Determinants of student achievement at the school level:

A multilevel moderated mediation approach

Abstract

This study aims to improve our understanding of the indirect influence of principal support, direct influence of math teacher expectations, and moderating impact of school type on student math achievement at the school level. The study analyzed data taken from the U.S. High School Longitudinal Study of 2009, a nationally representative database with 25,210 grade nine students in 944 public high schools. Multilevel structural equation modeling techniques were used to test a conceptual model that seeks to identify the relationships among the effects of principal support, math teacher expectations, and school type on student math achievement in traditional high schools and charter schools. In this study, as a mediator, math teacher expectations at the group level was an important link between principal support and student math achievement at the school level. Our study also found that school type moderates the relationship between math teacher expectations and collective math achievement. Such findings have implications for raising teachers' expectations for students in traditional public schools and sustaining and expanding charter school type at the level of educational policy reform.

Keywords: principal support, teacher expectations, student math achievement, mediating and moderating effort, charter schools

As a key educational policy agenda, improving student academic achievement has been a critical indicator for school effectiveness and performance. For example, the No Child Left Behind Act has required all public schools to face increasing accountability for the improvement of student achievement (Lochmiller, 2015). Charter schools have also been undertaken to strengthen the accountability for student academic achievement and respective academic standards (Denice & Gross, 2016; Haynes, Phillips, & Goldring, 2010; Wohlstetter, Nayfack, & Mora-Flores, 2008). Policymakers often support sustaining and expanding charter schools with increasing pressure to achieve higher student performance, despite numerous controversies about their effectiveness (Judson, 2014; Kim, Kim, & Karimi, 2012). In this context, all principals and teachers of public schools practically and theoretically find themselves facing more increased pressure to improve student academic achievement.

In terms of schooling, student academic achievement is usually understood as a constellation of many factors, such as school climate and characteristics, teaching behaviors, and teacher beliefs (Ker, 2016; Reynolds, Sammons, De Fraine, Townsend, & Van Damme, 2011). As student academic achievement is an essential function of school performance, principals and teachers may prioritize this goal in different ways. For instance, principals engage in instructional leadership and management, which plays a key role in encouraging student learning and improving academic performance. A large body of research validates the importance of the supporting role that principals play in improving school performance and student academic achievement (Crum & Sherman, 2008; Gamage, 2009; Huff et al., 2011; O'Donnell &White, 2005; Robinson, Lioyd, & Rowe, 2008). In relation to the role of principals, principal support that conceptually integrates both transformational and instructional leadership is specifically noted in improving student achievement (Goddard, Neumerski, Goddard, Salloum, & Berebitsky,

2010; Ingels et al., 2011).

Teachers, in contrast, may improve student academic performance based on their own pedagogical beliefs, subject matter knowledge, goal setting for school performance, and teaching methods, all of which are closely linked with improving student achievement. A distinct factor of how teachers influence student academic performance is specifically through their educational expectations (Jussim & Eccles, 1992; Mistry, White, Benner, & Huynh, 2009; Muller, 1998; Smith, Jussim, & Eccles, 1999; Tyler & Boelter, 2008). Why teacher expectation of students is critically influential on student achievement is because it plays a key role in building the teacher-student relationship, which leads to changing student attitudes and behaviors including learning motivation (Woolley & Grogan-Kaylor, 2006).

On the other hand, it is practically noted that student achievement is comprehensively impacted by a number of complex and interrelated factors of both the principal and teachers in terms of schooling. Research highlights the indirect influence of principal leadership on student achievement through the support that she or he provides to teachers (Hallinger & Heck, 1996; Hallinger, 2005; Leithwood & Mascall, 2008; Louis, Dretzke, & Wahlstrom, 2009). In the process of a relationship with students, teacher perceptions at the group level lead to expectations of appropriate conduct that become ingrained in a school climate (Brault, Janosz, & Archambault, 2014; Rubie-Davies, 2007). This conduct can also be critically influenced by instructional support from a principal (Grojean, Resick, Dickson & Smith, 2004). This means that the effect of a principal and teachers on student achievement should be investigated with a structural concept model.

More specifically, in this study, we highlight that existing studies regarding the effect of principal and teachers on student achievement were limited at the following three angles. First, a

large body of research showed evidence that principal leadership and teacher expectations affect student achievement respectively. However, much less is known about how principals impact student academic achievement by affecting the psychological and behavioral factors of teachers. Hallinger and Heck (1996) argue that researchers need to examine mediating factors when investigating the influence of principals on student achievement. Second, teacher expectations of students are influenced by school climate and composition (Brault, Janosz, & Archambult, 2014). In order to raise teacher expectations, understanding school factors or school types influencing them is needed. Prior studies have reported the positive influence of charter schools on student academic performance (e.g., Betts & Tang, 2011; Cremata et al., 2013; Flaker, 2014; Dobbie & Fryer, 2009; Orfield, & Luce, 2016; Winters, 2012). Nevertheless, there is a paucity of empirical research that reports detailed information on whether the relation between teacher expectations and student achievement differently depends on school type (charter schools vs. traditional public schools). Third, in terms of methodological perspective, prior studies have simply aggregated individual teacher ratings of principal support or teacher expectations to create a school-level variable. Because principal support and teacher expectations are climate constructs rated by individual teachers within the same school, unbiased estimates of their influences on student achievement require controlling for measurement errors at both the individual teacher and school levels and for sampling error in the aggregation of individual teacher ratings. To address these research foci, using a multilevel structural equation modeling, we not only explore whether the effect of principal support on student math achievement will be mediated by math teacher expectations, but also explore whether math teacher expectations will affect student math achievement differently based upon school type (charter school vs. traditional public school).

Theoretical Framework

Relationship between Principal Support and Student Achievement

Contemporary school principals need to perform a stronger leading role than only managing, in order to improve their school and students' performance (Ubben & Hughes, 1992). For more than 30 years, principal leadership has been examined from different perspectives (Author, 2012). The two most salient themes have been transformational leadership and instructional leadership (Goddard et al., 2010; Marks & Printy, 2003; Robinson et al., 2008). In a school context, transformational leadership has the largest body of research (Kantabutra, 2005). This type is frequently referred to as vision-based leadership. Regarding the effect of instructional leadership, Darling-Hammond and colleagues (2007) indicate that the principal come to the forefront as the instructional leader responsible for improving all the students' achievement in a school. Author (2016) also argue that as an instructional leader, principals play various key roles, such as improving school effectiveness, developing teacher professionalism, or improving student achievement in their schools. Instructional leadership generally refers to the management and improvement of teaching and learning. In summary, principal transformational leadership is particularly important for school change and reform, whereas instructional leadership is considered to be the critical factor for improving school performance or student outcomes.

Research in the domain of school leadership, on the other hand, proposes an integrating perspective where transformational and instructional leadership are mutually supportive (Goddard et al., 2010; Marks & Printy, 2003; Printy, Marks, & Bowers, 2009; Robinson et al., 2008). This integrating perspective argues that, for principal leadership, transformational and instructional leadership should not be considered separately from each other. Indeed, integrating

instructional and transformational leadership, rather than choosing between these leadership roles, emphasizes the importance of cooperation between principals and teachers for improving instruction (Goddard et al., 2010). In terms of practice, Goddard et al. (2010) designed and applied a measure of principal instructional support that draws on both constructs. In the same line, the High School Longitudinal Study of 2009 (Ingels et al., 2011) also used and measured the concept of principal support, which focuses on integrating both instructional leadership and transformational leadership. This concept of principal support that integrates instructional and transformational leadership is also used in our current study.

As a school leader, the principal needs to engage in direct coordination, control, and supervision of curriculum and instruction in order to define the school mission and goals that will impact instructional practice and student performance, as well as facilitate a learning culture. It is natural that the quality of principal leadership and support significantly influences student academic achievement (Crum & Sherman, 2008; Hallinger & Heck, 1996; Huff et al., 2011; Nettles & Petscher, 2006; O'Donnell &White, 2005). Therefore, the predominant school-based factor with the capacity to improve student performance can be the principal's supporting behavior. Research has also identified that principals' instructional support plays an essential role in facilitating the use of specific techniques, such as teachers' use of differentiated instruction (Carolan & Guinn, 2007; Supovitz, Sirinides & May, 2010), which is critical to effectively meet the various learning needs of students.

A principal's influence on student achievement, however, is indirect and mostly through instructional support provided to teachers (Heck & Hallinger, 2009; Leithwood & Mascall 2008; Louis et al., 2009). For example, principals contribute to improving student academic achievement by affecting teaching practices (Leithwood, Louis, Anderson, & Wahlstrom, 2004)

or facilitating a learning culture (Hallinger & Heck, 1996). In the same line, Leithwood et al. (2004) argued that the principal leadership role is second only to teacher instruction among schooling determinants with the capacity to improve student academic achievement. Larsen and colleagues (2015) also found that the quality of teacher-student interaction has a direct influence on student math achievement, whereas principal leadership has an indirect influence on student math achievement via teacher-student interaction quality. Given these research findings, it is clear that principals who aim to improve student achievement need to employ higher quality support in their school contexts.

Positive Role of Teacher Expectations for Student Achievement

A critical factor influencing student academic performance is teacher expectations (Mistry et al., 2009; Muller, 1998; Tyler & Boelter, 2008). Teacher expectations are conceptually distinct between the individual and group level (Brault et al., 2014). In the case of the expectation at the individual level, teachers take their expectations of a specific student, which focus on building a dyadic relationship between a teacher and student, whereas teacher expectations at the group level target forming expectations for many students, specific subjects, or school population. Group-level expectations play a comparative benchmark for teacher expectations of a specific student (Kornblau, 1982). Brault et al. (2014) also argue that group-level expectations may have greater influence than individual-level expectations. For example, Smith et al. (1999) found that middle school teacher expectations influence high student performance such as standardized test scores and enrollment in math courses. Muller, Katz, and Dance (1999) also identified the function of teacher expectations as the strongest predictor of student expectation to go on to college. In particular, Muller (1998) reported that in the case of mathematics achievement, “teachers’ expectations were a more important predictor of learning gains and proficiency than

were students' expectations" (p. 199). In this study, therefore, we focus on examining the effect of math teacher expectations at the group level.

While principal support has a fairly straightforward relationship to teacher educational expectations, the operation of teacher expectations to improve student academic achievement is more complex. Because students, specifically during adolescence, are sensitive to their teachers' behaviors and attitudes in school, they react to meet their teachers' expectations. If students obtain the approval of teachers in their reactions, teacher expectations and approval create self-confidence in students which in turn motivates them to persist in their efforts to improve their academic achievement (Hallinan, 2008). Based on their reactions to meet high teacher expectations, students are likely to have an effect on their attitudes toward learning (Mulford & Silins, 2003). As a result, when students meet their teachers' high expectations, they experience greater academic achievement. This argument supports the view that teacher expectations may have a significantly positive influence on student academic achievement. Furthermore, Muller (1998) identified teacher expectations as functioning as a more critical predictor in increasing student academic performance specifically in math than did the students' own expectations.

Two theoretical perspectives explain the effectiveness of teacher expectations in raising student academic achievement. First, the influence of teacher expectations on student academic performance, specifically math achievement, is theoretically supported by the principle of a teacher's self-fulfilling prophecies (Jussim & Harber, 2005; Mistry et al., 2009; Smith et al., 1999). For example, students attain better academic achievement when they are cognizant that their teacher thinks they can succeed in school (Voelkl & Frone, 2000). Wolley et al. (2010) also found that "when students think that their teacher believes that they can successfully learn mathematics, they would show higher levels of confidence in their abilities and interests in

mathematics, and in turn show greater achievement in mathematics" (p. 45). Using teacher-expectancy theory, Wiggan (2007) highlights how teacher expectations have important implications for student achievement. Specifically, teacher expectations are critical to teacher-student efforts in schooling and thus determine student academic achievement. Second, in terms of social psychology, the influence of teacher expectations on student academic achievement in schools is also supported by the ecological theory of Bronfenbrenner (Mistry et al., 2009). According to ecological perspectives, ecological systems adjacent to a person and the socializing agents within the systems critically affect human development. On the basis of ecological perspectives, for students, school is one of most proximate systems, and teachers play the role of a socializing agent in their developmental outcomes (Vandell, 2000; Wentzel, 2002).

Indeed, many studies have reported that teacher expectations focusing on student performance and instructional practices have direct effects on student math outcomes (e.g., Tyler & Boelter, 2008; Wolley et al., 2010). Jussim and Harber (2005) demonstrated that teacher expectations have a somewhat greater impact on student achievement test scores. Improvement of math outcomes linked with teacher expectations is usually explained through the mediation of learning motivation (Turner, Meyer, Midgley, & Patrick, 2003). In this study, we hypothesize that teachers with high expectations for student math performance and high achievement standards lead to more adaptive motivational patterns for students, which in turn contributes to building better math achievement.

Influence of Principal Support on Teacher Expectations

School leadership can be understood as a process whereby the principal influences faculty members to achieve a school goal (Northouse, 2004). Today, principals are expected to exhibit many different types of leadership such as visionary, instructional, and managerial (Copland,

2001). In particular, because the foci of a principal's role for instructional support are on motivating and inspiring teachers by impacting instructional practice (Quinn, 2002) and supervising teachers through coordinating and controlling curriculum and instruction (Bamburg & Andrews, 1990; Blasé & Blasé, 1999), their instructional support critically influences teacher perceptions. This leads to expectations of appropriate conduct becoming ingrained in a school climate (Grojean, Resick, Dickson & Smith, 2004).

As long as principals play a key role as a change agent to improve the quality of teaching and learning in their schools, their supporting work affects the educational value and philosophy of teachers (Fullan & Stiegelbauer, 1991; Huff et al., 2011). In this respect, it is essential that on the basis of her or his instructional leadership behaviors, a principal's support positively impacts the expectations that teachers hold for their instruction and student academic achievement. Increasing information about how school principals have an impact on teaching practices and educational expectations allows us to have a better understanding of how principal support influences student achievement (Wahlstrom, & Louis, 2008).

School Type as a Moderator between Teacher Expectations and Student Achievement

Regarding the effect of school type, traditional public schools are often compared to charter schools. A large body of the studies on charter schools has been conducted to confirm their more positive influence on student achievement, particularly in comparison to traditional public schools (e.g., Betts & Tang, 2011; Cremata et al., 2013; Dobbie & Fryer, 2009; Flaker, 2014; Hoxby, Murarka, & Kang, 2009; McDonald, Ross, Bol, & McSparrin-Gallagher, 2007; Orfield & Luce, 2016; Winters, 2012). However, some studies reported that students did not perform better in charter schools than in traditional public schools (e.g., Betts & Tang, 2011; Braun, Jenkins, & Grigg, 2006; Lubienski & Lubienski, 2006). Therefore, evidence is unclear regarding the effect

of charter schools on student achievement (Bifulco, Cobb, & Bell, 2009; Judson, 2014). As a result, how charter schools help better improve student academic achievement than traditional public schools is still a research issue to be examined.

In this vein, as one of the hypotheses set in the present study, we assume that based on school type, math teacher expectations will have a different influence on student math achievement. Regarding the different influence of math teacher expectations on student math achievement, we focus on identifying the organizational context of charter schools and the climate that contributes to establishing educational benefits for teachers and their students. Above all, charter schools are generally based on a unique system with regard to student enrollment that makes their teachers face increased pressure toward high performance. While traditional public schools have student enrollments linked to specific neighborhood attendance areas, charter schools operate student enrollment based on a parental choice that allows parents to choose their children's schools (see the elucidation by Lauen, 2009; McDonald et al., 2007; Wohlstetter et al., 2008). Specifically, as sustaining the status of charter schools depends on high school performance, teachers in charter schools face increased pressure to achieve school success, including high student achievement compared to teachers in traditional public schools (Wohlstetter et al., 2008). This increased pressure may affect the relationship between teacher expectations (e.g., in relation to setting or arranging more challenging academic standards, student-based norms, or forms of creative instructions) and student achievement.

In addition, a substantial body of research argues that charter schools help teachers retain more autonomy because they require performance-based accountability (Archer, 2000; Crawford, 2001; Oberfield, 2016). Gawlik (2007) demonstrated that charter schools with more autonomy are better equipped to meet the needs of their students, which in turn leads to

improvement in student achievement. At the theoretical level, the public financing of private education encourages school autonomy and school autonomy plays a key role in improving student learning outcomes and academic performance (Flaker, 2014). Because the status of charter schools demands greater accountability and autonomy at the level of the teacher, the staff in charter schools have greater autonomy related to their professional work, such as developing curricular themes or instructional methods, compared to teachers in traditional public schools (Oberfield, 2016). Given the fact that greater professional autonomy is associated with higher teaching quality (Gawlik, 2007), teacher expectations in charter schools can be more closely linked to student achievement in terms of the level of quality compared to teacher expectations in traditional public schools.

Based on the organizational context and climate of charter schools mentioned earlier, teacher expectations about schooling call for the design of innovative classroom programs and effective teaching practices to enable students to meet challenging academic standards. This aspect may influence teacher expectations regarding student academic achievement, particularly math achievement in charter schools, which may be greater than that of teacher expectations in traditional public schools. In this respect, we hypothesize that school type (charter school vs. traditional public school) plays a moderating role in the influence of teacher expectations on student achievement.

The Present Study

The purpose of the present study was to test both the mediating effect of math teacher expectations between principal support and student math achievement and the moderating effect of school type (charter school vs. traditional public school) on the relation between math teacher expectation and student math achievement at the school level by using multilevel structural

equation modeling (MSEM; see Marsh et al., 2012). Thus, the following three research hypotheses, which were set on the base of theoretical framework and existing studies, were tested in the present study:

1. *Research Hypothesis 1:* Principal support will have an indirect and positive influence on student math achievement through math teacher expectations at the school level (Model 1).
2. *Research Hypothesis 2:* School type (charter school vs. traditional public school) will play a moderating role on the relation between math teacher expectation and student math achievement at the school level (Model 2).
3. *Research Hypothesis 3:* The mediating effect of math teacher expectations and the moderating effect of school remains even after controlling for other variables including socioeconomic status, gender, minority status, and English as a primary language, school type, percentage of students receiving a free lunch, and math teacher ratio (Model 3).

In this study, we analyzed the math achievement of particularly students and math teacher expectations because math teacher support and expectations are especially important to improve student achievement in math courses (Kelly & Zhang, 2016), and many students have achievement anxiety in math (Wigfield & Meece, 1988). Above all, because our study identified the effect of principal support via teacher expectations and the moderating effect of school type on student achievement by testing a conceptual model, it differs from previous work that had only examined the influence of principal leadership, teacher expectations, and school type separately on student achievement.

Method

Data

The data for this study were from the U.S. High School Longitudinal Study of 2009 (HSLS: 09), a nationally representative database with a sample size of about 25,206 grade 9 students from 944 high schools. The HSLS:09 database consists of different types of sources including students, parents, teachers, counselors, and principals. Using a two-stage stratified random sampling procedure (i.e., schools were first selected and then students were randomly selected within the schools), a total of 944 high schools including public (charter) schools and private schools were initially selected (Ingels et al., 2011). Next, grade 9 students who attended traditional high schools in the 2009 fall term were randomly sampled from school enrollment rosters (about 27 students per school). The average number of students per school was 22.93. In this dataset, the sampled schools also identified the math teachers and courses. Math teacher participants linked to students sampled for the HSLS:09 base-year study were selected and asked to complete a teacher questionnaire. If students were assigned to multiple mathematics courses, one teacher was randomly chosen for the survey.

Since the focus of our study is on examining the degree of principal support and expectations indicated by math teachers and student math achievement, as well as the moderating role of school type (traditional public schools vs. charter schools), both school and individual students were the primary units of analysis. To determine our analytical sample size, we first excluded all cases with missing values on principal support, teacher expectations, math achievement and school type. Next, we used full information maximum likelihood estimation to treat missing values on select covariates (Enders, 2010). The resulting sample size was 15,629 students from 651 schools.

Variables and Measures

Dependent variable. We used student math achievement in schools from the HSLS:09 as the dependent variable in this study. In the case of student math achievement collected in the HSLS:09, all students took an assessment in algebraic reasoning that encompasses six domains of algebraic content and four algebraic processes in Fall 2009 (Ingels et al., 2011). The item response theory (IRT) based test scores used information from students' item response patterns and assessment item information to calculate a student ability estimate in mathematics. We used the math standardized theta score, which is the standardization of the IRT theta estimate (M = 50 and SD = 10) as the math achievement score in this study. The IRT-estimated reliability of the mathematics assessment was 0.92 (Ingels et al., 2011).

Principal support as an independent variable. We used the data from the teacher survey to identify principal support in the HSLS:09. The variable for principal support was a continuous measure of the extent to which a principal supports teachers in a school. The principal support used in this study was defined as a theoretical concept that integrates both principal instructional leadership and transformational leadership (Goddard et al., 2010). In the HSLS:09, the degree of principal support was measured by how much each math teacher agrees with 7 items (e.g., "School's principal deals with outside pressures interfering with teaching," "School's principal sets priorities and sees that they are carried out," "School's principal communicates kind of school that is wanted to staff," and "School's principal is interested in innovation and new ideas"). Each item consists of a 4 point Likert scale (1= strongly agree, 2= agree, 3= disagree, and 4= strongly disagree). The results of a multilevel confirmatory factor analysis with a unidimensional factor indicated that both the within- and between-level composite reliabilities were high (within-level ω = .868, between-level ω = .925).

Teacher expectations as a mediating variable. We included teacher expectations surveyed by the HSLS:09, which was a mediating variable in this study. Teacher expectations captured the degree to which each math teacher evaluates high school math teachers' expectations (e.g., about high standards for teaching, high standards for student learning, and working hard to make sure all students are learning) at the school (Ingels et al., 2011). More specifically, teacher expectations as a continuous variable at the group level were measured by the extent to which each math teacher agrees or disagrees with eight statements (e.g., "Math teachers in this school set high standards for teaching," "Math teachers in the school set high standards for students' learning," "Math teachers in this school believe all students can do well, and "Math teachers in this school make goals clear to students"). Each statement consists of a 4 point Likert scale (1= strongly agree, 2= agree, 3= disagree, and 4= strongly disagree). The results of a multilevel confirmatory factor analysis with a unidimensional factor indicated that while the within-composite reliability was moderate ($\omega = .796$), the between-level composite reliability was high ($\omega = .881$).

School type as a moderating variable. The school type variable included a traditional public high school and a charter school. These two school types sampled by the HSLS:09 were classified in the same category as a public school. However, we coded school type as a dichotomous variable indicating a charter school (one) or not (zero).

Control variables. In this study, the following variables were considered as control variables because they influence student achievement (e.g., Altschul, 2012; Goddard, Goddard, Kim, & Miller, 2015; Robinson-Cimpian, Lubienski, Ganley, & Copur-Gencturk, 2014). At the student level, *Gender*, a dichotomous variable, was coded indicating whether a student was female (one) or not (zero). A student's socioeconomic status (SES) was controlled by her or his math

achievement. In the HSLS:09, the survey developers created a SES variable as a composite of five components obtained from the parent/guardian questionnaire: (a) the highest education among parents/guardians of the responding student, (b) education level of the other parent/guardian in the two-parent family, (c) highest occupation prestige score among the parents/guardians, (d) occupation prestige score of the other parent/guardian of the two-parents, and (e) family income (Ingels et al., 2011). English as the primary language and minority status were each coded as binary variables. In addition, as control variables at the school level (e.g., Goddard et al., 2015), the percentage of students with free lunch, math teacher ratio, and ratio of the total number of math teachers to the total number of teachers, were specifically included.

Analytical Model

We employed a multilevel structural equation model (MSEM) using a robust maximum likelihood estimator in M*plus* Version 7.4 to examine whether the school-level components of teacher expectations mediates the school-level effect of principal support on the school-level component of math achievement and whether the effect of school-level teacher expectations on school-level math achievement is moderated by school type. MSEM has some advantages over conventional multilevel modeling in that it allows for the use of latent variables to account for measurement errors, a model-based approach to group-mean centering, and simultaneous examination of a theoretically different model for both the relationships among the within-level components and the relationships among the between-level components (Lüdtke, Marsh, Robitzsch, Trautwein, Asparouhov, & Muthén, 2008; Muthén & Satorra, 2008; Preacher, Zyphur, & Zhang, 2010). Moreover, the multilevel indirect effect in the model containing at least one variable measured at the between-level can be estimated with precision in the MSEM framework. MSEM further allows us to estimate both the level-specific moderation effects (i.e.,

either between- and between-level or within- and within-level interactions) and cross-level moderation effects (i.e., between- and within-level interactions) as well as the multilevel moderated mediation effects (Preacher, Zhang, & Zyphur, 2016).

Using Preacher et al.'s (2010) diagram convention, we hypothesized our MSEM as shown in Figure 1. The squares represent the observed variables, while the ovals represent the latent variables. We used multiple observable indicators to represent the school-level constructs of principal support and teacher expectations at both the student- and school-levels. Both student- and school-level math achievements were directly assessed by the student math achievement score. At the student level, we specified that the student math achievement score is only related to the control variables including gender, minority status, and socioeconomic status (SES). Both principal support and teacher expectations are climate constructs evaluated by math teachers within the same school, which are considered to be shared perceptions of teacher expectations and principal support among math teachers within the same school (see Marsh et al., 2012). Thus, we specified that these only covary with each other rather than being related to student math achievement at the student level. At the school level, we specified that student math achievement is related to principal support, teacher expectations, school type, and the interaction of school type with teacher expectations. Teacher expectations as a mediating construct was regressed on principal support. We used a latent moderated structural equation approach (Preacher et al., 2016) to specify the moderating effect of school type on school math achievement by regressing student math achievement on the latent product of teacher expectations with school type. Control variables including math teacher ratios and the percentage of those receiving a free lunch were also regressed on student math achievement.

Data Analysis Procedures

Data from HSLS:09 have a hierarchical structure (i.e., students nested within a school) developed using a complex sampling design. Ignoring the complex nature of the sample design leads to negatively biased estimates of the standard errors associated with the model coefficients (Asparouhov, 2005; Stapleton, 2006). Therefore, the use of multilevel modeling along with accommodation of survey design components, such as sampling weights and strata, is essential to estimate model parameters appropriately and to account for the dependence among the observations. The plausibility of our hypothesized multilevel model was evaluated based on a stepwise sequence: (a) examination of the descriptive statistics, (b) examination of the intraclass correlation coefficient (ICC) of each variable, (c) multilevel confirmatory factor analysis (CFA) model, (d) partially saturated CFA model, in which the saturated model is either at the student or school level, and (e) hypothesized model at both levels.

The overall model fit for the hypothesized model was assessed using the following four fit indices: standardized root mean square residual (SRMR), root mean square error of approximation (RMSEA), Tucker-Lewis index (TLI), and comparative fit index (CFI). We followed the recommended cutoff criteria from Hu and Bentler (1999) for evaluating a good model fit: SRMR below .08, RMSEA below .06, and TLI and CFI greater than .95. We also used level-specific fit indices such as CFI and RMSEA for model evaluation to identify whether the lack of a model fit was due to either the student- or the school-level model (see Ryu, 2014). Because of the use of a numerical integration algorithm for testing the interaction effect involving latent variables does not provide the four fit indices, we only reported relative model fit indices such as the Akaike Information Criterion (AIC), the Bayesian Information Criterion (BIC), and sample-size adjusted Bayesian Information Criterion (ABIC) in the model containing

an interaction term.

Results

Descriptive Statistics

Means or proportions and standard deviations for math achievement, teacher expectations, principal support and covariates are presented in Table 1. No substantial mean or proportion differences between the charter and general schools, except for the percentage of free lunch students, were found. On average, approximately 51% of students in charter schools received a free lunch, whereas about 40 % of students in general schools received a free lunch. Table 2 presents univariate skewness and kurtosis, and inter-correlations between math achievement, teacher expectations, principal support and select covariates. The absolute values of skewness and the kurtoses of the continuous variables ranged from .048 to .479 and from .086 to 1.876, respectively, indicating that the univariate normality assumption was deemed to be tenable. Math achievement was not significantly related to other variables at the student level. However, math achievement was positively correlated with teacher expectations and math teacher ratio at the school level. High correlations were evident between math achievement and the percentage of students receiving a free lunch at the school level. Socioeconomic status was significantly associated with minority status and English as the primary language. As expected, English as the primary language was negatively related to minority status. Teacher expectations correlated positively to principal support (r = .445), and both levels were associated negatively with the percentage of students receiving a free lunch at the school level.

To determine the plausibility of the hypothesized MSEM, we calculated the values of the ICCs for the variables being modeled at both levels. The estimated ICC for math achievement was .180, indicating that there was about 18 % variability in the math achievement difference

between schools. The estimated ICCs for teacher expectations and principal support ranged from .355 to .440 (M = .398, Mdn = .395, SD = .025) and .426 to .504 (M = .466, Mdn = .476, SD = .027), respectively, indicating that a large amount of variability in both teacher expectations and principal support occurs between schools modeled at the school level.

Multilevel Measurement Model

Before testing our model, we first evaluated whether the multilevel CFA model (i.e., math achievement, teacher expectations, and principal support correlated at both levels) fits the data well. The overall fit indices for the multilevel CFA model with correlated residuals specified between the two indicators of teacher expectations (i.e., TE1 and TE2) at the student level, suggested that the hypothesized model fits the data well, $\chi^2(203, N=15{,}629) = 902.875$, $p < .001$; RMSEA =.015; CFI=.949; TLI=.940; $SRMR_W$=.033; $SRMR_B$=.048. All standardized factor loadings of principal support were statistically significant, ranging from .510 to .792 at the student level and from .702 to .880 at the school level (see Table 3). The proportion of the observed variability in the principal support indicators explained by the student- and school-level factors ranged from 26% to 62.7% and from 49.3% to 77.4%, respectively. All the standardized factor loadings of teacher expectations were also significant ranging from .487 to .661 at the student level and from .460 to .909 at the school level. The proportion of the observed variability in the teacher expectation indicators explained by the student- and school-level factors ranged from 23.7% to 43.7% and from 21.2% to 82.7%, respectively.

To better determine whether a model misfit occurs from either the school-level or student-level model, we used a partially saturated model approach (Ryu & West, 2009). The overall fit indices for the saturated school-level model suggested that the student-level measurement model fits the data well, $\chi^2(101, N=15{,}629) = 474.618$, $p < .001$; RMSEA =.015; CFI=.973; TLI=.935;

SRMR=.033. In addition, the overall fit indices for the saturated student-level model suggested that the school-level measurement model fits the data well, $\chi^2(102, N=15{,}629) = 284.567$, $p < .001$; RMSEA =.011; CFI=.987; TLI=.969; SRMR=.047. This indicated that the underlying factors significantly account for the substantial relationships among the factor indicators at both levels.

Multilevel Structural Equation Model

To examine the mediating role of teacher expectations, we specified random intercepts and fixed slopes in MSEM (Model 1; see Figure 2). The overall fit indices strongly suggest that the hypothesized model fits the data well, $\chi^2(203, N=15{,}629) = 902.875$, $p < .001$; RMSEA =.015; CFI=.949; TLI=.940; $SRMR_W$=.032; $SRMR_B$=.048. The effect of principal support on teacher expectations was statistically significant (0.247), indicating that higher principal support was associated with higher teacher expectations. In addition, teacher expectations were positively associated with student math achievement (4.038). Although the effect of principal support was not significantly associated with collective math achievement, the indirect effect of principal support on school math achievement via teacher expectations was statistically significant with an indirect effect of 0.998, 90% CI [0.535, 1.462]. This means that teachers who perceive higher principal support are more likely to have higher teacher expectations, and this in turn mediated the effect of principal support on student math achievement.

To test the interaction effect of school type on math achievement (Model 2), school type and the latent product of teacher expectations with school type were introduced to school level in Model 1 (see Figure 3). Because there was no statistically significant relationship between principal support and collective math achievement in Model 1, we deleted a path from principal support to collective math achievement in Model 2. Values of information criteria such as AIC,

BIC, and ABIC for Model 2 were 350313.464, 350864.760, and 350635.949, respectively. School type was significantly associated with school math achievement (2.879), indicating that charter schools tend to have a higher math achievement score compared to general high schools. In addition, school type significantly moderated the relationship between teacher expectations and student math achievement (10.111), suggesting that charter schools contributed to an increased impact of teacher expectations on student math achievement. We further examined whether the mediating role of teacher expectations in the relationship between principal support and student math achievement is different for charter schools versus general schools. We found that the conditional indirect effect of principal support on student math achievement through teacher expectations for charter schools was significantly higher than that for traditional high schools (a moderated mediation effect of 3.412, 90% CI [1.551, 5.273] for charter schools and a moderated mediation effect of 0.864, 90% CI [0.495, 1.233] for traditional high schools).

To test whether a significant moderated mediation effect holds after controlling for select covariates (Model 3), we introduced socioeconomic status, gender, minority status, and English as a primary language to student level, and regressed school type, percentage of students receiving a free lunch, and math teacher ratio on math achievement at the school level (see Figure 4). Values of information criteria such as AIC, BIC, and ABIC for Model 3 were 428865.328, 429631.016, and 429313.224, respectively. All covariates except for gender were significantly associated with math achievement at both levels. At the student level, the significant effect of socioeconomic status indicated that a one-unit increase in socioeconomic status was associated with a 4.677-unit increase in math achievement. Moreover, a level of socioeconomic status one standard deviation above the mean was associated with math achievement of about .370 standard deviations above the mean, controlling for other covariates on math

achievement. The significant effect of minority status indicated that on average, minority students had a 1.599 lower math achievement score than White students. The percentage of free lunch (-.059) and math teacher ratio (13.601) were significantly associated with math achievement. After controlling for other covariates, school type continued to significantly moderate the relationship between teacher expectations and math achievement (a moderated mediation effect of 1.964, 90% CI [0.793, 3.136] for charter schools and a moderated mediation effect of 0.301, 90% CI [0.126, 0.475] for traditional high schools).

Discussion

As long as student achievement is critically counted toward school performance, it is essential that principals and teachers be accountable to improve it. Research highlights the importance of the role of strong principal leadership and teacher instruction and high expectations as critical factors for school success, specifically high student performance (Desimone, 2002; McDonald et al., 2007; Stringfield & Yakimowski-Srebnick, 2005). In this vein, we focused on exploring the effect of both principal support and teacher expectations on school-based factors as having the capacity to improve student achievement. We specifically examined whether principal support and teacher expectations as school climate constructs as well as charter school type contribute to the prediction of student math achievement by applying MSEM.

Our study's finding that math teacher expectations have a positive influence on student math achievement in school is in line with existing studies (e.g., Muller, 1998; Smith et al., 1999; Tyler & Boelter, 2008). As argued by Wiggan (2007), this finding shows that teacher expectations are important for teacher-student efforts and have particularly important implications for student achievement in school. This result implicates that teacher perceptions

and attitudes regarding student performance may affect the quality of teaching and learning at the school (Schroth & Heifer, 2009). In our study, the influence of math teacher expectations on student math achievement was analyzed at the school level. In terms of a theoretical perspective, the effect of math teacher expectations on student math achievement in school is appropriately supported by Bronfenbrenner's ecological perspective (Mistry et al., 2009; Vandell, 2000; Wentzel, 2002) in which school is one of the most proximate systems and teachers also play an important role as a socializing agent for the development of student achievement. In more detail, Mistry et al. (2009) argue that ecological perspectives drawn on macro theories do not necessarily specify concrete mechanisms by which teachers affect students' developmental performance.

As another focal point in our study, we found that the effect of math teacher expectations on student math achievement in schools is moderated by school type (charter school vs. traditional public school). In regard to discussing the implications of the effect moderated by school type, it is critical to refer to the theoretical and practical aspects of charter schools. We earlier addressed that charter school's context (i.e., increased organizational pressure by operating student enrollment based on parental choice) and climate might affect teacher expectations. Given the effect moderated by school type in this study, we can conclude that a charter school's organizational context and climate may create a qualitatively greater impact on the relationship between teacher expectations and student math achievement compared to those of traditional public schools. In this light, our finding supports the view that math teacher expectations in charter schools would be more closely linked to student math achievement due to the increased pressure resulting from the enrollment system. This finding is well supported by the arguments of Brighouse and Schouten (2014) about *high-commitment charter schools*. This

type of charter school demands that their teachers engage in longer working hours than teachers in traditional public schools to make an effort to find successful evidence of their students' achievements and to monitor the individual progress of each student. High-commitment charter schools also require their students to engage in excellent behavior and devote more time to schoolwork.

Many school districts across the country have adopted some form of school choice through opening charter schools (Betts, Rice, Zau, Tang, & Koedel, 2006). Although studies have reported that some charter schools have had a negative effect on student achievement (e.g., Braun, Jenkins, & Grigg, 2006; Lubienski & Lubienski, 2006; Zimmer et al., 2009), our current study found that the influence of math teacher expectations on student math achievement in charter schools is greater than that of math teachers' expectations in traditional public high schools. This finding provides a more critical aspect of knowledge building in the domain of the influence of teacher expectations on student achievement, which is different between charter schools and traditional public schools.

Implications and Conclusion

As a limitation of this study, our work relies only on student math achievement, math teacher expectations, and a small number of charter schools. This limitation suggests that there is a strong need for further studies by examining the relationships between the expectations of other subject teachers and student achievements or a lager sample size of charter schools. Even so, the results of our work provide an important insight that the impact of principal support on student achievement at the school level is indirect and fully mediated by teacher expectations, one that is also larger in charter schools than traditional high schools.

The results of our study have several implications for educational policy and practice as

well as a methodological issue to assess the influence of the variables of school climate on student achievement. First, the results of our study have methodological implications to create appropriate estimations of latent school climate constructs (principal support and teacher expectations). As advocated by Marsh et al. (2012), we applied MSEM to appropriately estimate the effect of principal support and teacher expectation, the variables aggregated by individual math teacher ratings in the same school. Estimating and interpreting the effect of these two variables on student math achievement in our study was conducted by controlling for measurement errors at both the individual teacher and school levels, as well as the sampling error in the aggregation of individual teacher ratings to form a school level's climate variable. In this respect, our study extends many existing studies which have only applied structural equational modeling of a single level for controlling for measurement error, or multilevel modeling (or hierarchical linear modeling) used to control for sampling error and to decompose the effects at the level of the individual teacher and school.

Second, the mediating effect found by our study shows that increased information about how school principals have an impact on teacher expectations allows for a better understanding of how their supporting behaviors influence student achievement (Wahlstrom & Louis, 2008). The mediating effect of teacher expectations in the relationship between principal support and student achievement means that principals should be prepared for the responsibility of their principalship, including instructional support and setting the school mission and goals of impacting instructional practice (Gamage, 2009; Huff et al., 2011), which may be closely linked to building teachers' educational expectations for students. In this respect, we suggest that principals need to focus on exercising both transformational and instructional leadership behaviors to encourage and inspire their teachers to improve student achievement.

Third, our research empirically supports the view that teacher expectations in concert with principal support play a strong predictor of student achievement in schools. Low expectations of teachers are generally transferred to lower achievement of students (Good & Brophy, 1997) because teachers with lower expectations may teach and require less of students than is needed to achieve schooling goals. In this respect, we suggest that all schools, particularly traditional public schools, need to raise their teachers' expectations for students. As a strategy to raise teacher expectations for students, Muller (1998) indicates that schools need to consolidate external assessments focusing on changing incentives for teachers and students to work together and campaigns to promote positive attitudes for teachers. We also highlight that teachers need to set higher expectations for academic performance. By meeting teacher expectations, students may try harder to make greater efforts to obtain approval from their teachers, which in turn increases confidence and motivation in learning, resulting in higher academic achievement (Hallinan, 2008; Mulford & Silins, 2003).

Finally, our study found that school type (charter school vs. traditional public school) moderates the influence of math teacher expectations on student math achievement. In our study, the effect of math teacher expectations on student math achievement in charter schools was greater than that of math teacher expectations in traditional public schools. This finding demonstrates evidence that charter schools have a distinct effectiveness with regard to the influence of teacher expectations on student achievement compared to traditional public high schools. In terms of educational practices, this result provides a positive evidence to sustain and expand the charter school type at the level of educational policy reform.

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Table 1

Means or Proportions and Standard Deviations of Variables

Variable	Charter (n = 441)		Traditional (n = 15,188)		All participants (n = 15,629)	
	Estimated mean[a]	SD	Estimated mean[a]	SD	Estimated mean[a]	SD
Student-level factors						
Math achievement	50.689	8.418	50.060	9.041	50.045	9.049
Teacher expectations	3.489	.316	3.358	.324	3.361	0.325
Principal support	3.374	.309	3.123	.394	3.123	0.391
Socioeconomic status	-0.105	.781	-0.075	.727	-0.078	0.729
Gender[b]	0.536	.498	0.489	.500	0.489	0.500
Minority[c]	0.330	.470	0.207	.404	0.219	0.413
English language[d]	0.144	.351	0.090	.286	0.092	0.288
School-level factors						
Math achievement	50.503	6.357	49.944	4.051	50.138	4.245
Teacher expectations	3.341	.389	3.343	.290	3.340	0.296
Principal support	3.288	.382	3.101	.405	3.097	0.406
Free lunch ratio	50.882	23.064	39.719	22.3264	40.162	22.613
Math teacher ratio	.123	.055	0.129	.032	0.129	0.032
School type[e]	—	—	—	—	0.025	0.158

Note. $N_{Charter}$ = 35; $N_{Traditional}$ = 616.

[a]Proportion of variables for gender, majority, English as the primary language, free lunch ratio, math teacher ratio and school type. [b]Male is reference. [c]White is reference. [d]English as the primary language is reference. [e]Charter school is reference.

Table 2

Correlation Coefficients and Univariate Skewness and Kurtosis for All Variables

Variable	1	2	3	4	5	6	7
Student level (n = 15,629)							
1. Math achievement	1.000						
2. Teacher expectations	-.006	1.000					
3. Principal support	-.024	.285**	1.000				
4. Socioeconomic status	.390	.012	.007	1.000			
5. Gender[a]	.015	-.009	-.015	.001	1.000		
6. Minority[b]	-.132	-.015	-.001	-.147**	.009	1.000	
7. English language[c]	-.062	.011	-.003	-.190**	.000	-.148**	1.000
Skewness	-.048	-.479	-.446	.414	—	—	—
Kurtosis	-.167	.086	.404	.121	—	—	—
School level (n = 651)							
1. Math achievement	1.000						
2. Teacher expectations	.296**	1.000					
3. Principal support	.046	.363**	1.000				
4. Free lunch ratio	-.716**	-.235**	-.024	1.000			
5. Math teacher ratio	.104*	-.024	.092*	-.028	1.000		
6. School type[d]	.023	.021	.098*	.076	-.030	1.000	
Skewness	—	—	—	.377	-.246	—	
Kurtosis	—	—	—	-.469	1.876	—	

Note. Skewness and kurtosis were calculated using data without missing values.

[a]Male is reference. [b]White is reference. [c]English as the primary language is reference. [d]Charter school is reference.

$^{*}p < .05$, $^{**}p < .01$.

Table 3

Parameter Estimates and Standard Errors for Multilevel Confirmatory Factor Analysis Model

	Student-level measurement model			School-level measurement model		
Parameter	*Unstand estimate*	*SE*	*Stand estimate*	*Unstand estimate*	*SE*	*Stand estimate*
Principal support (PS) by						
PS Item 1	1.000**	0.000	0.693	1.000	0.000	0.799
PS Item 2	0.673**	0.037	0.510	0.732**	0.058	0.702
PS Item 3	1.074**	0.046	0.777	1.102**	0.056	0.878
PS Item 4	1.116**	0.047	0.791	1.022**	0.063	0.866
PS Item 5	1.070**	0.043	0.792	1.021**	0.055	0.880
PS Item 6	0.908**	0.048	0.681	0.759**	0.062	0.734
PS Item 7	1.019**	0.043	0.642	0.973**	0.065	0.711
Teacher expectations (TE) by						
TE Item 1	1.000**	0.000	0.647	1.000	0.000	0.896
TE Item 2	1.081**	0.038	0.650	1.041**	0.028	0.909
TE Item 3	1.056**	0.062	0.582	0.739**	0.065	0.636
TE Item 4	1.031**	0.045	0.645	0.793**	0.045	0.727
TE Item 5	1.050**	0.085	0.487	0.647**	0.119	0.460
TE Item 6	0.961**	0.063	0.547	0.608**	0.064	0.577
TE Item 7	1.167**	0.063	0.661	0.857**	0.048	0.747
TE Item 8	1.071**	0.058	0.598	0.795**	0.053	0.676
Factor variances						
Math achievement	81.893**	1.158	1.000	17.996**	1.234	1.000
TE	0.076**	0.007	1.000	0.114**	0.015	1.000
PS	0.138**	0.011	1.000	0.170**	0.019	1.000
Factor covariances						
Math achievement ↔ TE	-0.002	0.045	-0.001	0.473**	0.092	0.330
Math achievement ↔ PS	-0.082	0.053	-0.024	0.077	0.081	0.044
TE ↔ PS	0.035**	0.004	0.341	0.054**	0.010	0.388
Residual variances and covariances						
PS Item 1	0.150**	0.009	0.520	0.097**	0.013	0.362
PS Item 2	0.178**	0.010	0.740	0.094**	0.008	0.507
PS Item 3	0.105**	0.006	0.397	0.062**	0.607	0.230
PS Item 4	0.103**	0.007	0.375	0.059**	0.007	0.251
PS Item 5	0.094**	0.006	0.373	0.052**	0.006	0.226
PS Item 6	0.131**	0.007	0.536	0.084**	0.008	0.461
PS Item 7	0.205**	0.009	0.588	0.158**	0.014	0.495
TE Item 1	0.106**	0.005	0.582	0.028**	0.004	0.197
TE Item 2	0.122**	0.006	0.577	0.026**	0.004	0.173
TE Item 3	0.166**	0.007	0.661	0.092**	0.008	0.595
TE Item 4	0.114**	0.007	0.584	0.064**	0.006	0.472
TE Item 5	0.271**	0.012	0.763	0.178**	0.015	0.788
TE Item 6	0.165**	0.011	0.701	0.085**	0.007	0.667
TE Item 7	0.134**	0.007	0.563	0.066**	0.011	0.441
TE Item 8	0.157**	0.013	0.643	0.086**	0.015	0.544
TE Item 1 ↔ TE Item 2	0.070**	0.005	0.613	—	—	—

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

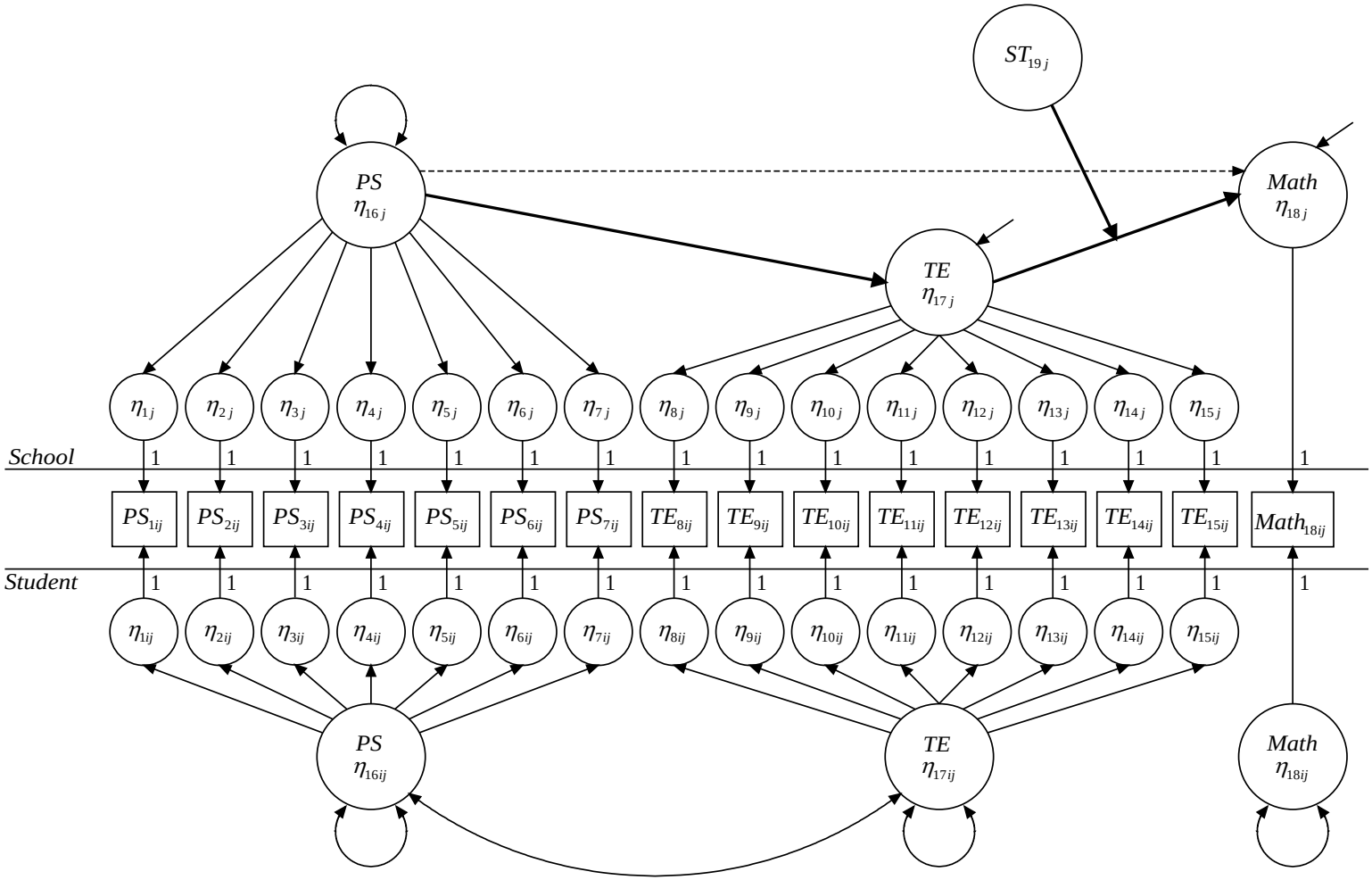

Figure 1. Conceptual Diagram of the Multilevel Moderated Mediation Model Showing the Relations of Principal Support, Teacher Expectations, School Type and Math achievement.

Note. PS = Principal support; TE = Teacher expectations; ST = School type.

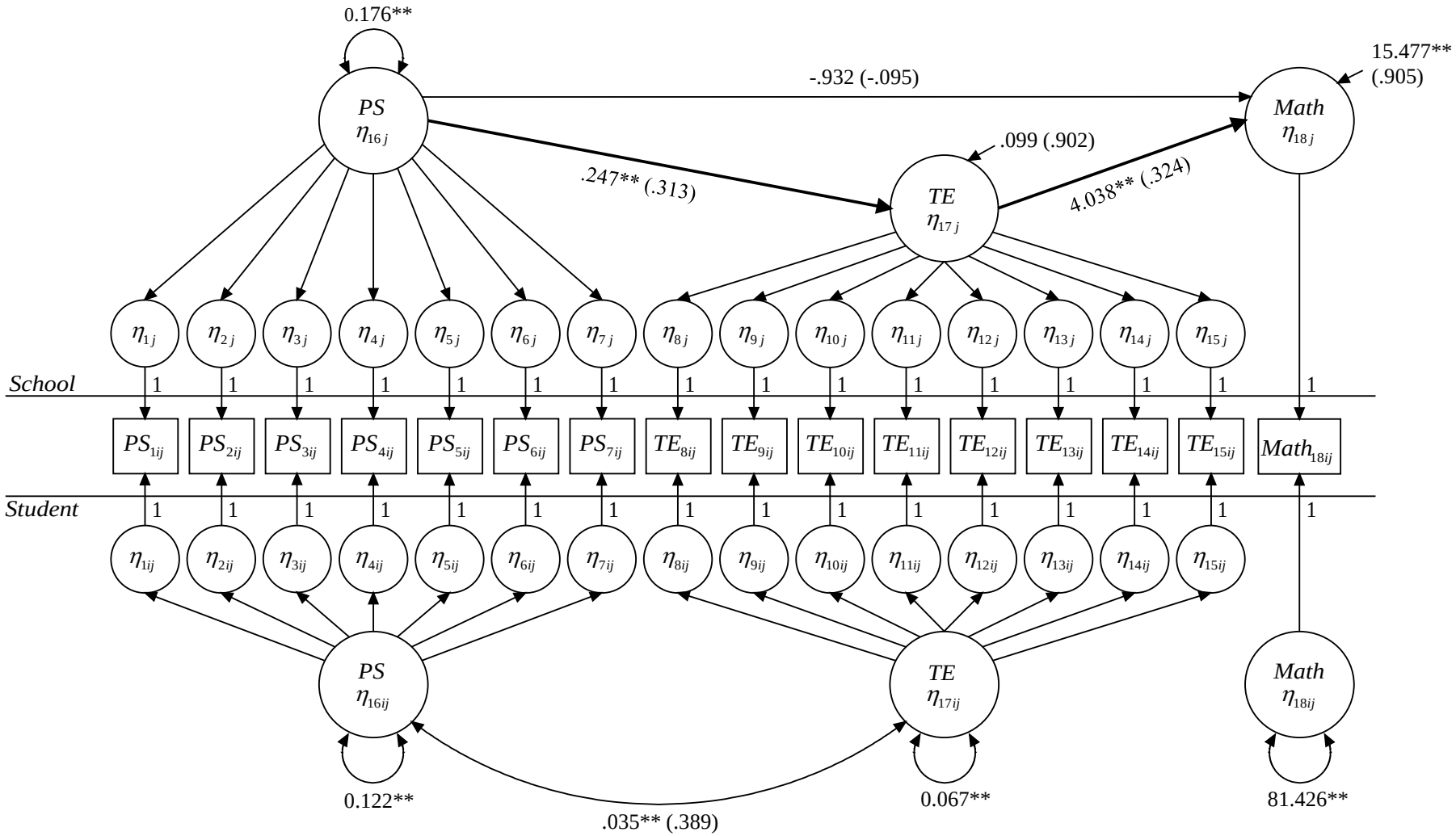

Figure 2. Multilevel Structural Equation Model 1 of Examing the Indirect Effect of Prinicipal Support onMath achievement via Teacher Expectations (N = 15,629).

Note. PS = Principal support; TE = Teacher expectations; ST = School type. Values in parentheses represent standardized estimates.

$^{*}p < .05$, $^{**}p < .01$.

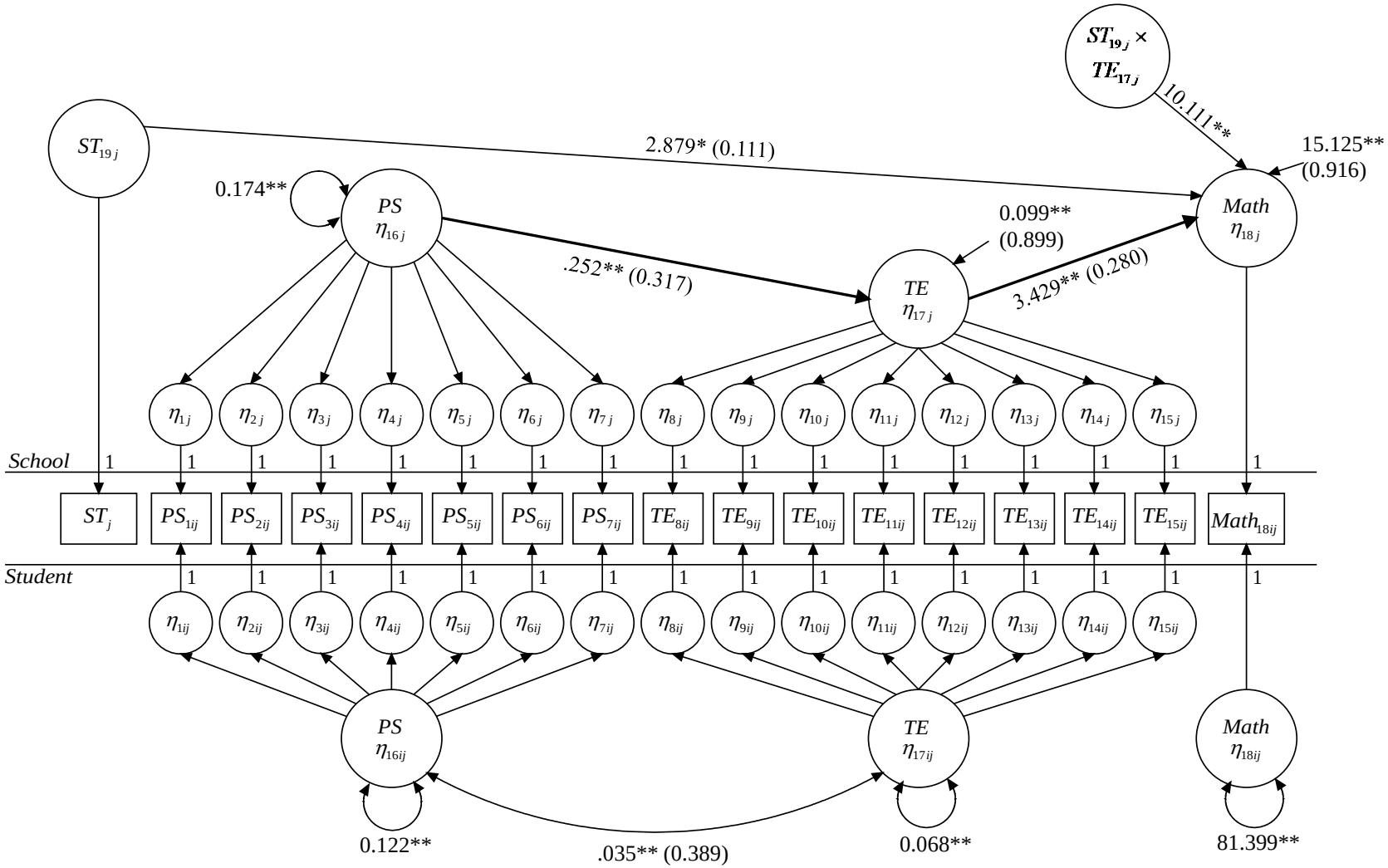

Figure 3. Multilevel Structural Equation Model 2 of Examing the Moderating Role of School Type in the Relationship Between Teacher Expectations and Math Achievement (N = 15,629).

Note. PS = Principal support; TE = Teacher expectations; ST = School type. Values in parentheses represent standardized estimates. $^{*}p < .05$, $^{**}p < .01$

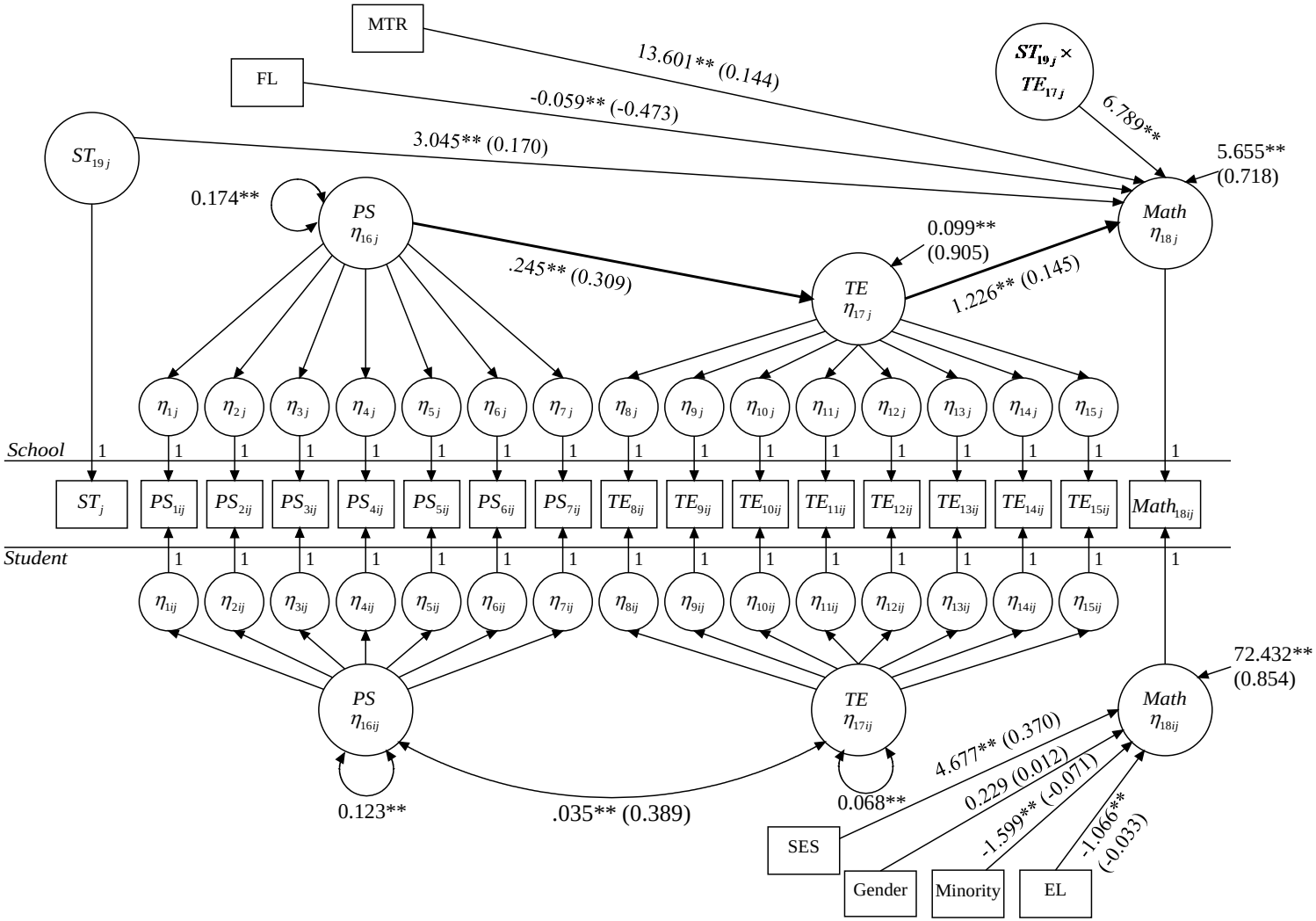

Figure 4. Multilevel Structural Equation Model 3 of Examing Both the Indirect Effect of Prinicipal Support and Moderating Role of School Type (N = 15,629).
Note. PS = Principal support; TE = Teacher expectations; ST = School type; FL = Free lunch ratio; MTR = Math teacher ratio; SES = Socioeconomic status; EL = English language. Values in parentheses represent standardized estimates. $^{*}p < .05$, $^{**}p < .01$.