Teacher emotional support moderates the relation between math self-efficacy and engagement in fifth grade math classrooms

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Abstract

This study examined the contribution of math self-efficacy and teacher-student interaction to social and emotional engagement in fifth grade math classes. Teacher-student interaction quality was measured using the Classroom Assessment Scoring System (Pianta, La Paro, & Hamre, 2008), an observationally-based measure consisting of three domains: emotional support, classroom organization, and instructional support. Teachers (n = 73) were observed and students (n = 387) were surveyed about their engagement in math class at three times during the school year. Students reported on their math self-efficacy once in the beginning of the school year. Results of multi-level models indicated that student math self-efficacy related positively to both social and emotional engagement in math. However, this effect was only present in classrooms with low to average levels of teacher emotional support. In classrooms with high levels of teacher emotional support, students reported similar levels of both social and emotional engagement, regardless of self-efficacy. This paper considers the way in which teachers interact with their students and how these positive interactions may compensate for students who possess lower levels of self-efficacy. Potential strategies to boost student self-efficacy are also discussed.

Keywords: teacher-student interactions, social engagement, emotional engagement

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Student engagement in learning has been receiving increased research attention, because of the important role it plays in predicting academic achievement (Furrer & Skinner, 2003) and decreased likelihood of dropout (Rumberger & Rotermund, 2012). Students with lower levels of engagement are more likely to show poorer academic achievement. This could, in turn, result in even less engagement in learning, creating a cycle of decline that perpetuates negative educational outcomes (Lorsbach & Jinks, 1999). However, engagement appears to be malleable; learning conditions can be altered in ways that enhance or decrease engagement in learning (Fredricks, Blumenfeld, & Paris, 2004). Teachers can learn and adopt strategies that improve their students' engagement (Pianta, Hamre, & Allen, 2012; Omitted). Such teaching strategies hold promise for reducing problems that stem from disengagement in school (Reschly & Christenson, 2012).

Students experience a wide variation in classroom experiences (Pianta, Belsky, Houts, & Morrison, 2007). Given the presence of this variability, it is important to consider the role of teachers' interactions with their students who are vulnerable to disengagement and underachievement. One such vulnerable group, particularly in mathematics, are those students who perceive themselves as having low self-efficacy to learn math. By definition, students with low self-efficacy dwell on past mistakes and tend to lessen their efforts in the face of difficulties (Bandura, 1977). Both academic self-efficacy and teacher-student interactions in the classroom have been shown to relate positively to student engagement (Klem & Connell, 2004; Sakiz, Pape, & Hoy, 2012).

Research examining teacher-student interactions, student self-efficacy, and their contribution to engagement is especially important in mathematics during the late elementary school years. Learning mathematics is often viewed as a cumulative task; students who fall behind may find it difficult to catch up (Bodovski & Farkas, 2007). This pattern may be context dependent: the presence of positive teacher relations may support students' mathematics learning. Additionally, the nature of positive teacher-student interactions could be more important for some students than others (e.g., Malecki & Demaray, 2006). As applied to self-efficacy in math, more positive interactions in the classroom may provide more benefit to students who have lower levels of self-efficacy, compared with students with higher levels.

Studying how student self-efficacy and teacher-student interaction quality relates to stuent engagement at transition points, such as upper elementary school, is particularly important for school psychologists. Such efforts can inform interventions to reduce negative academic outcomes. Focusing inquiry on those students who are particularly low in math self-efficacy can help school psychologists target limited resources to the students who need them most. And yet despite the importance of such work, there are few, if any, investigations that consider the role of teacher-student interactions for engagement outcomes depending on students' self-efficacy in math. The present study builds upon previous research by examining the extent to which teacher-student interactions moderate the relation between math self-efficacy and student engagement in fifth grade students. Specifically, we examine whether supportive teacher-student interactions are more important for some students than others depending on their self-efficacy.

Conceptual Framework

The theoretical framework for this study draws on the person-environment fit theory (Mitchell, 1969). This theory proposes that certain academic constructs, such as motivation or achievement, can be understood as a function of the interaction between the individual characteristics of a student and by the environmental characteristics in which a particular student resides (Eccles, Lord, & Midgley, 1991). Applied to the classroom, when a student's individual needs fit well with the demands of the classroom learning environment, they will be more likely to succeed; when this does not occur, however, they become more susceptible to academic decline.

We use the person-environment fit theory to advance the hypothesis that students with lower math self-efficacy are more likely to perform at similar levels to their high efficacy peers in environments that are supportive to their needs (i.e., classrooms with higher quality teacher-student interactions). In classrooms that are less supportive (i.e., in classrooms with lower quality teacher-student interactions) students with lower levels of math self-efficacy are likely to perform less well. Students with higher levels of math self-efficacy, on the other hand, are more likely to perform at higher levels regardless of the classroom environment.

Applications of person-environment fit theory can focus on distal outcomes (such as achievement or social skills) or more proximal outcomes (such as motivation or engagement). In the present study, we chose a proximal outcome, students' own perception of engagement in the math classroom, for two reasons. First, students' perception of engagement harnesses the advantage that by age 10, students can reliably report their engagement. Second, this construct taps an internal perception, which is in essence the students' appraisal of whether the affordances of the classroom are sufficiently supportive to engage them in the process of learning.

Engagement in Learning

Student engagement is regarded as a multi-faceted construct with behavioral and psychological components that are essential for learning (Finn & Zimmer, 2012). In this paper, we consider two specific facets of engagement: social and emotional. Social engagement can refer to the positive and negative interactions a student may have with their teachers and peers. For instance, social engagement may include talking to and assisting peers in class. More specifically, we define social engagement (also termed task-related interaction by Patrick, Ryan, & Kaplan, 2007) as the extent to which a student is actively engaged in positive exchanges with peers that are connected to the instructional content of the lesson. For example, a student who is socially engaged might work in a group to help one another solve a particular problem in class. Previous research has shown that low levels of social engagement (i.e., poor peer interaction in the classroom) has an inverse relation with classroom participation and achievement (Ladd, Birch, & Buhs, 1999). Additionally, social engagement (as well as academic engagement) in high school have been identified as the two most consistent indicators of student dropout (Rumberger & Rotermund, 2012).

Emotional engagement, on the other hand, refers to the emotions (i.e., enjoyment, interest, or pleasure) experienced when pursuing a particular subject or school-related task (Mahatmya, Lohman, Matjasko, & Farb, 2012). While other forms of engagement (e.g., social engagement) are found to be directly related achievement, emotional engagement is understood as a construct that is indirectly related to achievement (Finn & Zimmer, 2012). For example, Voelkl (1997) found that emotional engagement relates more strongly to student participation in classrooms than achievement. Additionally, emotional engagement is linked with self-efficacy. Research has shown that a student's self concept in the beginning of the year relates to interest in math and achievement later in the year (Marsh, Trautwein, Lüdtke, Köller, & Baumert, 2005).

The majority of engagement research examines engagement across content domains. There are very few studies that focus on the math domain, specifically. One such exception is work by Ryan and Patrick (2001), who describe that students' positive perceptions of teacher support and levels of mutual respect were related to changes in student engagement in math between seventh and eight grade. The lack of engagement research in the math domain is important in that engagement appears to be both context-specific to the immediate classroom environment and domain-specific to math content in general. Thus, assuming that a students' engagement is comparable in math as in ELA or science could lead to overgeneralizations.

Self-Efficacy

By fifth grade, children have a well-developed sense of their own efficacy in specific subjects that stems from their home, school, and peer experiences (Schunk & Pajares, 2005). Student perceptions of self-efficacy in learning, defined as an individual's own perception of their capacity to learn or perform in a particular domain, has been established as a critical construct underlying motivation and engagement (Linnenbrink & Pintrich, 2003; Schunk & Pajares, 2005; Zimmerman, Bandura, & Martinez-Pons, 1992). Research has shown that high academic self-efficacy is associated with higher levels of academic achievement (Appleton, Christenson, & Furlong, 2008) and both social competence and more positive relationships with peers (Kuperminc, Blatt, & Leadbeater, 1997).

Teacher-Student Interactions

Person-environment fit theory directs attention to understanding environmental context and its ability to form individual engagement (Fredricks et al., 2004). For example, both teacher support and classroom structure has been shown to be positively related with various forms of student engagement (Marks, 2000; Skinner & Belmont, 1993). However, many of the students examining the relationship between these interactions and student engagement tend to be either teacher-reported interaction or student-reported interaction in nature (Mercer, Nellis, Martínez, & Kirk, 2011). An observational measure of teacher-student interaction offers a different, and perhaps more objective, way to examine the context of the classroom.

In this study, we use the Classroom Assessment and Scoring System (CLASS; Pianta et al., 2008) as an observational measure of teacher-student interaction. The CLASS is comprised of 10 dimensions organized into three domains: emotional support, classroom organization, and instructional support. Emotional support refers how sensitive the teacher is to students' academic and social needs, how the teacher regards students' perspectives, and how the teacher fosters a positive learning environment. Instructional support refers to the teacher's promotion of higher order thinking and the extent to which the teacher provides quality feedback to the students. Classroom organization refers to how the teacher uses instructional time to enable learning opportunities and uses methods to prevent behavioral problems. While interest in using observational measures for teacher-student interactions has been increasing in recent years, very little research has used such a measure in mathematics classrooms exclusively (Omitted).

An additional question that arises is whether teacher-student interactions are equally important for all students. Malecki and Demaray (2006) have found that perceived teacher support had a stronger relationship to academic achievement for students with lower levels of socio-economic status compared to those with higher levels. By using an observational measure of teacher-student interaction, Hamre and Pianta (2005) found that higher levels of instructional support and emotional support resulted in achievement gains for first grade students classified as at-risk (through both demographic characteristics and functional problems) the year before. As mentioned previously, we use person-environment fit theory to propose that students who have lower math self-efficacy are likely to perform less well and be less engaged in environments with low quality teacher-student interactions.

Current Study

To summarize, students' engagement in math class may (or may not) occur as the product of their self-efficacy in math, and the emotional, organizational, and instructional characteristics of the teachers. As a result, measuring students' social and emotional engagement provides an important lens into how teachers orchestrate their classroom environment to produce opportunities to learn. Further, these measures provide an opportunity to examine how teachers' efforts matter more for some students than others depending on the students' own perception of their efficacy in the subject area. The present paper addresses several gaps in the literature by focusing on fifth-grade math classrooms to examine the extent to which teacher-student interactions might play a more important role on engagement in learning depending on whether students have lower or higher levels of self-efficacy in math.

Two research questions were addressed in this study. First, to what extent are both math self-efficacy and teacher-student interaction quality related to math engagement? Based on previous research (e.g., Schunk & Pajares, 2005; Skinner & Belmont, 1993), we hypothesize that both student math self-efficacy and teacher-student interaction quality will relate positively to student engagement in math. Second, does student math self-efficacy differentially predict engagement based on teacher-student interaction quality? In accordance with person-environment fit theory, we hypothesize that students who possess lower levels of math self-efficacy will report lower levels of engagement when they are in less supportive classroom environments. We expect that this effect will not be present for students with higher levels of math self-efficacy.

Method

Participants

The sample used in this study is derived from the Responsive Classroom Efficacy Study, which examined the impact of a social and emotional learning intervention (Omitted). Schools were assigned randomly to either the intervention (n = 13) or wait-list control (n = 11) conditions. All schools were from one school district located in a suburban area in a mid-Atlantic state. Schools were invited to participate in a more intensive data collection, resulting in 20 schools participating. Children were selected randomly from each classroom from a larger pool of consented children, bounded by two additional considerations: drawing relatively equivalent gender proportions within each class, and selecting children who were demographically representative of the school (based on ethnicity, free/reduced price lunch [FRPL], and English Language Learner [ELL] status). Approximately five children per classroom were selected in this manner (mode = 5), resulting in a total sample size of 387 children (53% female). Parents received a gift card for their child's participation.

Students in the final sample had an average age of 10.5 years (SD = .37) at the beginning of the school year. School records indicated that 22% of the sample was eligible for FRPL, defined as a household income of $40,793 for a family of four (roughly 180% below the federal poverty guideline in 2010-2011). In addition, 37% of students were either: 1) ELL; 2) previously received ELL services and were being monitored; or 3) previously received ELL services and were recently monitored within the past 24 months.

The sample consisted of 63 teachers, who had 12.5 years of experience on average (range: 1 - 38). All teachers held bachelor degrees, 68% held masters degrees, and all reported having a full state certification. Forty-eight teachers were Caucasian, five were Hispanic, two were multi-racial, one was Native American, and one was African American. These 63 teachers taught 73 distinct classrooms of students. Eight teachers taught more than one classroom of students, where six teachers taught two classes and two teachers taught three classes. Because the research questions pertained to teacher-student interactions (which vary as a function of having different teachers or students in the classroom), the nesting occurred at the classroom level. Teachers received financial compensation for participating.

Procedure

District data, including FRPL eligibility, ELL status, and initial math achievement measured by the fourth grade state test were recorded in the spring while the students were still enrolled in fourth grade. All other relevant variables used in this analysis, including classroom observations and child self-report data, were gathered over the course of the students' fifth grade year.

Teachers distributed questionnaires to all students to measure math self-efficacy and anxiety in the fall of the school year. Research assistants conducted classroom observations in math classes at three time points during the school year, corresponding to three windows (window 1: late September to late November; window 2: late November to mid-February; and window 3: late February to late April). Observations were conducted on days deemed “typical” by the teacher. The full length of each math lesson (mean = 63 minutes) was recorded for later coding of teacher-student interactions using the Classroom Assessment Scoring System (described in more detail in the Measures section). In total, two fifteen minute segments of each lesson were used for coding. The research assistant distributed student engagement questionnaires to the students immediately after each of the three classroom observations.

Measures

Math Self-Efficacy. Students’ math self-efficacy was assessed with the Academic Efficacy subscale of the Patterns of Adaptive Learning Scale (Midgley et al., 2000). This subscale was modified to apply to a math context and piloted in a sample of 39 children (pilot alpha = .89). Students rated five items such as, “I know I can learn the skills taught in math this year,” and “I can learn math even if the work is hard” on a scale ranging from from one (almost never) to four (all the time). These items were then averaged to create a composite value of math self-efficacy, where higher values indicated higher self-efficacy (alpha = 0.80).

Math Anxiety. Students’ math anxiety was assessed with the math anxiety subscale from the Student Beliefs about Mathematics scale (Kaya, 2007). Items were modified slightly to increase student comprehension and piloted in a sample of 31 children (alpha = .72). Students rated five items such as, “I feel nervous before a math test” and “My mind goes blank and I am unable to think when I work on math problems” on a scale from one (strongly disagree) to four (strongly agree). These items were then averaged to create a composite value of math anxiety, with higher scores representing higher anxiety (alpha = 0.67).

Initial Achievement. Students' initial mathematics achievement was measured using scores from a state standardized test, the Standard of Learning (SOL), administered in May of the students' fourth year (Virginia Department of Education, 2008). The tests contained 50 multiple-choice items designed to assess understanding in four skill categories: (a) number and number sense, (b) computation and estimation, (c) measurement and geometry, and (d) probability, statistics, patterns, functions, and algebra (Virginia Department of Education, 2008). Scores were scaled to range from 200 to 600, where a scaled score of 400 represents pass/proficiency and a 500 represents pass/advanced. A Plain English Math version of this test was used if the students were not proficient in English and was scored in the same manner.

Engagement in Mathematics. The engagement questionnaire was originally piloted in a smaller sample of 33 fifth graders in three schools prior to its implementation in this study. This resulted in an alpha for the complete measure of .90 and inter-item correlations larger than .50. In the current sample (N = 387), the engagement questionnaire was administered three times over the course of the academic year. A confirmatory factor analysis with the two factors of social engagement and emotional engagement in math yielded good model fit. See the Results section for results of the factor analysis. More information about the two engagement factors can be seen below.

Social engagement in mathematics. The student-report measure of social engagement consisted of four items measuring the degree to which students discussed math content to one another in math class for a particular day. This measure was adopted from Patrick et al. (2007) to be applied to a math domain, and includes items such as, "Today I helped other kids with math when they didn't know what to do." Refer to Table 1 for a full item list.

Emotional engagement in mathematics. The student-report measure of emotional engagement consisted of five items assessing students' enjoyment and interest in math class for a particular day. This measure was developed based upon similar measures created by

Kong, Wong, and Lam (2003) and Skinner and Belmont (1993), and includes items such as, "Math class was fun today." Refer to Table 1 for a full item list.

Teacher-Student Interaction Quality. The Classroom Assessment Scoring System (CLASS; Pianta et al., 2008), a theoretically-based and observational assessment tool, was used to measure the quality of teacher-student interactions. It has ten measured dimensions that correspond to three interaction domains: emotional support, classroom organization, and instructional support. Each dimension used a seven-point Likert scale. Emotional support is comprised of teacher sensitivity, regard for student perspectives, positive climate, and negative climate (alpha = .83). Teacher sensitivity refers to the teacher providing comfort and reassurance toward both the children's academic and social needs. Regard for students' perspectives refers to situations where the teachers' choice of activities to perform in the classroom relate to students' interests. Positive climate refers to classroom interactions between teacher and student that show respect, enthusiasm, and enjoyment. Negative climate refers to sarcasm, anger, or general harshness in the teachers' interactions toward the students (and is a reverse-scored item).

Classroom organization is comprised of instructional learning formats, productivity, and behavior management (alpha = .82). Instructional learning formats refers to teachers' use of activities and materials to help facilitate learning. Productivity refers to the teachers' use of instructional time to enable learning opportunities. Behavior management refers to proactive methods used to prevent behavioral problems.

Instructional support is comprised of concept development, quality of feedback, and language modeling (alpha = .72). Concept development refers to the teachers' use of strategies to promote higher order thinking. Quality of feedback refers to the specific feedback given by teachers' in regard to student work. Language modeling refers to the facilitation and encouragement of using more advanced language in the classroom.

Coders used a protocol-based training process which included four-phases: preparation, training, reliability, and calibration. Preparation consisted of reading manuals and conducting practice observations. Training consisted of a two-day interactive training session conducted in small groups, followed by joint observations with an expert coder. To assess reliability, ten 15-minute segments were assessed and compared to a gold standard, prepared by the instruments' authors. Coders' responses exceeded the minimum amount of reliability required, which consisted of being within one scale point of the gold standard on at least 80% of the responses. Finally, calibration consisted of additional sessions of independent coding that occurred between once or twice a month in a small group setting. This was followed by a discussion of coding practices. Additional checks included randomly selecting 10% of tapes for double coding . In addition, "audits" were conducted by master coders by coding one tape for each coder every 12 weeks.

Intervention Condition (RC). Schools were randomized to either a wait-list control (coded as 0) or RC intervention (coded as 1) condition two years prior to data collection, as described in (Omitted).

Analytic Approach

The first analytic step involved the reduction of the engagement data to create two variables: social engagement and emotional engagement in math. Confirmatory factor analyses (CFA) with tests of longitudinal measurement invariance across the three time points were conducted in MPlus version 7 (Muthén & Muthén, 2008–2012) using full information maximum likelihood estimation to handle missing data. Factor scores for the three time points were averaged to create a mean score on each measure for each student.

On average, five percent of the participants were missing on each variable and assumed to be missing at random given the exhaustive nature of the covariates and lack of systematic trends found in the missing data analyses. To adequately handle the missigness in the multi-level models, 10 imputed datasets were created using MPlus (Muthén & Muthén, 2008–2012), using an unrestricted two-level imputation precedure to account for the nested structure of the data. Despite the low rates of missingness, more imputations were considered initially as recommended by (Bodner, 2008), but this was found to yield identical results to 10 imputed datasets in this study. Thus, only the 10 imputations were used to increase computational efficiency.

To address the primary research questions, three-level multi-level regression models were used to test the main effects of self-efficacy and each CLASS domain as well as the cross-level interaction between math self-efficacy and the three CLASS domains on the two student engagement outcomes. All multi-level analyses were conducted using R version 3.0.1 (R Core Team, 2014). Models were estimated using the lme4 package (Bates, Maechler, Bolker, & Walker, 2014), and pooled estimates for the fixed effects were created using the mice package (van Buuren & Groothuis-Oudshoorn, 2011). Simple slopes analyses probing the cross-level interactions were conducted following the procedure outlined in Bauer and Curran (2005), with the imputed data estimates being pooled according to Rubin (2004).

After the final models were built, model assumptions such as normality of residuals and linearity, as well as outlier diagnostics and variance inflation factors among predictors were examined. A reflected inverse transformation was applied for the emotional engagement factor due to negative skew found in the residual distributions for these models. The interpretation of such a transformation still corresponds to higher values of the observed variable corresponding to more positive levels of emotional engagement (Tabachnick & Fidell, 2006). After this transformation, the aforementioned assumptions for all models were deemed to be met.

Multi-level Model Building. The two research questions involved: (a) the contribution of self-efficacy and teacher-student interaction quality on engagement and (b) the extent to which the relation between math self-efficacy and student engagement in math is moderated by teacher-student interaction quality. Student engagement in math was measured via two constructs (i.e., social and emotional engagement), while student-teacher interaction was measured via three CLASS domains (emotional support

[ES], classroom organization [CO], and instructional support [IS]).Two models were constructed, one for each engagement outcome. Both models incorporated all three CLASS domains as main effects, as well as cross-level interaction between all three CLASS domains with the math self-efficacy variable. Multi-level models were built using a bottom-up approach (Hox, 2010). First, an unconditional model was estimated to partition the variance between the three levels (school, classroom, student). Then, the final models were created with all predictors and the cross-level interactions of interest (i.e., CLASS domain × math self-efficacy). Note that because some teachers had multiple classrooms, a four-level multi-level model was considered. Analyses of the four-level model revealed identical results to the three-level model. For simplicity, results from the three-level model are reported here.

A generalization of the structure for these two models can be seen in the equation below, where $engagement_{ijk}$ respresents the engagement score for student i (n = 387) in classroom j (n = 73) in school k (n = 20). For brevity, all level-1 and level-2 covariates are modeled as fixed effects and are represented by the ellipsis in both levels.

Level 1:

$$Engagement_{ijk} = \beta_{0jk} + \beta_{1jk}(Math\ SE_{ijk}) + ... + e_{ijk}$$

Level 2:

$$\beta_{0jk} = \gamma_{00k} + \gamma_{01k}(ES_{jk}) + \gamma_{02k}(CO_{jk}) + \gamma_{03k}(IS_{jk}) + ... + r_{0jk}$$

$$\beta_{1jk} = \gamma_{10k} + \gamma_{11k}(ES_{jk}) + \gamma_{12k}(CO_{jk}) + \gamma_{13k}(IS_{jk}) + r_{1jk}$$

Level 3:

$$\gamma_{00k} = \eta_{000} + \gamma_{001}(RC\ Intervention_k) + \mu_{00k}$$

Centering Procedure. Centering decisions were determined to optimize testing both main effects (self-efficacy, teacher-student interaction quality) and a cross-level interaction (self-efficacy × teacher-student interaction quality). As such, the level-1 predictor, math self-efficacy, was group-mean centered. This centering approach is often the preferred centering method when examining cross-level interactions because it removes the potential confound of between-cluster variation in the level-1 predictor and creates a "pure estimate" of the interaction effect (Enders & Tofighi, 2007). All other level-1 and level-2 variables in the model were grand-mean centered to increase interpretability of the intercept estimate. In addition to this centering procedure, all fixed-effect estimates were standardized to ease the interpretability of the models.

Results

Confirmatory Factor Analysis

First, longitudinal measurement invariance was examined for the engagement factors. More specifically, the assumption of strong measurement invariance was tested in the factor model. This type of measurement invariance indicates that the loadings (metric invariance) and intercept estimates (scalar invariance) for each item are constrained to be equivalent across time. Only when this type of invariance holds can the constructs be compared across time, because otherwise changes might simply be due to an artifact in the measurement model (Little, 2013).

There was no theoretical reason to believe there would be substantial variation in the measurement model over the course of the academic year. As such, both loadings and intercepts across time were fixed in one simultaneous step. The constrained model showed no significant loss of model fit, $\chi^2(32) = 40.14, p = 0.15$. Model fit indices showed good fit for the constrained model as well, RMSEA = 0.033 (90% CI: [0.025, 0.040]), CFI = 0.97. Standardized factor loadings for the items across all three time points are shown in Table 1. Note that despite fixed factor loadings across time, the standardized factor loadings differ slightly. This is because the factor variances were different across time points. Factor scores were calculated for each factor at every time point and then averaged to create the two dependent variables of emotional engagement and social engagement.

Descriptive Statistics

Students typically reported high levels of math self-efficacy, on average scoring a 3.30 on a 4 point scale. Zero-order correlations showed a positive relationship between math self-efficacy and both the social ($r = 0.39$) and emotional ($r = 0.24$) engagement outcomes. All three CLASS domains showed very small correlations with the two engagement outcomes (all $|r| < .09$). Finally, social and emotional engagement were positively correlated (r = 0.52) indicating that these constructs are related, but still have substantial unique variance. Table 2 displays descriptive statistics for each independent variable and the correlation of each variable with the two engagement outcomes.

Multi-level Models

The first step of multi-level model building involved creating an unconditional model to partition the variance in the two outcomes between the classroom level and the school level. Intraclass correlation coefficients (ICCs) for the engagement outcomes revealed more variation at the classroom level than at the school level. The classroom-level ICC for the social engagement outcome showed 21.8% of the variability due to the classroom, while the emotional engagement outcome showed 13% of the variability due to the classroom. The school-level ICC for both social and emotional engagement were smaller, with only 4.4% and 2.6% of the variance in each outcome occuring at the school level, respectively.

The results for the social engagement model will be presented first, followed by the results for the emotional engagement model. Model results are presented via coefficient plots rather than tables. In these plots, the value of the standardized estimates lie on the x-axis, while the model estimate label lies on the y-axis. Estimates are drawn with their respective 95% confidence intervals. Thus, statistically significant results are evident when the confidence intervals do not include zero. Model coefficients for both the social engagement model and the emotional engagement model can be seen in Figure 1.

Social Engagement

In the socal engagement model, students with higher levels of math self-efficacy (relative to their class) showed higher levels of social engagement ($\beta = 0.21$, 95% CI: [0.09, 0.33], $p = 0.0005$). However, this main effect was qualified by a negative interaction with emotional support ($\beta = -0.25$, 95% CI: [-0.4, -0.1], $p = 0.001$), such that the association between math self-efficacy and social engagement was attenuated in classrooms with higher levels of emotional support. No other significant cross-level interactions occurred between math self-efficacy and the other two CLASS domains.

The significant cross-level interaction in the emotional support interaction model was inspected further, treating the emotional support variable as the moderator and testing simple slopes for significance at values of -1 SD, 0, and +1 SD. Results indicated that both classrooms with low ($\beta = 0.46$, 95% CI: [0.26, 0.66], $p < 0.0001$) and average ($\beta = 0.21$, 95% CI: [0.09, 0.33], $p = 0.0002$) levels of emotional support showed a positive relationship between math self-efficacy and social engagement with math, such that students who were high in math self-efficacy reported being more socially engaged with math within classrooms with lower to average levels of emotional support. Students in classrooms with high levels of emotional support, however, showed no such effect ($\beta = -0.04$, 95% CI: [-0.23, 0.14], $p = 0.67$), indicating that students in classrooms with higher levels of emotional support were reporting similar levels of social engagement, regardless of math self-efficacy. These results are visualized in Figure 2 (upper panel).

Emotional Engagement

Results for the emotional engagement model resembled the social engagement model. Again, students with higher levels of math self-efficacy relative to their class showed higher levels of emotional engagement ($\beta = 0.2$, 95% CI: [0.08, 0.33], $p = 0.002$). This main effect was also qualified by a negative interaction with emotional support ($\beta = -0.22$, 95% CI: [-0.38, -0.06], $p = 0.007$), such that the association between self-efficacy and emotional engagement was attenuated in classrooms with higher levels of emotional support. No other significant cross-level interactions occurred between math self-efficacy and the other two CLASS domains.

The significant cross-level interaction in the emotional support interaction model was inspected further, treating the emotional support variable as the moderator and testing simple slopes for significance at values of -1 SD, 0, and + 1SD. Results indicated that both classrooms with low ($\beta = 0.42$, 95% CI: [0.21, 0.63], $p < 0.0001$) and average ($\beta = 0.2$, 95% CI: [0.07, 0.33], $p = 0.0008$) levels of emotional support showed a positive relationship between math self-efficacy and emotional engagement with math, such that students who were high in math self-efficacy reported being more emotionally engaged with math within classrooms with lower to average levels of emotional support. Students in classrooms with high levels of emotional support, however, showed no such effect ($\beta = -0.02$, 95% CI: $[-0.21, 0.18]$, $p = 0.57$), indicating that students in classrooms with higher levels of emotional support were reporting similar levels of emotional engagement, regardless of math self-efficacy. These results are visualized in Figure 2 (lower panel).

Discussion

This study sought to better understand the relationships between teacher-student interactions, individual math self-efficacy, and math engagement in fifth grade math classrooms. There are two findings of note, with results being consistent for both social and emotional engagement in math. First, students with higher levels of math self-efficacy (relative to other students in their class) reported experiencing more social and emotional engagement in math class. This self-efficacy finding is consistent with other work describing student self-efficacy as critical element involved in students' motivation (Linnenbrink & Pintrich, 2003; Martin, Anderson, Bobis, Way, & Vellar, 2012). Second, the association between self-efficacy and engagement was only present in classrooms with low to average levels of emotional support. Students reported similar levels of social and emotional engagement in classrooms with high levels of emotional support, regardless of self-efficacy. This finding is also supported by previous research, where students at-risk for school problems who spent a year in classrooms with higher levels of emotional support and instructional quality resulted in achievement scores at similar levels to their low-risk peers (Hamre & Pianta, 2005).

Engagement and Self-Efficacy

The first finding highlighted the strong relationship between student self-efficacy and their social and emotional engagement in math lessons. Recall that social engagement reflected positive exchanges between peers that are connected to the instructional content of the lesson. When a student feels more effective in math, he or she may be more comfortable as working as part of a group and helping others. Additionally, viewing similar peers succeed can help to boost the self-efficacy and motivation of other students in class. When a student sees a peer succeed, it can instill a belief that they, too, can succeed at a given task (Schunk, 1985, 1987). This positive peer interaction has also been shown to be related to other outcomes beyond self-efficacy. Ryan (2001) found that a middle school students' peer groups in the fall were related to changes in both their enjoyment of school and their academic achievement over the year.

Emotional engagement, on the other hand, referred to the students' enjoyment and interest in math. Positive feelings toward learning a particular subject are critically important to both motivation and success, and these effects can be bi-directional. Singh, Granville, and Dika (2002) found that motivation and attitude were important predictors of both math and science achievement in a sample of middle school students. Additional research has found that interest was an important motivational predictor of a students' use of regulatory strategies (e.g. seeking/learning information and behavior management) when learning math (Cleary & Chen, 2009). While emotional engagement has shown these positive links in a general sense (e.g., I like math), this study measured engagement in response to specific lessons (e.g., Math class was enjoyable today). Continued interest and enjoyment in a subject like math on a day-to-day basis may not be tenable, especially when learning new, difficult material. This highlights the importance of self-efficacy to help maintain motivation in learning despite being challenged.

Teacher-Student Interaction Quality as a Moderator

The second finding showed that the positive relation between self-efficacy and engagement was only present with lower to average levels of emotional support. Recall that person-environment fit theory states that students are more susceptible to academic decline when there is a lack of alignment between their individual needs and the demands of their learning environment. This finding fits with such a theory and highlights the potential importance of having a child in a classroom that adequately addresses his or her emotional needs. In a classroom with lower levels of emotional support, a student's self-efficacy in learning a particular subject may act as a "buffer." In other words, a student with high levels of self-efficacy may be more resilient in learning situations that lack teacher warmth and responsiveness common to classrooms with a high level of emotional support. Students with lower levels of self-efficacy do not have this buffer, and thus may have a more difficult time in classrooms deficient in these positive interactions.

However, while this study suggests that high performing students seem to be more consistent across different classroom environments, this does not mean that positive teacher-student interactions are not important for them as well. A study of kindergarten students showed child self-regulatory ability was comparable for predicting engagement, regardless of teacher emotional support (Omitted). One plausible reason that we did not see associations between self-efficacy and engagement among classrooms with high levels of emotional support pertains to sampling. The sample of children selected had an average math self-efficacy of 3.30 on a scale from 1 to 4, thus representing a sample of fairly efficacious children. If the typical level of self-efficacy was much lower, it is possible we would have detected a greater influence of self-efficacy on engagement regardless of emotional support. This observation leads to the question of how much self-efficacy is enough to act as a buffer to environments with lower levels of emotional support.

Limitations

This study has several limitations that need to be considered. First, teacher-student interaction quality was represented by an observational measure, resulting in a classroom-level variable. While using an observational measure can help circumvent potential measurement issues found in self-report data (e.g., Fan et al., 2006), doing so ignores the fact that children in the same classroom have different relationships with their teacher. Thus, measuring it as a child-level variable could provide more detail regarding these unique relationships. Second, this study is descriptive and does not permit causal inferences. Finally, both math self-efficacy and engagement in math were student self-report. As such, interpretation of the positive relationship between self-efficacy and engagement requires caution because it may reflect systematic effects of a single reporter.

Future Directions

The field of school psychology lacks research focusing specifically on math classrooms. Thus, it is important to examine how constructs such as self-efficacy, teacher-student interactions, and engagement relate specifically to the math domain. Additionally, future research could pursue the ideas outlined in this paper in a longitudinal framework to better understand the potential bi-directional relationships between the student and the teacher in the context of a classroom. For example, Hughes and Chen (2011) found that peer liking and teacher-student relationship quality exhibited bidirectional effects on one another in a three year longitudinal study, such that students who reported higher levels of peer relationships at an earlier time point typically had teachers report higher levels of teacher-student relationship quality at a later time point. In the context of this study, such a longitudinal framework would allow the examination of how students with low self-efficacy respond to different classroom environments in subsequent years. For example, students with low self-efficacy coming from a supportive classroom might be more resilient in later classroom experiences compared to students with low self-efficacy who are always in classroom environments that do not fit their educational needs.

Implications for School Psychologists

The finding that student-teacher interactions differentially contribute to student engagement has implications for practice. As was previously mentioned, student engagement in learning has been shown to be context-dependent, drawing on both the perceptions and beliefs of the individual and quality of the teacher-student interactions within the classroom environment. With regard to teacher-student interaction, helping to guide teachers in managing the tone of their classroom could yield positive results. In a randomized control trial in secondary school students, Allen, Pianta, Gregory, Mikami, and Lun (2011) found that teachers using a web-based coaching program had more impactful interactions with students, resulting in increased student achievement gains.

School psychologists may also want to consider ways of enhancing student self-efficacy toward math, given that students with higher self-efficacy in math appear to be more resilient in classroom contexts that may not optimally meet their emotional needs. Additionally, student self-efficacy can also act as a buffer when students are being challenged by learning difficulties. One way to promote self-efficacy in the face of difficulty is to establish the belief that the students are challenged because they possess the ability to meet the high expectations being set by the teachers. Research has shown that setting these high standards and promoting the belief that the students can achieve those standards results in increased levels of identification with the particular skill in question (Cohen, Steele, & Ross, 1999). Promoting a growth mindset rather than a fixed mindset may be another approach for enhancing self-efficacy, given existing work linking growth mindsets to both motivation and achievement scores (Blackwell, Trzesniewski, & Dweck, 2007). Helping students to see the connections between effort and performance is one way to contribute to a growth mindset. Either establishing high standards in a supportive manner or establishing a growth mindset are two methods that hold promise for boosting student self-efficacy to begin a positive cycle of interest, engagement, and achievement.

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Table 1

Confirmatory Factor Analysis for Student-Reported Engagement

	Standardized Factor Loading		
Items	Time 1	Time 2	Time 3
Emotional Engagement			
Math class was fun today	0.82	0.81	0.82
Today I felt bored in math class	-0.63	-0.66	-0.59
I enjoyed thinking about math today	0.81	0.80	0.83
Learning math was interesting to me today	0.78	0.79	0.80
I liked the feeling of solving problems in math today	0.70	0.71	0.66
Social Engagement			
Today I talked about math to other kids in class	0.58	0.61	0.59
Today I helped other kids with math when they didn't know what to do	0.70	0.70	0.75
Today I shared ideas and materials with other kids in math class	0.62	0.66	0.68
Students in my math class helped each other learn today	0.55	0.57	0.64

Note: RMSEA = 0.033 (90 % CI: [0.025, 0.040]), CFI = 0.97

Table 2

Descriptive Statistics and Correlations of Each Predictor with Engagement Outcomes

Variables	Mean	SD	Min	Max	N	Correlation with Social Engagement	Correlation with Emotional Engagement
Gender	0.53	-	-	-	386	0.10	0.06
ELL	0.37	-	-	-	332	-0.07	0.13
Free/Reduced Lunch	0.22	-	-	-	386	0.01	0.12
Initial Achievement	506.38	70.68	284.00	600.00	332	0.17	0.02
Anxiety	1.78	0.59	1.00	3.60	373	-0.16	-0.10
Self-Efficacy	3.30	0.57	1.40	4.00	379	0.39	0.24
Teacher Degree	0.68	-	-	-	374	0.07	0.07
Teacher Experience (years)	12.43	8.65	1.00	38.00	374	-0.12	-0.02
Emotional Support	5.17	0.60	3.62	6.17	357	0.06	0.08
Instructional Support	3.36	0.66	1.83	5.17	357	-0.04	0.06
Classroom Organization	6.03	0.41	4.39	6.67	357	0.05	0.09
Intervention Status	0.55	-	-	-	387	0.09	0.02
Social Engagement	0.00	0.51	-1.24	0.90	384	-	0.52
Emotional Engagement	0.00	0.57	-1.78	0.71	384	0.52	-

Note: Child Gender (0 = male, 1 = female); ELL (0 = no, 1 = ELL or monitor/post-monitor status); Free/Reduced lunch (0 = no, 1 = yes); Teacher Degree (0 = no Masters, 1 = Masters) Intervention Status (0 = control, 1 = intervention)

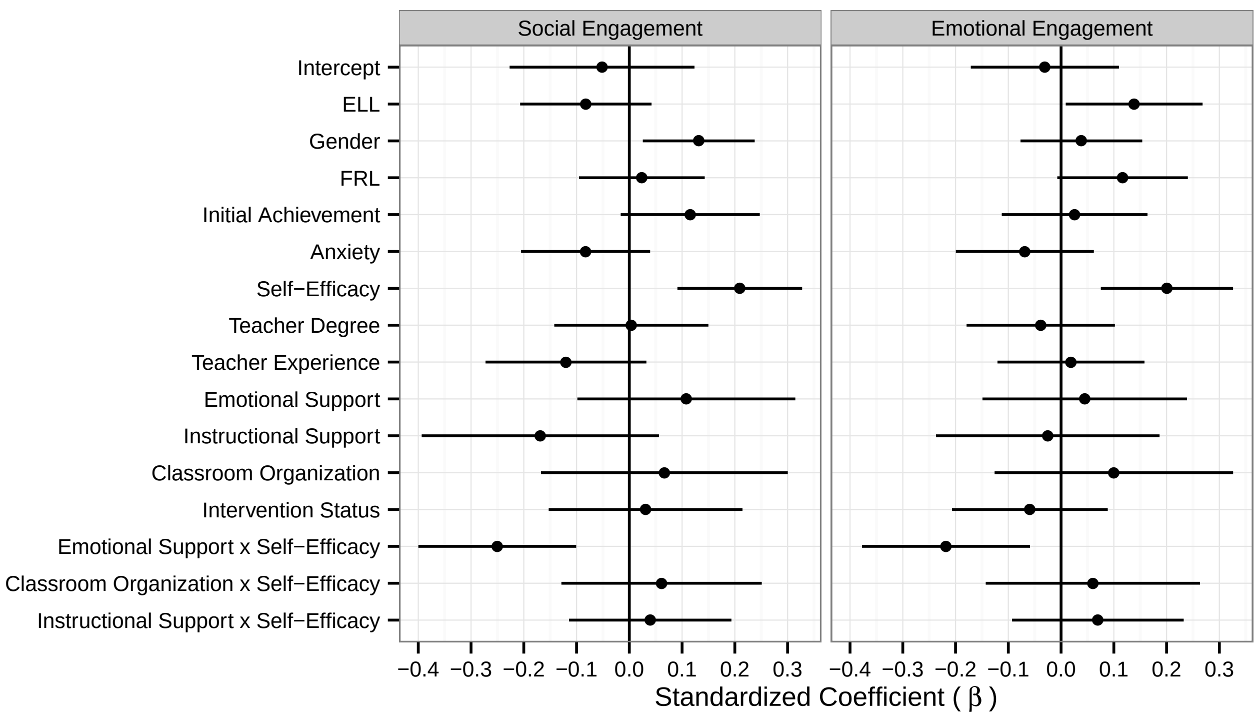

Figure 1. Fixed-effects results with 95% confidence intervals from the two final multi-level models with social engagement in math (left) and emotional engagement in math (right) as the outcome. Note that these estimates are standardized.

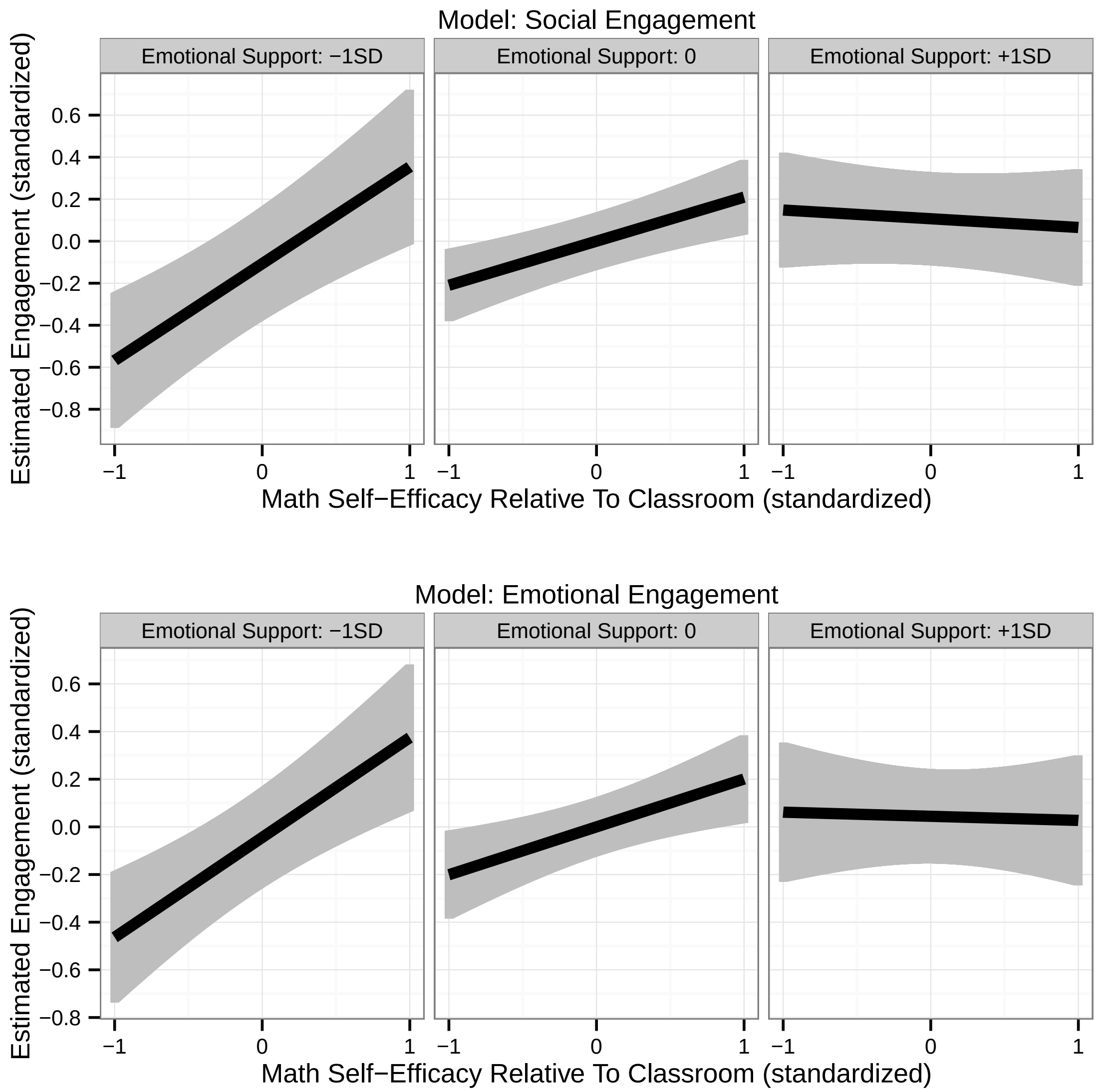

Figure 2. Plots of simple slopes to visualize the interaction between math self-efficacy and classroom emotional support with both student social engagement (on the top) and student emotional engagement (on bottom) in mathematics as the outcome. Here, emotional support is treated as the moderator. The gray intervals are standard errors, estimated via a multilevel non-parametric bootstrap procedure.