence indicates that implementing student-centered mathematics instruction may reduce the racial achievement gap (Jamar & Pitts, 2005; Salinas & Garr, 2009), but the generalizability of this evidence is limited. Most literature addresses how mathematics engagement influences the quality of teacher and parent support and teacher-student and parent-teacher interactions (Kelly & Zhang, 2016; Martin & Rimm-Kaufman, 2015; Robinson & Mueller, 2014) and how it affects education outcomes (Darensbourg & Blake, 2013; Rowan-Kenyon, Swan, & Creager, 2012). Relatively little research has concentrated on the relationship between students' ethnicity and their engagement in mathematics coursework (Darensbourg & Blake, 2013; Martinez & Guzman, 2013), and even less research has investigated the effect of student-centered instruction on mathematics engagement. An exception is a study that demonstrated the potential of student-centered mathematics instruction to improve overall mathematics engagement (Gningue, Peach, & Schroder, 2013), although the study did not address potential differences based on students' ethnicity.

Stereotype threat and student engagement

Stereotype threat could explain how or why student-centered instruction could have differential effects on student engagement for African American youth. Stereotype threat refers to the activation of the negative stereotypes about a particular group, such as African Americans, and is shown to have a detrimental effect on academic performance (Steele, 1997). Because stereotype threat originates from the fear of fulfilling negative stereotypes, which would damage one's self-image, the threat could be countered by providing other ways to affirm a positive academic self-image (Croizet, Désert, Dutrévis, & Leyens, 2000) or by ensuring that students feel empowered (Van Loo & Rydell, 2013). Student-centered instruction could reduce stereotype threat in both these ways by providing paths other than academic performance for African Americans to affirm a positive academic self-image. For example, inviting a student to share what strategy she used to solve an open-ended problem reflects the teacher's respect for her as a learner and positions the student as an intellectual authority who solves problems and can contribute to others' learning. This kind of sharing could help African American students overcome fear of stereotype threat by validating them as respected and valued members of the classroom community. When stereotype threat is reduced, anxiety or negative emotions that are detrimental to learning are less likely to be triggered (Mangels, Good, Whiteman, Maniscalco, & Dweck, 2012). This can, in turn, forestall declines in African American students' engagement in mathematics (Aronson, Fried, & Good, 2002).

On the other hand, student-centered instruction could actually worsen African American students' experience of stereotype threat. By design, student-centered instruction requires students to participate in a more active and public way than lecture-based classrooms. For example, students in classrooms with student-centered instruction are often asked to explain the reasoning behind their answers, which could increase the concern that negative stereotypes would be activated for African Americans because of how they speak or because of the direct attention on their display of knowledge or ability in mathematics. This increased scrutiny might transform the classroom into a place where African Americans feel they must constantly perform well to avoid confirming negative stereotypes, thereby potentially influencing these students' engagement in complex ways. For example, African American students could become less behaviorally engaged in an attempt to "lay low" and reduce the risk of stereotype threat, which could, in turn, undermine their emotional, cognitive, and social engagement in class. Alternatively, the opportunity to participate meaningfully in class could empower students and position them as comparable to their peers in mathematics ability and provide higher quality opportunities to learn mathematics, which could contribute to an increase in their engagement. Thus, stereotype threat could be a potential mechanism that contributes to the differential effects of student-centered instruction on African American students' engagement in their mathematics classes.

Present study

For this study there were four main research questions.

Research Question 1: What is the relationship of student-centered mathematics instruction with students' cognitive, behavioral, emotional, and social engagement in mathematics?

Research Question 2: Does ethnicity moderate the relationship of student-centered mathematics instruction with students' cognitive, behavioral, emotional, or social engagement in mathematics?

Research Question 3: What are the effects of student-centered instruction compared with the effects of a teacher-centered approach?

Research Question 4: What are the effects of the relative implementation of student- and teacher-centered instruction (operationalized as the difference between students' reports of student- and teacher-centered instruction) on mathematics engagement?

These questions allowed us to gain a full view of student-centered instruction and its relationship with mathematics engagement. In particular, our research questions involving teacher-centered instruction gave us a realistic point of comparison for everyday applications. Given how student-centered instruction encourages students to involve themselves in their learning, we hypothesized that student-centered mathematics instruction would have a positive relationship with students' cognitive, behavioral, emotional, and social engagement in mathematics. We also hypothesized that ethnicity would moderate the relationship between student-centered instruction and student engagement. We hypothesized that these effects were specific to student-centered instruction and so would either not be found in teacher-centered instruction or would be present to a lesser extent. Our final hypothesis was that favoring student-centered instruction over teacher-centered instruction would be associated with improved mathematics engagement.

To test these hypotheses we used a three-level modeling approach to examine the association between student-centered instruction and student engagement at the individual, classroom, and school levels and to compare these effects with those of teacher-centered instruction. The three-level approach allowed us to disentangle the differences between student perception, teacher behavior, and school policies. The individual level, made up of self-reports, accounts for all the factors affecting individual students. The classroom and school levels, in contrast, capture only factors that are shared by a class or a school. This approach is important because in addition to comparing the effectiveness of student-centered instruction by ethnicity, the method enabled us to tailor the implication of our analyses to both teachers and administrators.

Method

Sample and procedure

Participants in the study were middle school and high school students recruited from six socioeconomically diverse public school districts in the Mid-Atlantic region of the United States. The original student sample included 3,883 sixth- through 12th-grade students (17.5%, Grade 6; 18.8%, Grade 7; 19.4%, Grade 8; 12.9%, Grade 9; 10.9% Grade 10; 11.3%, Grade 11; and 9.2%, Grade 12). The student sample was 52.1% girls, 66.1% Caucasian, 23.8% African American, 7.2% multiracial, and 2.9% Asian American. Approximately 38.2% of the student sample qualified for free or reduced-price lunch, an indicator of economic disadvantage.

Informational forms were sent home that described the study purpose and procedures and included a place where parents or students could sign to opt out of the study. Only 2% of students returned parental opt-out forms, resulting in 98% of students who were present on data collection days participating in the study. Eligible students were provided with a computer-based survey that they completed during a full period of their mathematics class. Research staff members were available to answer questions about survey items. Student surveys were anonymous aside from being linked to the students' mathematics classes. Student demographic information was obtained through school records. All study procedures were approved by the Institutional Review Board at the University of Pittsburgh and by the school board and administrators in the districts in which the study took place.

Measures

Student-centered instruction

Student-centered instruction was assessed with six items that describe components of student-centered instruction, including a focus on conceptual understanding (e.g., "When I show my teacher an answer, he/she asks me to explain how I got that answer"), providing feedback that reduces the task's cognitive demand (e.g., "My teacher shows me how to solve problems by myself"), and supporting students' intellectual authority (e.g., "My teacher allows me to choose how to do my work in the classroom"). Item responses were on a 5-point Likert-type scale, ranging from 1 (*almost never* or *not true at all*) to 5 (*often* or *very often true*). Items were averaged, such that higher scores indicated greater use of student-centered instruction. Exploratory and confirmatory factor analyses verified this single-factor scale as a good fit for the observed data (root mean square error of approximation = .064; standardized root mean square residual = .010; comparative fit index = .998; Tucker-Lewis index = .996; see Hu & Bentler, 1999). The scale also demonstrated good reliability in our sample ($\alpha = .81$).

Classroom-level and school-level variables were created by aggregating the measure of student-centered instruction.

Teacher-centered instruction

Teacher-centered instruction was assessed with six items that measure direct involvement of the teacher. This included items that captured a teacher's tendency to guide students through difficult problems (e.g., "When we can't solve a really challenging problem, my teacher will give us a set of steps to follow") and willingness to let students find their own mistakes (e.g., "My teacher catches my mistakes before I do") Item responses were on a 5-point Likert-type scale, ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Items were averaged, such that higher scores indicated greater use of teacher-centered instruction ($\alpha = .75$).

Student engagement (behavioral, cognitive, emotional, social)

We measured students' behavioral, emotional, cognitive, and social engagement using the Mathematics Engagement Scale, a well-validated scale with strong construct validity, predictive validity, and measurement invariance across gender, ethnicity, grade, and socioeconomic status (SES; Wang et al., 2016). We assessed behavioral engagement with eight items that capture both classroom participation (e.g., "I ask questions in mathematics class") and involvement in learning (e.g., "I put effort into learning mathematics"). Item responses were on a 5-point Likert scale, ranging from 1 (*not at all like me*) to 5 (*very much like me*). We averaged items such that higher scores indicated greater behavioral engagement ($\alpha = .82$).

To assess cognitive engagement, we used eight items that focus on the student's mental flexibility (e.g., "I think about different ways to solve a problem") and effort made to think about problems (e.g., "I go through the work that I do for mathematics class and make sure that it's right"). Item responses were on a 5-point Likert-type scale, ranging from 1 (*not at all like me*) to 5 (*very much like me*). We averaged items such that higher scores indicated greater cognitive engagement ($\alpha = .75$).

We assessed emotional engagement using ten items that address both positive (e.g., "I feel good when I am in mathematics class.") and negative emotions (e.g., "I often feel frustrated in mathematics class.") about mathematics with negative feelings reverse-coded. Item responses were on a 5-point Likert-type scale, ranging from 1 (*not at all like me*) to 5 (*very much like me*). We averaged items such that higher scores indicated greater emotional engagement ($\alpha = .89$).

For social engagement assessment, we used seven items that emphasize the ability to learn from others (e.g., "I build on others' ideas") and cooperation with classmates (e.g., "I try to work with others who can help me in mathematics"). Item responses were on a 5-point Likert-type scale, ranging from 1 (*not at all like me*) to 5 (*very much like me*). We averaged items such that higher scores indicated greater social engagement ($\alpha = .89$).

Demographics

All demographic variables (i.e., students' gender, SES, and ethnicity) were collected from school records and used as control variables in our analysis. We operationalized SES as a dummy variable at the student level on the basis of whether the student was eligible for a free or reduced-price lunch. Gender was represented as a dummy variable at the student level (1 = female, 0 = male). Ethnicity was obtained by asking students if they identified as black or African American and separating those that did not identify as solely African American or Caucasian (e.g., Asian). Those who did not identify as African American or Caucasian were not included in the analyses due to small sample size. Those who identified as African American were coded as a 1 on a dummy variable.

Data analysis strategy

The study used a multilevel path analysis model with Mplus, version 7.2 (Muthén & Muthén, 2014) to focus on any ethnicity-based differences in the effects of student-centered instruction. Because of the small sample size, we excluded students who did not identify as solely African American or Caucasian, which reduced the number of subjects to 3,488. On any given variable, missing data ranged from 0% to 14.5%, with an average of 3.38% missing data. Eleven percent of students had missing data on the free/reduced-lunch variable, 12.5% students had missing data on the student-centered instruction variable, and 14.5% had missing data on the teacher-centered instruction variable. Students with missing data for the student-centered instruction variable were more likely to be African American compared with those who did not have missing student-centered instruction data. For the data analysis, we used maximum likelihood parameter estimates with standard errors and a chi-square test statistic (MLR) because this method has been proven to be robust even if the MAR assumption is violated. Given the clustering nature of the data (students nested in classrooms) and ICC values of the student engagement (behavioral: intraclass correlation coefficient [ICC] = .172; cognitive: ICC = .097; emotional: ICC = .176; and social: ICC = .054), we used multilevel modeling approaches to account for the violation of the assumption of independence. We confirmed the violation of independence when running a null model of the four dimensions of mathematics engagement: behavioral (ICC = .172), cognitive (ICC = .097), emotional (ICC = .176), and social (ICC = .054).

We built the data analysis model progressively starting with a two-level model that included the interactions between student-centered instruction and demographic variables or classroom-level variables. We subsequently introduced these interactions and then the classroom measures of mathematics engagement. In our final three-level model, we added school as the top level because the relative importance of student-centered instruction has important practical implications at the school level as well as at the individual and classroom levels. We ran the model again with the teacher-centered instruction variable replacing the student-centered instruction variable to provide a frame of reference for the effects of student-centered instruction. Last, we ran a third model with a compound variable representing the implementation of student-centered instruction relative to teacher-centered practices. The compound variable was constructed from the difference between student-centered instruction and teacher-centered instruction, with a positive score indicating a greater use of student-centered instruction, a negative score indicating a greater use of teacher-centered instruction, and a score of zero indicating an equal amount of both.

To improve the ease of interpreting our results, we grand mean–centered student-centered instruction, teacher-centered instruction, and the compound variable at the individual, classroom, and school levels and used composite scores rather than latent constructs because of computational limits in Mplus with multiple interactions in a multilevel model. We included gender and SES as control variables as well as an SES interaction with student-centered instruction to disentangle differences in ethnicity and class.

Results

Descriptive statistics

Table 1 presents descriptive statistics for the African American and Caucasian students. No continuous variable was significantly skewed. The African American group had lower engagement in all dimensions except emotional engagement, which was slightly higher. African American students also tended to report higher amounts of both student-centered instruction and teacher-centered instruction.

Table 1. Descriptive statistics for the sample divided by ethnicity ($N = 2{,}719$).

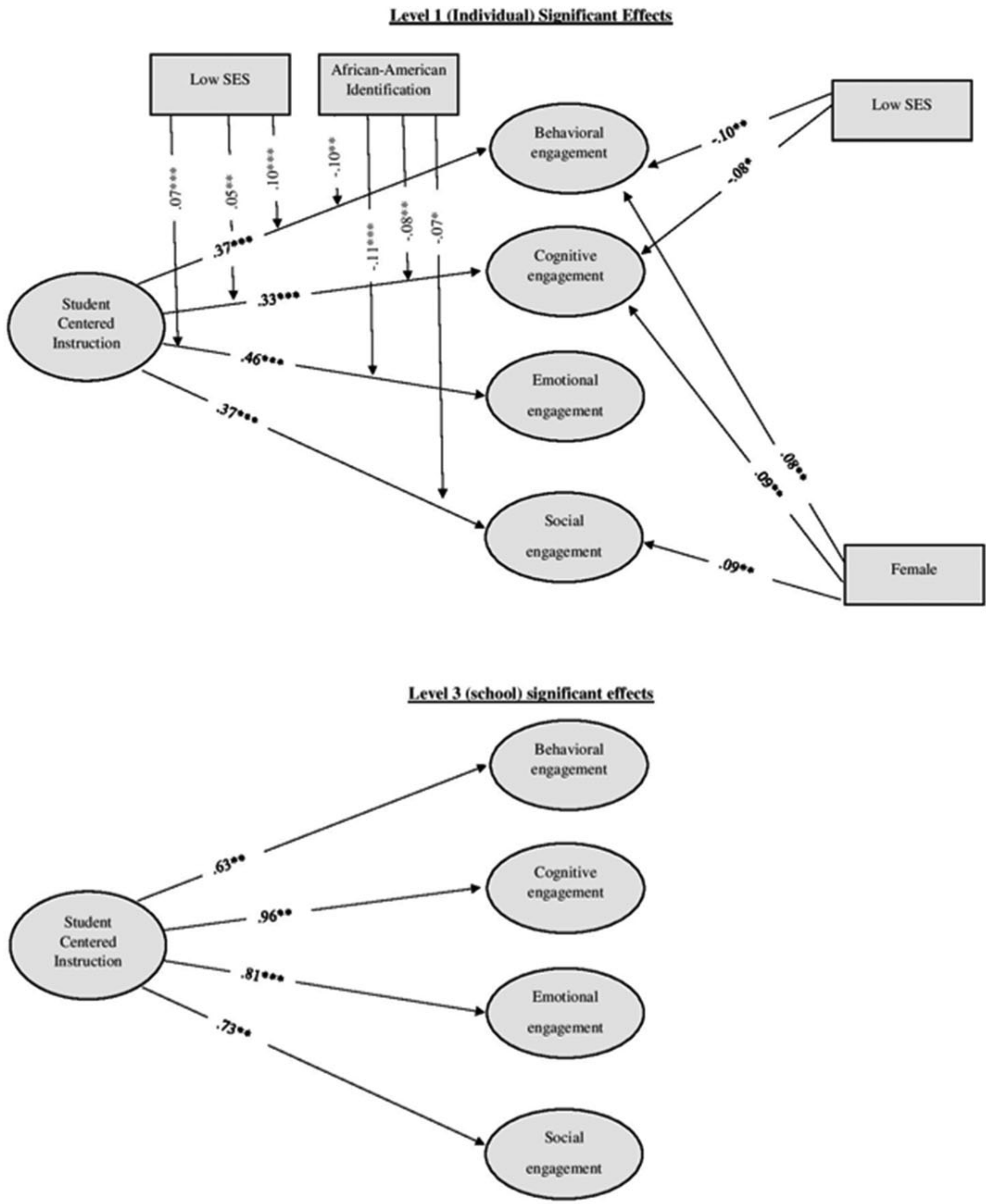
	Ethnicity									
	African American ($n = 582$)					Caucasian ($n = 2{,}137$)				
	%	*M*	*SD*	Min	Max	%	*M*	*SD*	Min	Max
Low socioeconomic status	84.70					16.60				
Female	51.80					50.30				
Student-centered instruction		3.84	0.69	1.00	5.00		3.76	0.65	1.00	5.00
Teacher-centered instruction		3.96	0.75	1.00	5.00			0.65	1.00	5.00
Behavioral engagement		3.69	0.51	1.00	5.00		3.94	0.47	1.13	5.00
Cognitive engagement		3.68	0.51	1.25	5.00		3.80	0.43	1.13	5.00
Emotional engagement		3.69	0.73	1.00	5.00		3.67	0.83	1.00	5.00
Social engagement		3.71	0.53	1.43	5.00		3.81	0.46	1.00	5.00

Final path analysis model (student-centered instruction)

The final model with student-centered instruction, presented in Figure 1, had the same number of parameters as the baseline model so had zero degrees of freedom. Accordingly, no fit statistics were available. The paths from the individual-level student-centered instruction to behavioral, cognitive, emotional, and social engagement were significant at the $p < .001$ level. Student-centered mathematics instruction positively predicted students' behavioral ($\beta = .37$), cognitive ($\beta = .33$), emotional ($\beta = .46$), and social ($\beta = .36$) engagement in their mathematics classes. None of the paths from the classroom-level aggregates of student-centered instruction were significant. At the school level, the paths from student-centered instruction were also significant for all four dimensions: behavioral ($\beta = .61$), cognitive ($\beta = .96$), emotional ($\beta = .81$), and social ($\beta = .57$). At the individual level, there was a significant negative interaction between being African American and having student-centered instruction in all four dimensions of mathematics engagement, as shown in Figure 2. In other words, while there was still a positive association between student-centered instruction and engagement for African American students, the association was significantly weaker than it was for Caucasian students. The strongest differences in the relationship between African American students' engagement and student-centered instruction were in their emotional engagement ($\beta = -.11$, $p < .001$) and behavioral engagement ($\beta = -.097$, $p = .001$). These differed from the SES interactions with student-centered instruction that were meant to distinguish the effects of ethnicity and SES, hereafter referred as SES control interactions (see Figure 1). At the individual level, there was a significant explained variance for the four dimensions: behavioral ($R^2 = .129$), cognitive ($R^2 = .17$), emotional ($R^2 = .21$), and social ($R^2 = .13$). There was no significant explained variance at the classroom level. At the school level, there was a significant explained variance for emotional engagement ($R^2 = .66$). In summary, there were significant relationships between student-centered instruction and all four dimensions of mathematics engagement on the individual and school levels. On the individual level, we were able to determine that there is a racial difference in the strength of the relationship between student-centered instruction and engagement in mathematics coursework.

Final path analysis model (teacher-centered instruction)

The final model with teacher-centered instruction is presented in Figure 3. The paths from the individual-level teacher-centered instruction to behavioral, cognitive, emotional, and social engagement were significant at the $p < .001$ level. Teacher-centered mathematics instruction positively predicted students' behavioral ($\beta = .33$), cognitive ($\beta = .28$), emotional ($\beta = .37$), and social ($\beta = .37$) engagement in their mathematics classes. None of the paths from the classroom-level aggregates of teacher-centered instruction were significant. At the school level, the paths from teacher-centered instruction were only significant for emotional engagement ($\beta = .67$). At the individual level, there was a significant negative interaction between being African American and students' report of teacher-centered instruction in two dimensions of mathematics engagement, cognitive engagement ($\beta = -.10$) and emotional engagement



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

Figure 1. Path model showing student-centered instruction's effects on dimensions of student mathematics engagement with standardized coefficients.

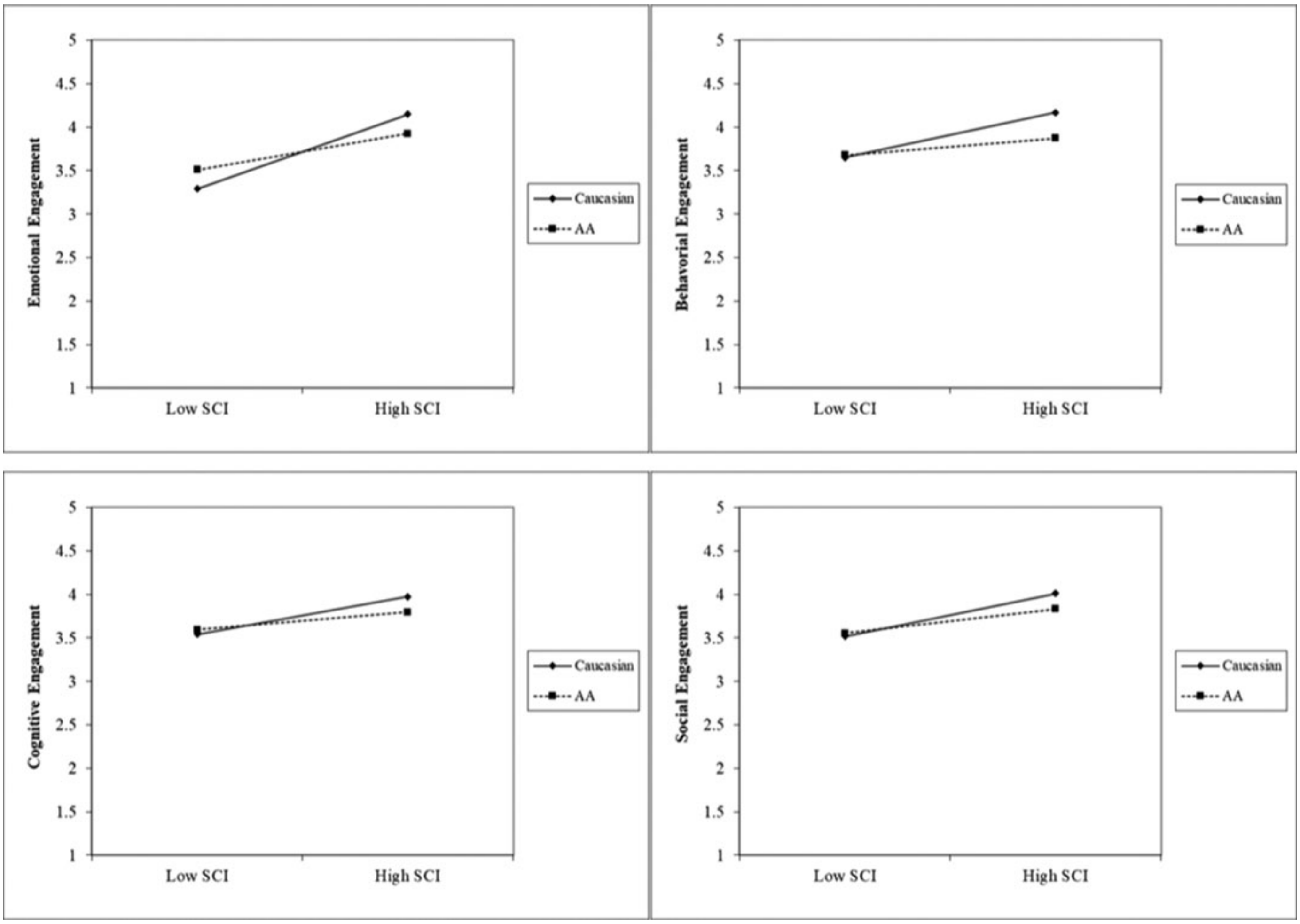


Figure 2. Ethnicity interaction effects on the types of engagement with low and high 1 *SD* from the mean.

($\beta = -.12$). Similar to the student-centered instruction model, these interactions were not related to SES. Both SES control interactions were positive, but only one, cognitive engagement, was significant (see Figure 3). At the individual level, there was a significant explained variance for the four dimensions: behavioral ($R^2 = .119$), cognitive ($R^2 = .09$), emotional ($R^2 = .12$), and social ($R^2 = .12$). There was no significant explained variance at the classroom level or at the school level. In summary, the teacher-centered model generally mimicked the student-centered instruction model, but many of the relationships were less strong or not statistically significant. This was especially true for the model at the school level, where teacher-centered instruction only had a significant relationship with emotional engagement rather than all four dimensions.

Difference model

The difference model with the compound variable is presented in Figure 4. The compound variable was created by subtracting the teacher-centered instruction measure from the student-centered instruction measure ($M = -0.14$, $SD = 1.03$). This represented whether a student reported more teacher use of student-centered than teacher-centered instruction. The paths from the compound variable to behavioral, cognitive, emotional, and social engagement were significant at the $p < .001$ level. The compound variable positively predicted students' behavioral ($\beta = .25$), cognitive ($\beta = .21$), emotional ($\beta = .31$), and social ($\beta = .25$) engagement in their mathematics classes. None of the paths from the classroom-level aggregates of the compound variable were significant. At the school level, the paths from the compound variable were significant for behavioral engagement ($\beta = .68$) and emotional engagement ($\beta = .62$). At the individual level, there was a significant negative relationship for the SES control interaction for cognitive engagement (see Figure 4). At the individual level, there was a significant explained variance for the four dimensions: behavioral ($R^2 = .10$), cognitive ($R^2 = .07$), emotional ($R^2 = .10$), and social ($R^2 = .064$). There was no significant explained variance at the classroom level. At the school level, there was a significant explained variance for behavioral engagement ($R^2 = .46$). In summary, the comparison model showed that students' relative perception of more student-centered instruction than teacher-centered instruction was associated with increases in all four dimensions of mathematics engagement at the individual level and for behavioral engagement at the school level. In contrast to the models that examined students' reports of student-centered instruction and teacher-instruction independently, there was no

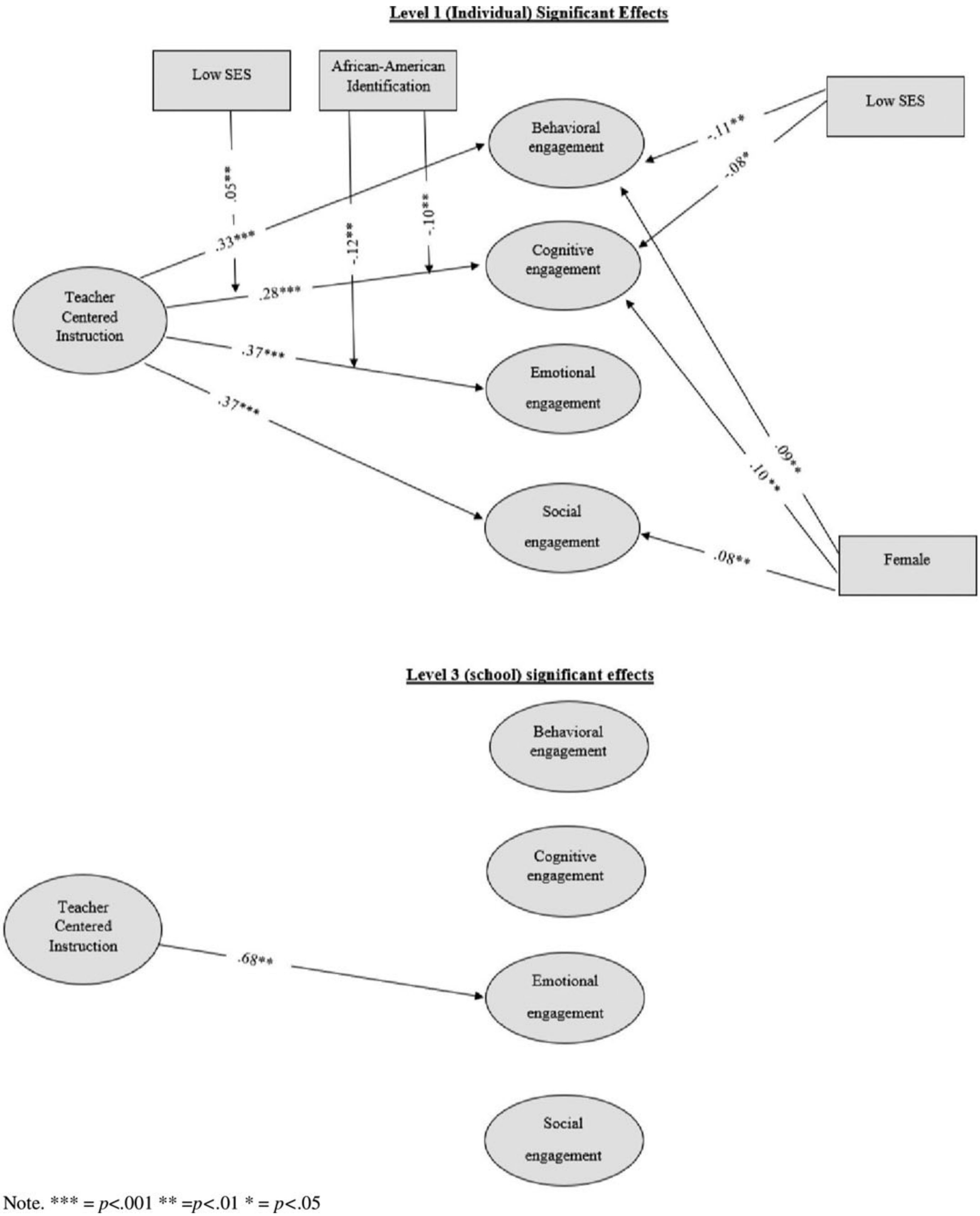


Figure 3. Path model showing teacher-centered instruction's effects on dimensions of student mathematics engagement with standardized coefficients.

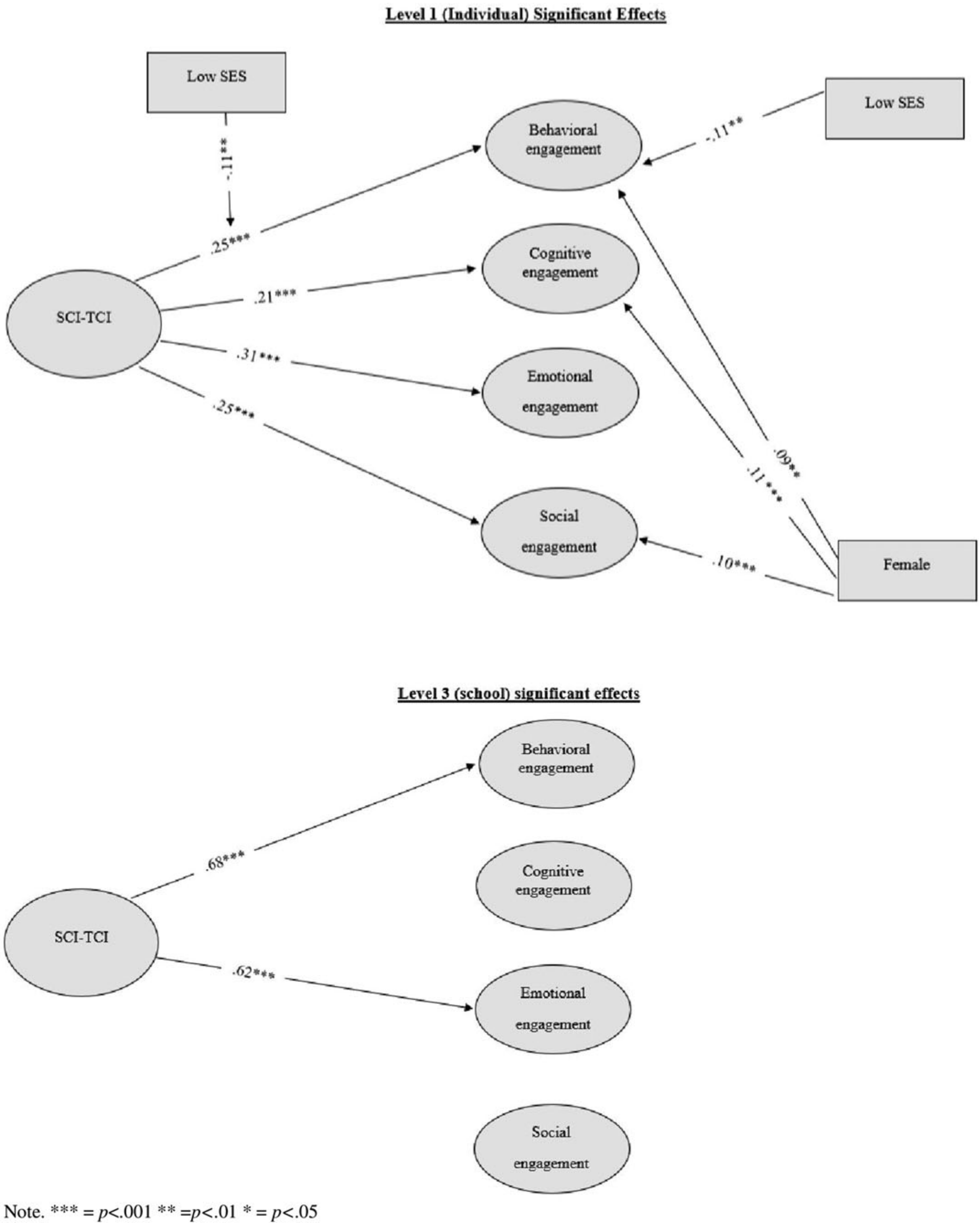


Figure 4. Path model comparing student- and teacher-centered instruction's effects on student mathematics engagement with standardized coefficients through a compound variable (SCI-TCI).

significant interactions between the compound variable representing the difference between student- and teacher-centered instruction and students' ethnicity.

Discussion

A significant aim of education research, policy, and practice is to better understand how instructional practice can support African American youth's engagement in mathematics class. In this study, we confirmed that student-centered instruction has an overall positive influence on students' mathematics engagement and that the effect of student-centered instruction on engagement is stronger than that of teacher-centered instruction. However, student-centered instruction seems to have less of a positive effect for African American students. Specifically, compared with Caucasian students, African American students' reports of student-centered mathematics instruction had positive, but weaker, associations with their behavioral, cognitive, emotional, and social engagement. At the same time, this held true for teacher-centered instruction's relationship with cognitive and emotional engagement, suggesting that there might be a shared characteristic of student- and teacher-centered instruction that results in a less effective increase in engagement for African Americans, discussed in more detail subsequently.

These findings make several important contributions to the field. Primarily, they show a positive relationship between student-centered mathematics instruction and students' engagement—when considered independently and in relation to the presence and effects of teacher-centered instruction. This provides needed evidence in support of the theory that positioning students as intellectual authorities with responsibility for their learning can positively change the quality of their involvement in mathematics coursework compared with a more teacher-directed approach. However, at the same time, our findings suggest that ethnicity matters in students' experience of instruction, especially for student-centered instruction. This contributes to the body of literature that outlines racial differences in education, such as differences in achievement (Bacharach, Baumeister, & Furr, 2003) and attitudes toward education (Suizzo, Pahlke, Chapman-Hilliard, & Harvey, 2016), and shines a light on the need to examine differential experiences of student-centered instruction to better understand student-centered instruction as a tool to improve racial equity.

Student-centered instruction and mathematics engagement

The general finding that there is a positive relationship between student-centered instruction and increased levels of student engagement becomes more complicated when we consider the levels at which the types of instruction are examined in the models. Literature indicates that individual (Kim, Park, Cozart, & Lee, 2015), classroom (Kiemer, Gröschner, Pehmer, & Seidel, 2015), and school factors (Leithwood & Jantzi, 2000) have different impacts on engagement. Accordingly, it was important to examine student-centered instruction's effectiveness at each of these levels.

The analyses showed that there is a positive relationship between both student- and teacher-centered instruction and student engagement at the individual student level, but not at the classroom level. This indicates that individual students' perception or reported experience of instruction could be a stronger predictor of individual engagement than the teacher's instructional practice to the class overall and adds to literature that presents individual teacher-student interactions as an important factor in academic outcomes (Klem & Connell, 2004; McHugh, Horner, Colditz, & Wallace, 2013). Teachers may treat students in the same class very differently—students who are more engaged could receive more student-centered instruction. Conversely, students who are more engaged could be more tuned in to receiving or perceiving student-centered instruction. More research is needed to disentangle whether students' individual reports are related to differences in teacher practice or student perceptions or reports of practice. Either way, students' report of their mathematics teachers' instruction seems to be an important predictor of their engagement.

The significant association between student reports of student-centered instruction and their engagement in mathematics at the school level suggests that there is an important organizational or institutional process at play. Schools or teachers in schools who have a shared implementation of student-centered instruction could socialize students to the norms and goals of student-centered instruction and could help students develop the cognitive and social skills to engage in it. This interpretation is particularly convincing given the strength of student-centered instruction's relationship to increasing students' engagement at this level. Even in the difference model, the relationships with emotional and behavioral engagement were still significantly positive pointing to unique benefits of student-centered instruction for these dimensions. The impacts at the school and individual level are evidence for student-centered instruction's increased use, but more research needs to be done, perhaps exploring the effects of ethnicity moderation at the school level.

Ethnicity and student-centered instruction

More studies are needed because our research, while far from conclusive, raises the possibility that styles of instruction considered to be high quality could have unintentional disproportionate or negative effects on some students based on their ethnicity. In this case, both student-centered and teacher-centered mathematics instruction seems less effective for African Americans for some dimensions of engagement, pointing to a shared characteristic as a cause. It could be that both activate stereotype threat in African American students, which undermines the improvement in engagement exhibited by their peers. This interpretation would be consistent with studies that hypothesize that stereotype threat results in general disengagement to protect self-esteem

(Davies, Spencer, Quinn, & Gerhardstein, 2002; Gupta & Bhawe, 2007). As our finding shows, for both types of instruction, the differential effect is strongest for emotional engagement, but weakest or nonsignificant for social engagement. If stereotype threat contributes to the differential effect, African Americans would engage less emotionally because emotion is the primary mechanism through which stereotype threat works. In contrast, African Americans would disengage the least from their peers because greater social support is linked with higher self-esteem (Brown, Andrews, Harris, Adler, & Bridge, 1986), and lowering social engagement too much might end up hurting rather than protecting their self-esteem.

However, there are many alternate explanations that could explain why teacher-centered and student-centered instruction contribute less to African American students' engagement. One such explanation is that teacher-centered and student-centered instruction are used by motivated teachers, but that a different approach from either is more effective for African American students. For example, research has shown that African American students prefer "teachers who established community- and family-type classroom environments" (Howard, 2001). Neither teacher-centered instruction, with its focus on the teacher as the purveyor of knowledge, or the individualism of student-centered instruction necessarily create such an environment.

A more complicated explanation is that African American students' self-efficacy is possibly undermined by teachers that use student-centered instruction and by teachers who use teacher-centered instruction. Self-efficacy, the belief in one's ability to achieve a certain outcome, is crucial to academic engagement (Linnenbrink & Pintrich, 2003; Zimmerman, Bandura, & Martinez-Pons, 1992) and is also especially relevant for African American students (Uwah, McMahon, & Furlow, 2008; Witherspoon, Speight, & Thomas, 1997). Both teachers that utilize teacher-centered instruction and student-centered instruction could unnecessarily focus more of their energy on African American students that could undermine their self-efficacy. This explanation would be consistent with literature indicating that teachers focus disproportionately on African American students for disciplinary (Fenning & Rose, 2007) and remedial measures (Blanchett, 2006). The same biases that result in disproportionate attention in these areas could also affect instruction causing African American students to doubt their self-efficacy.

Importantly, these are only three possible explanations, but even if our study cannot determine the cause of moderating effects of students' ethnicity, the results enable us to focus on understanding the effects of instructional practice instead of focusing on student ability or on African American students' proposed inability to relate to the precision of mathematics or the content of mathematics classes (Ladson-Billings, 1997). If African American students receive or perceive higher levels of both student- and teacher-centered instructional practices than their Caucasian peers, like they report, and if both are associated with dampening effects of African American students' engagement, then this study reveals that classroom instruction could contribute to achievement disparities of African American students in mathematics.

Taking the totality of the results into account, our study provides strong evidence for student-centered instruction increasing engagement in mathematics beyond that of traditional teacher-centered teaching at the student level and suggests that it is beneficial at the school level even if it is not necessarily directly responsible for improvement in all dimensions of mathematics engagement. This evidence is important for the core rationale of shifting toward student-centered instruction in mathematics, particularly as the results indicate a sizable effect across all four dimensions at the school level. This is promising, but further research on how to maximize the effectiveness of student-centered instruction to improve engagement among all students—especially African Americans—is needed.

Although we do not know the reason from our data, ethnicity seemed to have an important impact on the strength of the relationship of student-centered instruction with mathematics engagement. As the interaction figure (see Figure 2) shows, typically African American students with lower amounts of student-centered instruction had higher or equivalent engagement relative to Caucasian students, but as the amount of student-centered instruction increased, their Caucasian peers overtook them. The study results suggest that a component of student-centered instruction may result in an engagement gap between Caucasian and African American students, which could widen the achievement gap. Given the policy push for more student-centered instruction, gaining a more detailed view of ethnicity and student-centered instruction is essential.

Study limitations and future directions

Our study has some limitations that merit discussion. The lack of a qualitative assessment of students' perceptions and experiences of student-centered instruction, in particular, or of instruction in their mathematics courses, in general, restricted the extent to which we could determine what other practices might unintentionally be included in student-centered instruction. In addition, it also prevents us from determining if there are any shared characteristics with teacher-centered instruction. The difference model did not detect a statistically significant effect of favoring student-centered instruction over teacher-centered instruction for African American students leaving the question open of whether student-centered instruction has any unique components that limit its ability to improve mathematics engagement for this population. A mixed-methods approach with classroom observations of the instruction given and student interactions would help resolve this issue. Alternatively, future researchers should test some of the theories we outlined. For example, future researchers should explore whether stereotype threat is activated in student-centered mathematics classrooms by comparing the strength of African American students' implicit associations with stereotypes in high student-centered instruction versus low student-centered instruction classrooms. If stereotype threat is the mechanism, researching interventions, such as a stereotype threat workshop, or classroom environment factors, such as ethnic makeup, would be a priority.

The study also took place in one state, which could limit the ability to generalize results. A nationally representative sample could examine the generalizability and replicability of our findings. Moreover, this study was correlational, curtailing our ability to draw causal conclusions between student-centered instruction and the dimensions of mathematics engagement. A longitudinal, experimental study would be preferable if we aim to draw more solid causal connections. Finally, the relatively small number of schools did not allow us to examine the interaction effect of ethnicity and SES at the school level. Future study should investigate whether the intersection effect between ethnicity and SES differs by school characteristics.

Despite these limitations, our study provided important groundwork for student-centered instruction in mathematics, presenting empirical evidence that supports improvement on mathematics engagement and concerns about its effectiveness for diverse students and establishing a clear foundation from which ethnicity and student-centered instruction can be examined. It points to the existence of both the usefulness of student-centered instruction as the tool to improve engagement and a potential difficulty of using it for African American students.

Implications for practice and policy

Our findings have important applications for both education practice and policy. First, the lack of significant classroom-level effects could indicate that teachers vary in their practice among students within a class, or that there is significant and important variation in students' perception of instruction in the same class. Previous research has documented that teachers adapt their instructional strategies and the amount of individualized support they offer in response to student characteristics like their academic skills (Kiuru et al., 2015) and classroom behavior (Nurmi & Kiuru, 2015), which could explain why or how instructional practice can vary more within a particular classroom than between teachers in the same school (Raudenbush, Rowan, & Cheong, 1993). Student-centered instruction could be particularly prone to within-classroom variation because it involves a high amount of student-teacher interaction and individualized support that can vary from student to student. These relationships are crucial to student success and also tend to be worse for African Americans (Hughes & Kwok, 2007).

The strong relationship between school-level student-centered instruction and the dimensions of mathematics engagement emphasizes that instruction is not just a classroom-level process. Rather, the collective instructional practice of teaching staff is itself a salient characteristic of schools. Our results suggest that schools' implementation of student-centered instruction throughout their mathematics coursework contributes to student engagement beyond that of teacher-centered instruction, which supports a school-wide approach to implementation. However, additional research needs to be done to understand the implications for schools with a large number of racial minorities or a high proportion of minorities in the overall student population. Student-centered instruction appears to work for both African American and Caucasian students, but the efficacy gap suggests that for student-centered instruction to truly reduce increased inequality in educational outcomes it needs to be modified.

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ORCID

Eli Talbert http://orcid.org/0000-0003-2052-2917
Tara Hofkens http://orcid.org/0000-0001-7835-398X

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