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Does Math Self-efficacy Mediate the Effect of the Perceived Classroom Environment on Standardized Math Test Performance?

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Abstract

We examined the effect of the perceived classroom environment on math self-efficacy and the effect of math self-efficacy on standardized math test performance. Upper elementary school students (n = 1163) provided self-reports of their perceived math self-efficacy and the degree to which their math classroom environment was mastery-oriented, challenging, and caring. Individual student scores on the California Standards Test for Mathematics were also collected. A series of two-level models revealed that students who perceived their classroom environments as more caring, challenging, and mastery-oriented had significantly higher levels of math efficacy, and higher levels of math efficacy positively predicted math performance. Analysis of the indirect effects of classroom variables on math performance indicated a small significant mediating effect of self-efficacy. Implications for research on self-efficacy and the perceived classroom environment are discussed.

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In the current high-stakes testing environment, any attribute of a student that positively influences achievement is of interest. The degree to which a student believes that he/she is capable of performing specific tasks, referred to as self-efficacy, is particularly relevant given that self-efficacy has been argued to have powerful effects on achievement behavior (Bandura, 1986). Those with higher self-efficacy are proposed to have higher aspirations, stronger commitments to their goals, and recover more quickly from setbacks than those lower in self-efficacy. Beliefs in one's efficacy can vary across academic subjects (e.g. reading vs. writing) and self-efficacy for mathematics has received close attention. Students with higher math self-efficacy persist longer on difficult math problems and are more accurate in math computations than those lower in math self-efficacy (Collins, 1982; Hoffman & Schraw, 2009). Math self-efficacy is also a stronger predictor of math performance than either math anxiety or previous math experience (Pajares & Miller, 1994; Pajares & Miller, 1995, respectively) and influences math performance as strongly as overall mental ability (Pajares & Kranzler, 1995).

The demonstrated importance of self-efficacy in academic achievement has provoked widespread interest in specific factors that affect a student's self-efficacy beliefs. Bandura's (1997) social-cognitive theory proposed that self-efficacy is most strongly affected by one's previous performance and research largely supports this (Chen & Zimmerman, 2007). His theory also suggests that self-efficacy is affected by observing others (e.g. watching peers succeed at a task), verbal persuasion (e.g. encouragement from parents and teachers), and interpretation of physiological states (e.g.

lack of anxiety may be a signal that one possesses skills). Although several studies indicate that manipulating features of learning environments along these theoretical premises has immediate and detectable effects on self-efficacy (Schunk, 1982, 1983, 1984; Schunk & Hanson, 1985), it seems possible that students' perceptions of their learning environments also affect their efficacy beliefs. Ames (1992) argued that learning environments may not provide a common experience for all students and that students' subjective interpretations of their environment determine how they respond to it. For example, a teacher might be described by an objective observer as helpful, but if a student perceives him/her as unhelpful, then the perception of unhelpfulness will guide the students' behavior more than the teachers' actual helpfulness. Focusing on perceptions of the classroom environment is consistent with Bandura's (1997) theory, which suggests that self-efficacy is influenced by how an individual interprets relevant information. For example, a student might interpret a perceived unhelpful teacher as evidence that he/she lacks ability. In the current study, we focus on three aspects of the perceived classroom environment that affect self-efficacy: Mastery-orientation, Challenge, and Caring.

The degree to which students perceive their classroom environment as one that encourages mastery versus performance goals has been prominently studied (Ames, 1992; Dweck, 1986; Maehr & Nicholls, 1980, respectively). Classrooms structured around mastery goals emphasize effort and the intrinsic value of learning; students who adopt mastery goals are more likely to believe that effort leads to success (Weiner, 1979) and display positive attitudes towards learning (Ames & Archer, 1988). In contrast, classrooms structured around performance goals emphasize ability and competition between peers; students who adopt performance goals are more likely to use shallow learning strategies (Meece et al., 1988) and avoid challenging tasks (Dweck, 1986). Although both of these classroom goal structures theoretically influence the achievement goals that students adopt, only mastery goal structures are consistently related to self-efficacy. Several studies have found that students who perceive their classroom environment as more mastery oriented have higher academic self-efficacy (Dorman, 2001; Friedel et al., 2007; Middleton & Midgley, 1997), whereas performance oriented classrooms have been found to be unrelated, positively related, and negatively related to self-efficacy (Friedel et al., 2007; Wolters et al., 1996; Schunk, 1996, respectively). Studies using path analysis have also found that self-efficacy mediates the influence of mastery-oriented classrooms on performance (Bong, 2008; Greene, Miller, Crowson, Duke, & Akey, 2004). In particular, Wolters (2004) found that mastery goal structure had a significant positive effect on students' math grades, but when math self-efficacy was included in the model, the effect of mastery structure on course grades became non-significant.

The degree to which a classroom environment is perceived as challenging also influences self-efficacy. A challenging environment is one in which students are provided with progressively difficult tasks as their proficiency increases. Vygotsky (1978) argued that challenge is essential for intellectual development and Grolnick et al. (2002) proposed that individuals are born with a need to test their abilities and master their environment. Accordingly, evidence indicates that students enjoy learning when tasks are challenging (Zahorik, 1996). Although challenge has been most prominently discussed as an important facilitator of intrinsic motivation (e.g. Malone & Lepper, 1987), some researchers suggest that it also leads to stronger beliefs in one's academic abilities (Meyer, Turner, & Spencer, 1997; Stipek, 2001). Participating in challenging activities allows students to notice their incremental improvement in a subject, which increases feelings of self-competence. In support of this, Gentry and Owen (2004) reported that middle and high school students who perceived their classroom as challenging were more likely to have higher academic self-efficacy. Similarly, Meyer, Turner, & Spencer (1997) found that fifth and sixth-grade students who were characterized as "challenge-seekers" had higher math self-efficacy, while students who were characterized as "challenge-avoiders' had lower math self-efficacy.

Finally, the degree to which students perceive their classroom as a caring environment also has an important influence on self-efficacy. In a caring classroom (also referred to as Teacher Involvement: Newman, 2002; Personalization: Frasier & Fisher, 1982), the teacher expresses personal interest in students, provides emotional support, and generally creates a comfortable atmosphere. Murdock and Miller (2003) suggest that students who perceive their teachers as caring are more likely to view themselves as academically capable and set higher educational goals for themselves. Positive relationships between students and teachers provide a critical developmental resource for children; students are more likely to seek help when they need it and develop a wide range of competencies when they feel emotionally supported by their teachers (Crosnoe, Johnson, & Elder, 2004; Pianta, Hamre, & Stuhlman, 2003). Accordingly, evidence suggests that students who perceive their teachers as more caring have significantly higher academic self-efficacy (Murdock & Miller, 200; Patrick et al., 2007). Pianta et al. (2008) also found that fifth-grade students had higher performance on math tests when their classrooms were rated higher in emotional support. In addition, the effect of emotional support on math achievement was larger than the effect of quantity of math instruction. The authors noted that, "this is especially interesting because math is perhaps not a subject where teacher-student relations are as much a focus," (Pianta et al., 2008, p.389).

In summary, math self-efficacy appears to play an important role in math achievement and mediates the influence of mastery-oriented classroom environments on math achievement. Global academic self-efficacy also seems to be positively affected by caring and challenging classroom environments. However, several issues remain unclear. Little is known either about the influence of caring and challenging classroom environments specifically on math self-efficacy or whether math self-efficacy mediates the influence of challenging and caring classroom environments on math achievement. Further, virtually nothing is known about the relationships between math self-efficacy, perceived classroom environment, and achievement in the context of standardized math test performance.

These are important gaps in the literature in light of the *No Child Left Behind* (NCLB) Act of 2002 that requires all students to take standardized math tests annually in grades 3 through 8 and once during high school. Scores on these tests are increasingly being used for "high-stakes" purposes that affect both students and teachers. According to the National Center for Fair and Open Testing (2007), standardized test scores of fourth, fifth, and sixth graders can be used for the following purposes in California: to place students into instructional groups (e.g. remedial or special education programs), determine school eligibility for federal funding, make decisions about whether principals, teachers, and staff are offered continued employment, and determine whether or not teachers get bonuses. Several researchers have argued that the implementation of NCLB has led to a focus on testing and evaluation that permeates the school environment (Meece, Anderman, & Anderman, 2006; Ryan et al., 2007). It is important to examine how student motivation (e.g. self-efficacy) and classroom environments are related to one another in this legislated performance-oriented environment.

In the current study, we predicted that math self-efficacy mediates the influence the perceived of classroom environment on standardized math test performance (Figure 1). Specifically, we predict that students' perceptions of the degree to which their classroom environment is mastery-oriented, challenging, and caring has a direct and positive influence on math self-efficacy, and math self-efficacy has a direct and positive effect on student performance on standardized math tests. Each of these three aspects of the classroom environment will positively affect self-efficacy for the following reasons. Mastery-orientation will have a positive influence on math self-efficacy because environments that encourage students to take pride in their effort and value learning for its own sake, rather than simply emphasize the importance of good grades, will allow students to feel more confident in their ability. Challenge will also be associated with higher math self-efficacy because being afforded the opportunity to progressively master tasks that are slightly beyond one's current capacity allows a student to observe his/her own progress and gradually increase beliefs in his/her ability. Finally, caring will have a positive influence on math self-efficacy because Bandura (1993) argued that affective processes affect self-efficacy. In particular, environments that arouse anxiety and other negative emotions have a negative affect on efficacy beliefs (Usher, 2009). We hypothesize that environments in which teachers take a personal interest in and emotionally support students are less likely to arouse negative emotions than environments in which teachers are impersonal and emotionally disconnected, and therefore caring environments will positively affect self-efficacy.

Methods

Participants

The 1,163 participants in our study were fourth, fifth, and sixth graders who attended elementary school in an inland southern California suburban school district during the 2005-06 and 2006-07 academic years. The schools were located in low to middle income neighborhoods, with 59% (n = 682) of our participants receiving free and/or reduced lunch. Participants came from 88 separate classrooms. The mean cluster size was 13.22 (SD = 5.95) and ranged from 2 to 25 students per classroom. The majority of our sample consisted of Latino/a (62%) and Caucasian (31%) students and other ethnic groups included African American (4%), Asian (1%), Pacific Islander (<1%), Filipino/a (<1%), and American Indian or Alaska Native (<1%). In the 2006-07 academic year, 43% (n = 495) of participants were in 5^{th} grade and 57% (n = 668) were in 6^{th} grade. Finally, 51% (n = 594) of our sample were females and 49% (n = 569) were males.

Data were gathered as part of a larger study on math performance and math pedagogy, which included 3,259 elementary school students. Participant inclusion for the current study was based on four criteria. Students were included only if: they were considered by the school district to be a fluent English speaker; their gender, ethnicity, and free lunch status were available through the district database; their California

Standards Test for Mathematics scores for both the 2005-06 and 2006-07 academic years were available through the district database; and finally, they completed the Student Motivation Questionnaire in both the 2005-06 and 2006-07 academic years. Applying these criteria resulted in a final sample of 1,163 students.

Measures

The Student Motivation Questionnaire (SMQ: Karabenik & Maehr, 2004; Karabenik & Maehr, 2007) was the primary instrument used in the current study. This questionnaire was developed by a group of researchers on the National Science Foundation funded Math-Science Partnership-Motivation Assessment Project (MSP-MAP). A major goal of MSP-MAP was to provide Math-Science Partnerships with self-report instruments that provide reliable and valid scores for assessing a variety of student motivation variables and perceptions of the classroom environment. These instruments were created through extensive literature reviews of existing instruments. Items for each scale were adapted from existing scales and they were specifically worded to be relevant to math and science classes. For the current study, we were provided with items to measure the following variables in math classes: Math Self-efficacy, Perceptions of Teacher Mastery Goal Structure, Perceptions of Teacher Challenge, and Perceptions of Teacher Caring. All items were responded to using a Likert-rating of 1 to 5 (1 = not at all true, 3 = somewhat true, and 5 = very true) and scores for each scale were created by averaging the ratings on the items associated with a particular scale. Information for each of these scales follows.

Math Self-efficacy. Four items adapted from existing scales (e.g. Tasks Self-efficacy: Pajares & Miller, 1995; Academic Self Efficacy: PALS: Midgley et al., 2000) were used to assess math self-efficacy. These items assessed student's beliefs in their ability to successfully learn what was taught in their math class (α = .84). The following items were used: "I'm sure that I can learn everything taught in math," "I'm sure that I can do even the hardest work in my math class," "Even if a new topic in math is hard, I'm sure that I can learn it," and "I'm sure that I can figure out the answers to problems my teacher gives me in math class." The average 2006-07 math self-efficacy score in our sample was 3.83 (SD = .91).

Perceptions of Teacher Mastery Goal Structure. Four items from Midgley et al.'s (2000) Patterns of Adaptive Learning Scales (PALS: Classroom Mastery Goal Structure) were adapted to assess student perceptions of mastery goal structure. These items measured student perceptions of the degree to which their math teacher encouraged effort and the intrinsic value of learning (α = .63). The following items were used: "My teacher thinks really understanding our math lessons is the main goal," "My teacher thinks it's important to understand our math work, not just memorize it," "My teacher thinks how much you improve in math is really important," and "Our math teacher accepts nothing less than our full effort." The average rating of perceived mastery goals in 2006-07 was 4.32 (SD = .65).

Perceptions of Teacher Challenge. Four items from Midgley et al.'s (2000) Patterns of Adaptive Learning Scales (PALS: Academic Press) were adapted to assess student perceptions of challenge. These items measured student perceptions of the degree to which their math teacher provides challenging work (α = .61). The following items were used: "When we've figured out how to do a math problem, our teacher gives us more challenging work," "Our math teacher doesn't let us get away with doing easy work but really makes us think," "Our math teacher pushes us to take on challenging work," and "Our math teacher makes sure that the work we do really makes us think." The average rating of perceived challenge in 2006-07 was 3.71 (SD = .74).

Perceptions of Teacher Caring. Three items were created using existing definitions (e.g. Wentzel, 1997) and existing scales (e.g. Classroom Life Measure: Teacher Support: Johnson et al., 1985) to assess student perceptions of teacher caring. These items measured student perceptions of the degree to which their teacher displays personal interest in the emotional well-being of his/her students. (α = .75). The following items were used: "Our math teacher takes a personal interest in students," "Our math teacher cares about how we feel," and "Our math teacher listens to what I have to say." The average rating of perceived caring in 2006-07 was 3.72 (SD = .1.23).[1]

California Standards Test for Mathematics. Individual student results from the late spring 2005-06 and 2006-07 administrations of California Standards Test for Mathematics were obtained. Each student completed a 65-item test that was appropriate to his/her grade level (e.g. 4^{th}, 5^{th}, or 6^{th} grade) each year. Item content was based on California content standards, which define the knowledge and skills that each student should acquire at each grade-level. The California Standards Test (CST) for Math for grades 4 through 6 contains questions in four content areas: number sense; algebra and functions; measurement and geometry; and statistics, data analysis, and probability. Test scores were calculated by summing the number of items correctly completed.

Procedure

There were two waves of data collection for each academic year. The Student Motivation Questionnaire (SMQ) was administered in the early spring of the 2005-06 and

2006-07 academic years and the CST for Math was administered at the end of the 2005-06 and 2006-07 academic years. To minimize wordiness in referring to our variables, herein we will refer to all variables measured in the 2005-06 academic year as a “2006” variable, and refer to all variables measured in the 2006-07 academic year as a “2007” variable.

Distribution and return of the SMQ was handled by the district assessment and accountability office, which distributed and picked up the questionnaires in sealed envelopes. At each school site, researchers met with 4th, 5th and 6th grade teachers and explained the protocol for the class survey administration. Rather than administer surveys to their own students, teachers were asked to trade rooms with a colleague so that students could complete surveys in the presence of a teacher other than their own. The teachers provided practice questions to students before they completed the actual survey in order to clarify the procedures. All questions were read aloud by the teachers, who were told to provide sufficient time to allow students to complete the survey (approximately 30 minutes). Because of the time involved, teachers rarely re-administered the survey to students who were absent on the day of the testing. In the 2006 academic year, only student responses on the math self-efficacy section of the SMQ were used in analyses. In the 2007 academic year, student responses from the math self-efficacy and perceptions of teachers sections of the SMQ were both used in analyses.

Information regarding student ethnicity, gender, English Language Proficiency, Free or Reduced Lunch status, and scores on the CST for Math in the 2006 and 2007 academic years was accessed from the district database. Scores on the CST for Math for the 2006 academic year served as control data for models in which 2007 CST math scores were the outcome variable. The school district and University Institutional Review Board waived parental permission for both the SMQ and data records collection because the questionnaire was administered by district personnel (teachers), no one student or group of students was singled out in the process of data collection, and the data were made available to teachers in aggregate form only for instructional purposes.

Missing Data. Missing data for individual Likert items from the SMQ were handled using single imputation via the EM algorithm (Acock, 2005; Dempster, Rubin, and Laird, 1977). Imputations were based on observed relationships between all Likert items within the same year. The amount of missing data per item ranged from 0.04% to 3.96%. There were no missing data for CST scores in either year or for any categorical variable including grade level, gender, or free lunch status. Fifteen cases were removed from the analysis because they lacked information concerning cluster (classroom) membership.

Tests for Mediation. To examine the mediating influence of math efficacy, we used the framework provided by Baron and Kenny (1986) and recent publications that have expanded upon it (Kenny, Kashy, & Bolger, 1998; Mackinnon, Krull, & Lockwood, 2000; MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002; Mackinnon, Fairchild, & Fritz, 2007; Mackinnon & Fairchild, 2009). According to this framework, mediation is tested against 4 conditions such that at least of two of these conditions (conditions 2 and 3 below) must be met to establish mediation.[2] First student perceptions of teacher caring, teacher challenge, and teacher mastery orientation should be significantly related to both student year-end math performance (condition 1) and math efficacy (condition 2). Math efficacy should significantly impact student year-end math performance (condition 3), and it's impact should be robust to the inclusion of the teacher variables, such that models in which math performance is regressed on math efficacy and teacher variables simultaneously should show significant and consistent effects for math efficacy, while showing nonsignificant effects for teacher variables (condition 4).

We performed tests of conditions 1 through 4 using two-level linear models with maximum likelihood estimation. Two-level analyses were chosen due to the hierarchical nature of the data. Students were nested in classrooms such that the residual variance for any *single level* analysis would contain variance attributable to both students and the classrooms in which students are nested. We included no classroom level predictors, and use two-level analyses only to separate residual variability attributable to classrooms from residual variability attributable to students such that potential bias in standard errors is removed (Raudenbush & Bryk, 2002). In each analysis we controlled for student gender, free lunch status, and grade level. In cases where 2007 math performance was examined as the outcome, we controlled for 2006 student math performance. In cases where 2007 student math efficacy was the outcome variable, we controlled for 2006 math efficacy.

In each case, the inclusion of control variables allowed us to interpret the effects of explanatory variables as if all students had entered 2007 with the same score on math performance or math efficacy, respectively. Our control variables and study design helped to address the possibility of a specification error, involving the possibility that the outcome variable (2007 math performance) actually causes the mediator (2007 math efficacy), and that the mediator causes student perceptions of teachers. Since math efficacy was measured temporally prior to math performance (math efficacy was measured in the early spring 2007 and math performance was measured in late spring 2007), and since student scores on math performance from the previous year (2006) were covaried, our test of the impact of math efficacy on math performance was not confounded by preexisting differences in math ability, nor does it reflect levels of math efficacy that may have resulted from a high or low score on a recent high profile math performance assessment. Similarly, our test of the impact of 2007 teacher variables on 2007 math efficacy was not confounded by preexisting differences in math efficacy (2006) and, as such, rules out the possibility that any observed effects of teacher variables on math efficacy is a result of preexisting levels of math efficacy.

For each dependent variable we first estimated a model containing only control variables. Next we examined models containing both control variables and student-level explanatory variables of interest entered both individually and simultaneously. Examining and comparing student-level residual variances between models allowed us to estimate the portion of variability attributable to the explanatory variables of interest. We also compared models using two fit statistics, including Akaike's Information Criteria (AIC) and Bayes' Information Criteria (BIC), to determine whether models improve when explanatory variables were included and to identify optimal sets of explanatory variables.[3]

Numeric variables were standardized ($M = 0$, $SD = 1$) and categorical variables coded such that the model intercepts represent predicted outcome variable scores for a 5th grade male student who does not receive free lunch, is in a sample average classroom, and has sample average scores on all numeric variables in the model. Coefficients for each categorical control variable represent the change in model intercepts, in standard deviation units, associated with a positive one unit change in the explanatory variable. Similarly, coefficients associated with explanatory variables represent the change in the model intercept, in standard deviation units, associated with a positive one standard deviation increase in the explanatory variable.

Results

Bivariate Correlations. Bivariate correlations between study variables are shown in Table 1. As expected, math efficacy (2007) was positively related to all variables measuring student perceptions of teachers (2007). Math efficacy (2007) was also significantly related to both 2006 and 2007 math performance. Small but significant correlations were observed between teacher challenge and math performance (2007) and teacher mastery orientation and math performance (2007). All variables measuring student perception of teachers were significantly and positively related to one another. Finally, female students showed lower math efficacy than males in 2007 and students who received free lunch tended to have lower math performance scores than students who did not receive free lunch.

Math Performance Regressed on Teacher Variables. Our initial series of models examined math performance as the outcome. The initial model, containing only control variables, indicated significant (and positive) effects only for previous year math performance, t (1071) = 45.54, $p < .001$, and being in 6^{th} grade, t (1071) = 3.04, $p < .01$. A considerable portion of the residual variance was attributable to classrooms (28%), while most (72%) was attributable to students. All subsequent models in this series indicated a similar pattern of effects for control variables. When examining the influence of teacher variables entered individually, both teacher challenge (t (1071) = 2.26, $p < .05$)

and mastery orientation (t (1071) = 2.45, $p < .05$) were significant. Teacher caring, however, did not exert a significant impact. A final model examined the three teacher variables entered simultaneously. In this case, two of the explanatory variables, including teacher caring and challenge, did not approach significance. Mastery orientation, however, did exert a significant impact, t (1068) = 2.02, $p < .05$. Comparative examination of fit statistics across models indicates that the model containing teacher mastery as the single explanatory variable provides the optimal fit, followed closely by the model containing teacher challenge as the single explanatory variable. Student-level residuals remained essentially unchanged across all models. The pattern of results indicates that while both teacher challenge and mastery orientation exert a significant individual impact on year-end math performance, only the latter exerts a unique effect among the teacher variables. Additional details including standardized coefficients and standard errors can be examined in Table 2.

Math Efficacy Regressed on Teacher Variables. Our second series of models examined math efficacy as the outcome. The initial model, containing only control variables, indicated a significant positive effect for previous year math efficacy, t (1071) = 14.95, $p < .001$. A significant impact for gender was also observed, t (1071) = -2.00, $p < .05$, indicating that females had lower levels of math efficacy. Most (94%) residual variance in math efficacy was attributable to students. All subsequent models in this series indicated a similar pattern of effects for control variables. We continued by examining the influence of teacher variables entered individually. These models revealed significant effects for teacher caring (t (1070) = 9.38, $p < .001$), challenge (t (1070) = 8.04, $p < .001$) and mastery orientation (t (1070) = 8.65, $p < .001$), and resulted in student-level residual variance decreases of 6.4%, 5.1%, and 5.1%, respectively. The final model examined the impact the control variables and all teacher variables entered simultaneously. This model again revealed significant effects for previous year math efficacy and gender, and a significant unique effect for each teacher variable including teacher caring (t (1068) = 5.17, $p < .001$) challenge (t (1068) = 4.01, $p < .001$) and mastery (t (1068) = 3.21, $p < .001$). The final model showed a 9.1% reduction in residual variance compared to the initial model. Comparative examination of fit statistics and residuals showed that models containing at least one teacher variable were superior to the model containing only the control variables, while the model in which teacher variables were entered simultaneously showed the optimal fit. The pattern of effects indicates that each teacher variable exerts a positive individual and unique impact on math efficacy. Additional model details can be examined in Table 3.

Math Performance Regressed on Math Efficacy. The final series of models again examined math performance as the outcome. The initial model, containing only control variables, was described earlier and presented in Table 2. The model containing both control variables and math efficacy, revealed a similar pattern for control variables, a significant and positive effect for math efficacy, t (1071) = 5.27, $p < .001$, and a 3.6% decrease in student-level residual variance. In the next four models, we examined whether the positive and significant effect of math efficacy was robust to the inclusion of teacher variables entered both individually and simultaneously. In each model the teacher variables were nonsignificant while math efficacy remained significant and essentially unchanged with regard to magnitude. Comparative examination of fit statistics and residual variances indicated that the model containing the control variables and math efficacy as the *only* explanatory variable showed the optimal fit. The pattern of effects shows that students with higher levels of math efficacy achieve higher scores on year-end math performance. Additional details including standardized coefficients and standard errors can be examined in Table 4.

Indirect Effects. Overall, results are consistent with existing frameworks for establishing that teacher variables exert a mediated or "indirect effect" on math performance via their relationship to math efficacy (e.g., Baron & Kenny, 1986; Kenny, Kashy, & Bolger, 1998; Mackinnon, Krull, & Lockwood, 2000; MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002; Mackinnon, Fairchild, & Fritz, 2007; Mackinnon & Fairchild, 2009). Students who perceive their teachers to be more caring, challenging, and mastery oriented experience increased levels of math efficacy. Elevated levels of math efficacy then positively impact student math performance. We estimated the magnitude of the indirect effect for each teacher variable by multiplying the coefficient obtained by regressing math efficacy on each teacher variable (entered individually) by the coefficient obtained by regressing math performance on math efficacy (from the best fitting model in Table 4).

To examine whether indirect effects were significant, we used the Sobel test (Sobel, 1982; MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002) . The Sobel test is $ab / b^2sa^2 + a^2sb^2$, where a is the coefficient obtained by regressing the mediator on the initial variable, b is the coefficient obtained by regressing the outcome variable on the mediator, sa^2 is the squared standard error for coefficient a, and sb^2 is the squared standard error for coefficient b. We report standardized coefficients to describe the magnitude of each indirect effect, but, as recommended, used unstandardized coefficients and standard errors to compute the Sobel test. Null hypothesis decisions, however, were the same whether standardized or unstandardized coefficients were used.

In multilevel models, calculation of mediated/indirect effects involving only variables assessed on lower level units (students in the current study) requires adjustment only in the case that the impact of the all variables involved in each mediation chain have significant nonzero variability attributable to upper level units (classrooms in the current study). Because math self-efficacy is involved in each mediation chain, we checked for this possibility first by estimating the variability in the impact of math efficacy on math achievement across classrooms. We found that this variability estimate was near zero and nonsignificant ($\sigma^2 = .0004$, $p = .24$; when adding this source of variability to the first model shown in Table 4 (furthest left)). In light of the zero variability in math efficacy slopes across classrooms, we estimate the indirect effect of each initial variable with no adjustment for the multilevel nature of our models (Kenny, Korchmaros, & Bolger, 2003).

We found that the indirect effect of teacher caring on math performance was small and significant ($z = 4.50$, $p < .001$), indicating that a one standard deviation increase in teacher caring results in a .02 standard deviation increase in math performance. The indirect effect of both mastery and challenge were of the same magnitude (.02), and were also both significant ($z = 4.50$, $p < .001$ and $z = 4.41$, $p < .001$, respectively).

Discussion

Bandura's (1993) theory proposed that self-efficacy is a mediating agentic mechanism for academic achievement: academic experiences affect self-efficacy and this, in turn, affects student achievement. Previous research widely supports that learning environments effect self-efficacy (Schunk, 1982, 1983, 1984; Schunk & Hanson, 1985) and self-efficacy beliefs for math have a strong influence on math achievement (Pajares & Kranzler, 1995; Pajares & Miller, 1994; Pajares & Miller, 1995). The main goal of the current study was to extend this research by examining the relationships between math self-efficacy, perceived classroom environment, and achievement in the context of standardized math test performance. We found that students who perceived their classroom environments as more caring, challenging, and mastery oriented had significantly higher levels of math efficacy than those in less caring, challenging, and mastery-oriented classrooms. In addition, we found that higher levels of math efficacy positively affected student math performance. Finally, our results suggest that student perceptions of the classroom environment do not directly impact math performance on standardized tests, but they do impact math performance indirectly via the mediating, albeit small, effect of math efficacy.

Another goal of the current study was to examine the influence of perceived challenge and caring in the classroom specifically on math self-efficacy. Few studies have examined this, particularly with a data set that allows for control of previous math performance and previous math self-efficacy. The current data suggest that both challenging and caring environments positively influence math self-efficacy. It is interesting to note that perceptions of teacher caring effected math self-efficacy as strongly as perceptions of challenge and mastery. This may be surprising given that displaying a caring attitude towards students seems less relevant than challenge and mastery-orientation to skills development in math, and therefore less relevant to self-efficacy. However, Bandura (1993) argued that affective processes are one of the main influences on self-efficacy. It is not hard to imagine that when students believe that their math teachers have a personal interest in their well-being and concerns, they have less anxiety and are more confident in their ability to do their math work. Moreover, this finding supports Pianta et al.'s (2008) observation that emotional support in math instruction may be more important than is typically acknowledged.

Limitations

Before discussing the implications of this work to future research, it is important to acknowledge limitations of our study. First, previous research has typically observed a stronger relationship between math self-efficacy and math performance than that observed in the current study (e.g. Pajares & Graham, 1999). Pajares (1996) suggests that the magnitude of association between self-efficacy and performance depends largely on the match between the self-efficacy index and the criterion performance task. For example, asking students to rate their confidence in their ability to solve a specific math problem (e.g. 1 + 1) should correlate highly with their success in solving that exact math problem, whereas asking students to rate their global confidence in their ability to do math should be relatively less related to their performance on a multidimensional math test. Moreover, a metanalysis found that self-efficacy beliefs had a weaker relationship with standardized test performance than other types of performance outcomes, such as specific skills tasks (e.g. subtraction problems) and classroom-based performance indices (e.g. course grades) (Multon, Brown & Lent, 1991). The authors concluded that this is because studies using, "standardized achievement measures involved self-efficacy indices that less closely matched their companion performance measures" (Multon, Brown &

Lent, 1991, p.35). In the current study, students rated their self-efficacy to do well in their math class, not their efficacy for solving specific problems, and these ratings were correlated with performance on state mandated standardized math tests. It seems likely that the distal match between our self-efficacy and performance indices attenuated the observed relationship between math self-efficacy and math performance.

The indirect effects of student perceptions of the classroom environment on standardized math test performance were also modest. Although the true magnitude of these effects may indeed be small, it is possible that these effects were underestimated in our study because of our use of composite scores in measuring self-efficacy. Hoyle and Kenny (1999) note that error in the measurement of the mediator (e.g. self-efficacy) results in underestimation of mediated effect sizes. We initially considered a structural equation modeling (SEM) framework because it allows the mediator to be modeled without error; however, SEM would have introduced cross-classified random effects in our models due to the presence of both latent and manifest control variables in the previous year. There is currently no method for dealing with this issue in SEM. Consequently, the fact that our mediator was not measured free of error may have attenuated our ability to detect the true magnitude of indirect effects.

The brevity of our self-efficacy and perceptions of teachers scales may have also resulted in observed effects that underestimated the true effects. Due to practical considerations, such as the age-range of our sample, administering instruments on multiple occasions, and using class time for survey completion, we used shorter scales. A main disadvantage of shorter scales is that they tend to provide less reliable scores than longer scales, and lower reliability results in underestimation of the true magnitude of relationship between variables (John & Benet-Martinez, 2000). Still, it is important to note that reliability is assessed for the greater purpose of establishing validity (reliability is not an end in and of itself) and several studies suggest that two, even one-item scales can provide scores that are nearly as valid as scores on longer scales despite the sacrifice in reliability (Gosling et al., 2003). For example, Robins, Hendin, and Trzesniewski (2001) found that scores on a single-item scale of self-esteem correlated with scores on the widespread ten-item Rosenberg Self-Esteem Scale (Rosenberg, 1965) at $r = .75$, on average. Moreover, scores on the one-item scale and ten-item scale correlated similarly with a variety of criterion measures (e.g. physical health, positive group behavior, and college GPA). In sum, our relatively short scales may have attenuated our ability to detect true effects, but were not necessarily less valid than longer versions.

Finally, it is important to acknowledge the high correlations observed between the mastery, challenge, and caring scales. Although large correlations between scales is usually considered undesirable in that it might indicate redundancy in scale content, previous research has also found large correlations between various scales measuring student's perceptions of aspects of the classroom environment that facilitate learning (Fisher & Fraser, 1983; Fraser & Fisher, 1982; Gentry & Owen, 2004; Trickett & Moos, 1973). These constructs are often highly correlated with one another because there is a common denominator underlying them: a teaching disposition that anticipates and is responsive to student learning needs. A teacher who recognizes that students need to feel emotionally supported probably also recognizes that they need to feel appropriately challenged, and a teacher who recognizes that students need to feel challenged probably also recognizes that they need to believe that their efforts matter. Moreover, despite the high correlations between teacher variables, we observed unique effects for all teacher variables on self-efficacy and a unique direct effect for mastery-orientation on standardized math test performance.

Implications

The current results suggest a variety of directions for future research. First, further research is needed to more accurately determine the magnitude of relationship between self-efficacy beliefs and standardized test performance. One possibility is that the effect of self-efficacy on standardized test performance is small. Another possibility, suggested by the previously mentioned metanalysis, is that self-efficacy is often weakly related to standardized test performance because the self-efficacy indices only distally match the performance criteria of the standardized tests (Multon, Brown & Lent, 1991). Therefore, we would expect the relationship between self-efficacy and standardized test performance to be larger when self-efficacy and performance indices are more highly concordant. In addition, it is possible that self-efficacy more strongly mediates the effect of perceptions of the classroom environment on standardized test performance when self-efficacy and performance indices are more highly concordant.

Second, our finding that perceptions of the classroom environment indirectly effect math performance through self-efficacy suggests that what teachers do in the classroom matters. Although the indirect effects of our classroom environment variables were small, it is interesting to consider that they might add up. For example, providing a challenging classroom environment (in and of itself) might only slightly increase students self-efficacy beliefs; however, providing a challenging, caring, and mastery-oriented classroom environment might increase students self-efficacy beliefs by a more notable degree. Moreover, there are several additional classroom variables, beyond those measured in the current study, that might further work together to influence student's self-efficacy beliefs. These possibilities can be examined in future research by measuring a wider variety of perceptions of the classroom and examining their influence on self-efficacy and math performance.

Third, the finding that perceptions of teacher caring and challenge effected math self-efficacy is relatively new. An interesting direction for future research involves examining the grade-level generalizability of our results. Our students were in fifth and sixth grade and it is worth considering if perceptions of caring would have a positive effect on math self-efficacy in later grades; perhaps older students are more responsive to cognitive (e.g. challenge and mastery-orientation) than affective aspects of the classroom environment. However, Patrick et al. (2007) found that perceptions of teacher caring had a strong effect on academic self-efficacy in seventh and eighth grade students. Moreover, several studies observe that motivation (e.g. self-efficacy) and achievement decline when students enter middle school and a commonly suggested reason for this is the change in classroom environment from elementary to middle school (Eccles & Midgley, 1989). Students typically perceive middle school classroom environments as more performance-oriented and less mastery-oriented than elementary school classrooms (Anderman & Midgley, 1997). Future research should examine the possibility that students also perceive middle school classroom environments as less caring than elementary school classrooms and the possibility that this plays a role in declines in math self-efficacy and math performance in middle school.

Another direction for future research is the possibility that student ability levels moderate the effect of classroom environments on self-efficacy. Greer (1993) suggested that students of different ability levels might interpret and respond to the classroom environment differently. For example, the math self-efficacy of a student with high math ability might not be strongly affected by a caring teacher, but might be strongly affected by a challenging one. In contrast, the math self-efficacy of a student with low math ability might be strongly affected by a caring teacher, but might not be affected by or even negatively affected by a challenging one.

It is also important to examine how math self-efficacy might mediate the effect of student perceptions of performance-orientation on standardized math test performance. We were unable to examine this as we did not have a measure of student perceptions of their teachers' performance-orientation. Based on the research previously reviewed (e.g. Ames, 1992; Dweck, 1986; Maehr & Nicholls, 1980), we would expect that students who perceive their classroom as higher in performance-orientation would have lower math self-efficacy, which would in turn negatively affect math performance. However, researchers have recently suggested that questionnaires should be developed to measure two different kinds of performance-orientation (Church, et al., 2001; Wolters, 2004): performance-approach and performance-avoidance. Classrooms structured around performance-approach goals encourage students to be interested in and take pride in their grades, whereas as classrooms structured around performance-avoidance goals encourage students to compare their grades to others and to feel bad when their grades are not better than others. Future research should explore the possibility that students who perceive their classroom as higher in performance-approach orientation have higher math self-efficacy and standardized test performance, while students who perceive their classroom as higher in performance-avoidance orientation have lower math self-efficacy and standardized test performance.

Conclusion

Ryan et al. (2007) noted that a fundamental assumption underlying NCLB is a belief that high-stakes tests will motivate students to perform at higher standards. The standardized test scores for fourth through sixth graders in the current sample were not high-stakes in the sense of using them as a basis for grade promotion, however, they can be used to place students into instructional programs and they are used to determine school eligibility for federal funding. Consequences like these have led to an intense focus on testing and evaluation that permeates the school environment and affects everyone from students, teachers, and administrators. The current study suggests that one way to increase scores on standardized math tests is to increase student's math self-efficacy, and teachers can positively influence math self-efficacy by creating a caring, challenging, and mastery-oriented classroom environment. Further research is needed to identify other attributes of students that affect their performance on standardized tests and how aspects of the perceived classroom environment affect these student attributes.

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Footnotes

[1] We used confirmatory factor analysis with adjustment for clustered observations to examine our theoretical expectation that the eleven items measuring student perceptions of teachers would be best expressed as three correlated latent constructs, including student perceptions of teacher mastery orientation, challenge, and caring. All factor analyses were conducted using 2006-07 data. We compared three models: a three factor solution; a two factor solution consisting of the teacher caring factor and a second factor on which challenge and mastery orientation items were assigned to load together; and a two factor solution consisting of the teacher challenge factor and a second factor on which mastery orientation and caring items were assigned to load together. Based on these comparisons, we concluded that the three factor solution was optimal, χ^2 (41) = 101.99, $p < .001$, CFI =.97, TLI = .96, RMSEA = .04.

[2] Conditions 1 and 4 are not required to establish mediation, but indicate whether mediation is complete and consistent. Complete mediation occurs when the antecedent(s) is significantly associated with the outcome, but is no longer associated with the outcome when the mediator is included in the model. Complete mediation implies that the mediator is the primary mechanism that accounts for any relationship between the antecedent(s) and the outcome. Consistent mediation requires that the sign of the coefficient(s) describing the relationship between the antecedent(s) and the outcome does not change depending on whether the mediator is included in the model.

[3] Smaller values of both AIC and BIC indicate a superior model fit.

Figure Caption

Figure 1. Conceptual framework for examining the mediational relationship between student math efficacy and student perceptions of teachers. Solid lines indicate direct effects and dashed lines indicate control variables.

FIGURE 1.

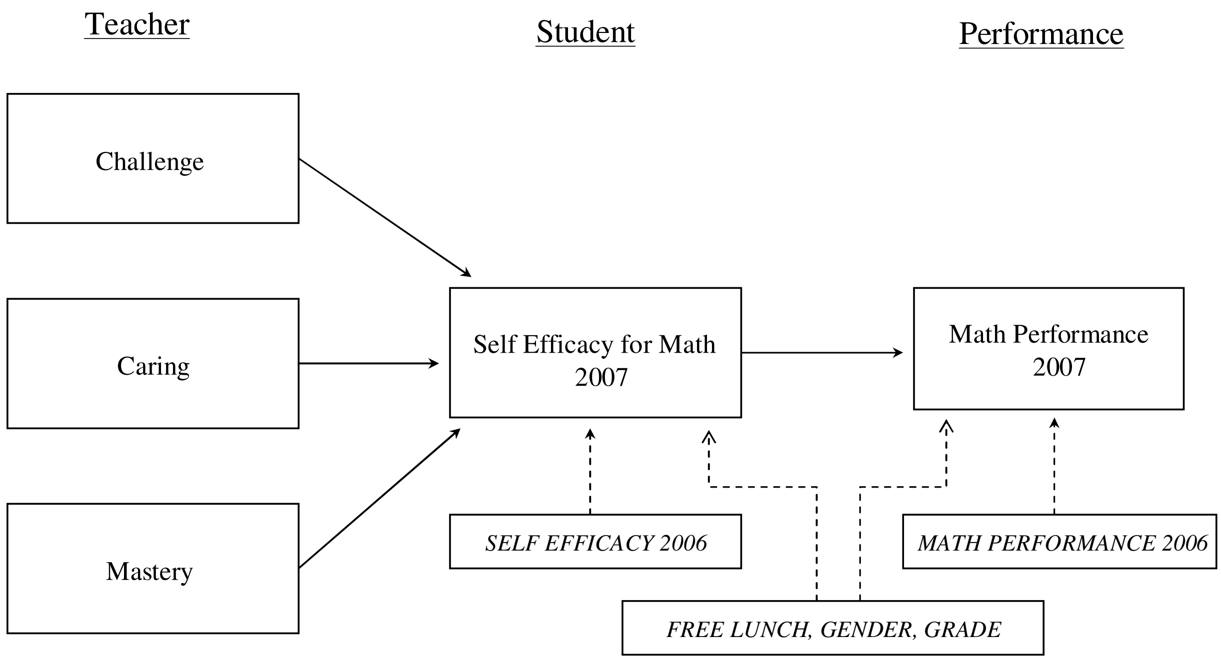
Teacher
Student
Performance
Challenge
Caring
Mastery
Self Efficacy for Math 2007
Math Performance 2007
SELF EFFICACY 2006
MATH PERFORMANCE 2006
FREE LUNCH, GENDER, GRADE

Table 1

Bivariate Correlations Between Study Variables

	1	2	3	4	5	6	7	8	9
1. Gender (Female)	--								
2. Free Lunch	.03	--							
3. Grade (6th)	.05	.02	--						
4. Math Performance 2006	-.02	**-.13**	**-.09**	--					
5. Math Performance 2007	**-.06**	**-.12**	**-.20**	**.78**	--				
6. Math Self-efficacy 2006	-.05	-.03	-.02	**.31**	**.29**	--			
7. Math Self-efficacy 2007	**-.09**	-.05	-.05	**.33**	**.37**	**.41**	--		
8. Caring 2007	.01	.04	**-.18**	**.06**	.06	**.10**	**.27**	--	
9. Challenge 2007	-.03	.04	.01	.03	**.09**	**.12**	**.26**	**.34**	--
10. Mastery 2007	**.07**	.03	-.01	**.07**	**.12**	**.14**	**.28**	**.50**	**.43**

Note. N = 1163. Point-biserial, Phi, and Pearson Correlations were calculated where appropriate. Bolded correlations are significant at $p < .05$ at least.

Table 2

Math Performance 2007 Regressed on Teacher Variables

	Explanatory Variables in the Model									
	None (Control Variables Only)		Teacher Variables Entered Individually						Teacher Variables Entered Simultaneously	
Fixed Effects	β	SE	β	SE	β	SE	β	SE	β	SE
Intercept	-.08	.058	-.08	.058	-.08	.057	-.07	.057	-.07	.057
Math Efficacy 2006	.80***	.018	.80***	.018	.80***	.018	.80***	.018	.80***	.018
Gender (Female)	-.05	.031	-.05	.032	-.05	.032	-.06	.032	-.06**	.032
Free Lunch	-.04	.035	-.04	.035	-.05	.035	-.05	.035	-.05	.035
Grade Level (6th Grade)	.20**	.067	.20**	.066	.20**	.065	.20*	.065	.19**	.064
Caring 2007	--	--	.01	.018	--	--	--	--	-.03	.021
Challenge 2007	--	--	--	--	.04*	.017	--	--	.03	.019
Mastery 2007	--	--	--	--	--	--	.04*	.017	.04*	.020
Random Effects	σ²	SE	σ²	SE	σ²	SE	σ²	SE	σ²	SE
Classroom	.11***	.021	.11***	.021	.10***	.020	.10***	.020	.10***	.013
Students	.28***	.012	.28***	.012	.28***	.012	.28***	.012	.28***	.012
Fit Statistics										
AIC	1978.60		1980.50		1975.50		1974.70		1975.70	
BIC	1996.00		2003.40		1995.40		1994.50		2004.00	

Note. N = 1163 students nested in 88 teachers.

*p ≤ 05,**p ≤ .01, ***p ≤ .001

Table 3

Math Efficacy 2007 Regressed on Teacher Variables

	Explanatory Variables in the Model									
	Math Efficacy		Math Efficacy and Teacher Variables Entered Individually						Math Efficacy and Teacher Variables Entered Simultaneously	
Fixed Effects	β	SE	β	SE	β	SE	β	SE	β	SE
Intercept	.13*	.066	.10	.063	.14*	.063	.16**	.062	.13*	.061
Math Efficacy 2006	.40***	.026	.37***	.026	.37***	.026	.37***	.026	.36***	.025
Gender (Female)	-.11*	.053	-.12*	.051	-.10*	.051	-.15**	.051	-.13**	.050
Free Lunch	-.05	.056	-.08	.054	-.07	.054	-.07	.054	-.09	.053
Grade Level (6th Grade)	.09	.070	.01	.066	-.09	.065	-.09	.063	-.03	.063
Caring 2007	--	--	.24***	.027	--	--	--	--	.15***	.031
Challenge 2007	--	--	--	--	.21***	.026	--	--	.12***	.029
Mastery 2007	--	--	--	--	--	--	.23***	.026	.11***	.031
Random Effects	σ^2	SE	σ^2	SE	σ^2	SE	σ^2	SE	σ^2	SE
Classroom	.05***	.018	.04**	.015	.03**	.015	.03*	.014	.03*	.013
Students	.78***	.034	.73***	.032	.74***	.032	.74***	.032	.71***	.012
Fit Statistics										
AIC	3071.90		2997.80		3000.11		3002.20		2959.90	
BIC	3089.20		3017.60		3031.30		3022.00		2984.60	

Note. N = 1163 students nested in 88 teachers.

*p ≤ 05,**p ≤ .01, ***p ≤ .001

Table 4

Math Performance 2007 Regressed on Math Efficacy and Teacher Variables

	Explanatory Variables in the Model									
	Math Efficacy		Math Efficacy and Teacher Variables Entered Individually						Math Efficacy and Teacher Variables Entered Simultaneously	
Fixed Effects	β	SE	β	SE	β	SE	β	SE	β	SE
Intercept	-.08	.057	-.08	.057	-.08	.057	-.07	.056	-.07	.057
Math Performance 2006	.77***	.018	.77***	.018	.77***	.018	.77***	.018	.77***	.018
Gender (Female)	-.04	.032	-.04	.032	-.05	.035	-.05	.032	-.05	.032
Free Lunch	-.04	.035	-.04	.035	-.05	.035	-.05	.035	-.05	.035
Grade Level (6th Grade)	.19**	.065	.19*	.065	.19*	.064	.19*	.064	.18**	.064
Math Efficacy 2007	.09**	.017	.10**	.018	.09**	.018	.09**	.018	.09**	.018
Caring 2007	--	--	-.02	.018	--	--	--	--	-.04	.022
Challenge 2007	--	--	--	--	.02	.017	--	--	.02	.019
Mastery 2007	--	--	--	--	--	--	.02	.017	.03	.020
Random Effects	σ²	SE	σ²	SE	σ²	SE	σ²	SE	σ²	SE
Classroom	.10***	.019	.10***	.019	.10***	.020	.10***	.019	.10***	.019
Students	.27***	.012	.27***	.012	.27***	.012	.27***	.012	.27***	.012
Fit Statistics										
AIC	1953.20		1954.10		1954.20		1953.80		1954.10	
BIC	1973.10		1976.40		1976.50		1976.10		1981.40	

Note. N = 1163 students nested in 88 teachers.

*p ≤ 05,**p ≤ .01, ***p ≤ .001