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ARTICLE



Examining integrated leadership systems in high schools: connecting principal and teacher leadership to organizational processes and student outcomes

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ABSTRACT

Research on school leadership suggests that both principal and teacher leadership are important for school improvement. However, few studies have studied the interaction of principal and teacher leadership as separate but linked systems in how they relate to student outcomes. In this study, we examine how leadership pathways are related in the context of high schools and compare findings to research in elementary schools. Using survey and administrative data from high schools in a large urban context, the paper explores direct and indirect pathways from leadership to student achievement growth. The results indicate that there are 2 pathways through which principal leadership is related to student learning in high schools. One pathway is mediated by teacher leadership, whereas the second pathway does not include teacher leadership. We find that similar to elementary schools, the learning climate is the only organizational factor that links principal and teacher leadership with student achievement.

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Principal leadership; teacher leadership; structural equation modeling; survey research; learning climate; student achievement

Introduction

There is a substantial body of research examining the importance of school leadership for school improvement covering nearly four decades of work and examining multiple leadership roles – primarily the school principal, but also including the roles of assistant principals, teachers, and other school personnel. However, much of this work is compartmentalized and examines sources of leadership separately (Neumerski, 2013), or combines principal and teacher sources of leadership together to understand their joint influence on school processes and student outcomes (e.g., Hallinger & Heck, 2010a, 2010b; Heck & Hallinger, 2009; Leithwood & Jantzi, 1998; Leithwood & Mascall, 2008; Louis, Dretzke, & Wahlstrom, 2010; Spillane, 2006). As a consequence, a significant knowledge gap remains in current research on how principal and teacher leadership interact and how they link to student learning (Neumerski, 2013).

Among the few studies that have examined principal and teacher leadership as separate but linked systems, Leithwood and Jantzi (1999, 2000a, 2000b) examined

how principal and teacher leadership were related to student engagement. Another study by Sebastian, Allensworth, and Huang (2016) linked principal and teacher leadership to student achievement growth using data on urban elementary schools. The main finding in this study was that teacher leadership played a key mediating role between principal leadership and student achievement through the school learning climate. In this study, we extend previous work (see Sebastian et al., 2016) to understand whether teacher leadership in urban high schools has a similar mediating role between principals and school processes to improve student learning.

There are a number of reasons to question whether the roles of principal and teacher leadership would work differently in high schools than in elementary schools. High schools and elementary schools are different in the ways staff work together, in interactions of staff and leaders with parents and the community, and in ways they implement district policies (Flannery, Sugai, & Anderson, 2009). Urban high schools, in particular, face tremendous challenges that are different from those faced by elementary schools and secondary schools in other contexts, such as high dropout rates (Croninger & Lee, 2001; Fine, 1986), low college readiness (Roderick, Nagaoka, & Coca, 2009), and problematic school climates (Reid, Peterson, Hughey, & Garcia-Reid, 2006). These challenges may call for different leadership responses where different organizational factors may be important for student learning in comparison to the elementary school context. Empirical research with large-scale datasets focusing on the relationship between school leadership, school processes, and student learning in urban high schools is relatively rare. The majority of studies examining how school leadership is related to student achievement is based on elementary school data. Studies that do use high school data (e.g., Hoy, Tarter, & Bliss, 1990; Marks & Printy, 2003; Sebastian & Allensworth, 2012; Silins & Mulford, 2002) bear a limitation that we described earlier – they focus only on principal leadership or they do not separate teacher leadership from principal leadership. Thus, there are substantial gaps in the literature on high school leadership that this study helps to fill.

The conceptual framework, data sources, and analytical procedures used here are the same as those used in a study of elementary schools by Sebastian et al. (2016). We use data collected from one of the largest districts in the United States, Chicago Public Schools (CPS) to address these specific research questions:

- (1) What are the pathways through which principal and teacher leadership relate to student learning in urban high schools?
- (2) Does teacher leadership mediate the relationship between principal leadership and student learning as it does for urban elementary schools?

Review of relevant literature

School leadership

Over 40 years of research on school leadership has led to a diverse body of work that suggests that school leadership is indirectly related to student achievement via an array of school organizational processes (Dumay, Boonen, & Van Damme, 2013; Hallinger,

2005; Hallinger & Heck, 1996a, 1996b, 1998; Leithwood, Louis, Anderson, & Wahlstrom, 2004; Louis, Leithwood, Wahlstrom, & Anderson, 2010). In order to operate a school, principals assume multiple responsibilities not limited to administration and management, external and internal relations with various stakeholders, and involvement in instruction and learning (Grissom, Loeb, & Master, 2013; Walker, 2009). Horng, Klasik, and Loeb (2010) examined observational data collected from principals and estimated that principals spent about 27% of their time on administration, 21% on organization management, 15% on internal relations, and 5% on external relations. Although these responsibilities are necessary for running a school and supporting a learning environment, they do not relate to student learning directly. Principals' allocation of time for daily instruction practices and instructional programming (both of which are more relevant to student learning) only consisted of 6% and 7% of their work time (Horng et al., 2010). Since principals assume multiple responsibilities, much of which does not directly involve instruction, it is perhaps not surprising that school leadership research consistently shows that principal leadership does not directly relate to student learning (Hallinger & Heck, 1996a, 1996b, 1998; Leithwood et al., 2004; Louis, Leithwood, et al., 2010).

The bulk of research on school leadership so far has focused on principals' indirect role in supporting high-quality instruction. This aspect of leadership work, described as Instructional Leadership, has motivated school leadership work since the 1980s and is still widely studied today (Hitt & Tucker, 2016). Although researchers have used varying definitions of instructional leadership, certain components have been commonly referenced across most studies – setting a school vision/mission and goals, encouraging trust and collaboration, and actively supporting good instruction (Supovitz, Sirinides, & May, 2010).

An important debate in school leadership and organizational research is about who participates in school leadership. In early leadership research, principals were considered sole authoritative heads of hierarchically structured organizations, so only principals were assumed to take on leadership roles (Leithwood & Mascall, 2008). In reality, teachers assume important formal and informal leadership roles in their schools, directly among their colleagues, or indirectly in supporting the principal's mission, goals, and initiatives (Darling-Hammond, Bullmaster, & Cobb, 1995; Scribner, Sawyer, Watson, & Myers, 2007). More recent school leadership research has started to recognize the importance of leaders other than the school principal, especially teachers.

A number of conceptualizations are prominent in understanding the importance of teacher leadership, including viewing school leadership as distributed (Spillane, 2006; Spillane, Camburn, Pustejovsky, Pareja, & Lewis, 2008; Spillane & Diamond, 2007; Spillane, Halverson, & Diamond, 2001, 2004), collective/shared (Leithwood & Mascall, 2008; Printy & Marks, 2006), or collaborative (Hallinger & Heck, 2010a, 2010b). While there are many different definitions and conceptualizations of teacher leadership (Neumerski, 2013), many quantitative studies highlight teachers' influence over key school-wide decision-making processes (Louis, Dretzke, & Wahlstrom, 2010; Louis, Leithwood, et al., 2010). The present study also examines teacher influence in decision making as a measure of leadership; focusing on the decision-making or influence aspect of teacher leadership is based on an understanding that all forms of leadership ultimately entail exercising some form of influence (Yukl, 1994).

Most studies incorporating teacher leadership roles use a definition of school leadership that combines principal and teacher leadership roles (along with other leadership sources) into broad constructs of school leadership (e.g., Hallinger & Heck, 2010a, 2010b; Heck & Hallinger, 2009). While this approach is a useful way of understanding one aspect of distributed leadership, there are some advantages to studying principal and teacher leadership as separate but linked systems. Principals and teachers play different leadership roles, in which principals can be considered the prime movers (Bryk, Sebring, Allensworth, Luppescu, & Easton, 2010). Even with considerable principal–teacher collaboration and sharing of leadership responsibilities, teachers might still view principals, their own leadership, and other sources of leadership in a hierarchical manner (Leithwood & Mascal, 2008). Oftentimes, teachers hope to undertake leadership roles but expect their principals to provide directions and vision (Johnson et al., 2014). Therefore, quantitative studies linking principal and teacher leadership still need to account for a directional ordering between the two sources of leadership.

There are few studies that examine principal and teacher leadership as distinct, but linked, systems, and their relationship with student achievement. Louis, Leithwood, et al. (2010) studied mediated effects of principal instructional leadership and shared leadership on student achievement (also see Louis, Dretzke, & Wahlstrom, 2010). Their measure of shared leadership included the roles of teachers, students, and department chairs. Principal instructional leadership and shared leadership were specified as parallel constructs that were correlated with one another as they both indirectly influenced teaching and learning via professional community. Leithwood and Jantzi examined the relationships of both principal and teacher leadership with students' reports on an academic engagement scale. These studies showed weak total relationships between either form of leadership and academic engagement; neither principal nor teacher leadership related to students' academic engagement in two of the studies (1998, 2000a), while two other studies showed that principal leadership was related to student engagement whereas teacher leadership was not (Leithwood & Jantzi, 1999, 2000b). Supovitz et al. (2010) examined principal leadership and teacher peer influence and found that both were related to instruction and learning. Their measure of peer influence included teacher conversations and interactions around learning and teacher advice networks. While these interactions can be considered as one form of leadership, other studies have considered these interactions as measuring teacher professional community (Bryk, Camburn, & Louis, 1999; Grodsky & Gamoran, 2003; Kruse, Louis, & Bryk, 1995; Louis, Marks, & Kruse, 1996). The present study also examined professional community a key mediator linking leadership with instruction and learning.¹ Sebastian et al. (2016) examined principal and teacher leadership as separate but linked constructs in how they related to instruction and student learning in elementary schools. To our knowledge, no study has examined these relationships in high schools.

In summary, over the past few decades, leadership theory has developed to generate more inclusive models (e.g., distributed, shared, and collaborative) that consider participation of a broader range of school personnel, especially teachers. Principals are no longer perceived as the sole source of leadership (Leithwood & Mascal, 2008), and as a result, research on teacher leadership and other sources of leadership has gained considerable traction (Darling-Hammond et al., 1995; Lambert, 2003; Lieberman & Miller, 2011; Muijs & Harris, 2007; Murphy, 2005). Yet, quantitative research linking

teacher leadership and principal leadership and connecting both sources to teaching and learning is quite limited.

Organizational processes

Besides debates on how leadership is defined and who participates in leadership, another important debate in school leadership research is about *how* leadership connects to student outcomes. Researchers focus on different mediating processes depending on their respective theoretical frameworks, making comparisons across leadership studies difficult (Louis, Dretzke, & Wahlstrom, 2010). Some studies focus on global organizational factors that integrate multiple mediating factors together. For example, Hallinger and Heck (2010b) integrated “standards emphasis and implementation”, “focused and sustained action on improvement”, “quality of student support”, and “professional capacity of the school” under “school academic capacity” (pp. 663–664). Leithwood and Jantzi (2000b, p. 433, 2008, p. 510); used “school conditions” to cover many processes, including “school goals”, “school culture”, decision making, “supports for instruction”, and “professional learning community”, among others. One drawback of using a global factor to represent varied school organizational factors is that it does not show which specific aspects are effective in mediating the relationship between leadership and learning.

Three major frameworks have been utilized so far in empirical studies to organize the mediating processes through which leaders influence student learning, only one of which, the Essential Supports Framework (Bryk et al., 2010), is based on empirical studies using survey and achievement data (Hitt & Tucker, 2016).² The Bryk et al. (2010) framework identifies four core organizational processes that connect leadership to student learning. As shown in Figure 1, these are the professional capacity of staff (which includes the quality of professional development and the professional community of staff), the school learning climate, parent–community ties, and strong classroom instruction. Detailed descriptions of each of these components and the theoretical underpinnings of each are outlined in Bryk et al. (2010), which also examined the empirical evidence supporting these processes as they related to organizational outcomes.

For this study, we adapted the Bryk et al. (2010) model to inform our conceptual and analytical framework. While the Bryk et al. (2010) model provides a general description of how school leadership connects to instruction and learning, we separate principal and teacher sources of leadership and study their connected links to organizational processes and student achievement (see Figure 1). Besides being the only major framework in leadership research that is based on empirical longitudinal work (Hitt & Tucker, 2016), there are practical considerations involved in our adoption of the of the Bryk et al. (2010) framework. The survey data for this study came from the University of Chicago Consortium on Chicago School Research (Chicago Consortium), which uses the Bryk et al. (2010) framework to develop their survey items and measures. Therefore, the data used in this study were collected based on the Bryk et al. (2010) framework and allow us to empirically test that specific framework.

Studying different leadership sources as separate and linked systems raises the possibility that they could work on different sets of organizational processes to improve instruction and learning. In the context of Chicago elementary schools, Sebastian et al.

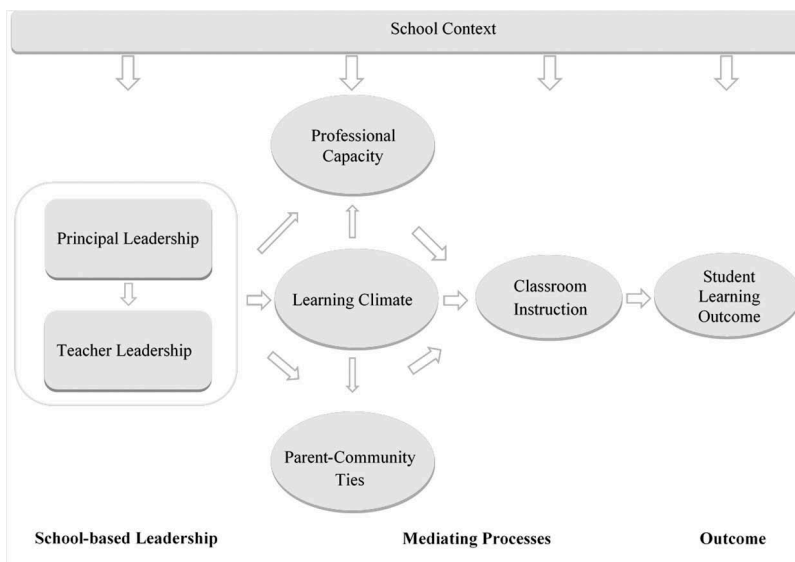


Figure 1. Five essential supports for school improvement.

Note: Professional development and learning community are two critical aspects of professional capacity. Adapted from *Organizing schools for improvement lessons from Chicago*, by A. S. Bryk, P. B. Sebring, E. Allensworth, S. Luppescu, and J. Q. Easton, 2010, Chicago, IL: University of Chicago Press.

(2016) found that only learning climate linked principal and teacher leadership to classroom instruction and learning. Moreover, teacher leadership completely mediated the relationship between principal leadership and learning climate, which suggests that perhaps at the elementary level, principals should fully partner with teacher leadership to improve learning climates and student achievement; this path of influence was the most important for explaining differences in student achievement growth across schools. Similar comparisons of pathways linking different leadership sources, separate organizational mediating processes, instruction, and learning have not yet been done at the high school level.

School context

Prior leadership studies have mostly controlled for school contextual characteristics such as school size, student body demographic characteristics, and selectivity (students' prior achievement). The discussion on the influence of school contextual characteristics in Bryk et al. (2010) points to moderating effects of context, that is, the role of context in influencing mediational relationships. Perhaps due to the modeling complexity involved in examining moderation and mediation together, such studies are not common; school contextual characteristics have largely been included as covariates. Because the present study follows the same models of a previous study using the Consortium surveys and CPS administrative data (Sebastian et al., 2016), we will be able to indirectly examine the moderating role of one important contextual variable – school level (elementary versus high). In the next section, we discuss the importance of examining this particular contextual variable.³

School leadership and student learning by school level

Comparing CPS high schools with elementary schools in terms of how school leadership is related to student learning can reveal whether specific mediational pathways vary by school level. As we discussed earlier, because high schools and elementary schools differ in a number of ways, we cannot assume principal and teacher leadership have similar relationships with student learning and that the same mediators are important.

The majority of empirical research in school leadership has been concentrated on investigating a general relationship between leadership and student learning without considering differences depending on the level of school, that is, elementary, middle, or high school (e.g., Hallinger, 2005; Hallinger & Heck, 1996a, 1996b, 1998; Leithwood et al., 2004; Louis, Leithwood, et al., 2010; Witziers, Bosker, & Krüger, 2003). Marks and Printy (2003) included data collected from elementary, middle, and high schools to examine leadership effects on achievement. Their study compared overall leadership levels but did not examine the moderating influence of school level in how leadership linked to achievement. Mitchell, Kensler, and Tschannen-Moran (2015) studied leadership in elementary, middle, and high schools and found that academic press declined from elementary to high school; their study did not further discuss how leadership effects on learning might change across different school levels. Ogawa and Weaver Hart (1985) showed that leadership explained a smaller proportion of variation in mathematics achievement in high schools than in elementary schools but also did not compare mediational relationships. Leadership studies to date have also examined elementary schools more often than high schools. In Hitt and Tucker's (2016) review of empirical leadership studies that used one of three major leadership frameworks, 11 studies of 56 included high school data along with elementary and middle school data, and only four used high school data alone. Bryk et al. (2010) also tested the essential supports framework with student achievement and survey data from only Chicago elementary schools. A prior study by Sebastian and Allensworth (2012) examined the essential supports framework with high schools, but did not examine the role of teacher leadership, focusing only on the principal.

Overall, a number of questions remain: Are there different pathways between principal and teacher leadership and learning in high schools versus elementary schools? Do factors such as teacher capacity and learning climate play the same mediating role between leadership and student learning as in elementary schools, and how are these related to different forms of leadership? The present study does not directly compare high schools to elementary schools, but because the analytical model and site of study (CPS) are the same as a previous study (Sebastian et al., 2016), we can contrast the findings to understand differences between high school and elementary school organizational processes.

Method

Data

For this study, we used teacher and student survey data from the Chicago Consortium, and CPS administrative records of student achievement, demographic background information, and school characteristics. CPS is the third largest school

district in the United States. Of the 400,545 students enrolled in CPS, 159,134 (39.7%) are African American, 181,169 (45.2%) are Hispanic, 36,890 (9.2%) are White, 14,564 (3.6%) are Asian or Hawaiian/Pacific Islander, 4,223 (1.1%) are Multi-racial, 1,227 (0.3%) Native American/Alaskan, and 3,228 (0.8%) have no racial information available. About 85.0% of these students are eligible for free or reduced-price lunches (Chicago Public Schools, 2016). The Chicago Consortium surveys have been developed to be aligned with the Bryk et al. (2010) framework; teacher surveys collect information on organizational aspects such principal leadership, professional community and development activities, school learning climate, and parent–community ties. The student surveys also collect student perspectives on organizational factors, for example, school safety, teachers’ expectations, and classroom instruction. We matched the high school teacher and student survey data collected in the academic years 2006–2007, 2008–2009, 2011–2012, and 2012–2013 with CPS high school administrative data during the same period, 2006–2007 through 2012–2013.⁴ The average survey response rates across these years was 66.35% for teachers and 62.45% for students (see Table 1).

We matched the survey and administrative data at the school level because the Chicago Consortium teacher surveys are anonymous and we do not have data to link teacher and student surveys with specific classrooms. As the student data could be linked across years, we were able to utilize the achievement data to estimate individual students’ growth in student achievement as they moved from 9th grade to 11th grade using their scores on standardized tests in those years. Schools can vary in the average growth of a typical student after controlling for background characteristics. This school-level variation in student achievement growth between 2006–2007 and 2012–2013 was the outcome in our analysis. We linked this to school organizational conditions during those same years by averaging measures of the five essential supports. In brief, we looked at average levels of school organizational conditions across a 7-year period and examined their relationships to student

Table 1. Number of teachers providing survey information.

| Year | | Teacher Surveys | Student Surveys |
|-----------|---------------------------|-----------------|-----------------|
| 2006–2007 | <i>N</i> | 4,407 | 63,215 |
| | <i>N-Schools</i> | 99 | 104 |
| | <i>Participation Rate</i> | 90.15% | 86.36% |
| 2008–2009 | <i>N</i> | 6,082 | 56,098 |
| | <i>N-Schools</i> | 100 | 98 |
| | <i>Participation Rate</i> | 79.86% | 82.63% |
| 2011–2012 | <i>N</i> | 4,936 | 71,633 |
| | <i>N-Schools</i> | 125 | 123 |
| | <i>Participation Rate</i> | 91.27% | 96.64% |
| 2012–2013 | <i>N</i> | 5,428 | 73,801 |
| | <i>N-Schools</i> | 130 | 133 |
| | <i>Participation Rate</i> | 93.45% | 98.21% |

Note: Response rates are calculated at the school level and show the percentage of schools which had a greater than 10% response rate on their student and teacher surveys.

achievement growth during those same years. After omitting missing data, the total sample included 121 high schools.

Measures

Informed by our research questions and conceptual framework, we have four groups of measures: leadership, organizational processes, student achievement, and contextual factors. [Appendix 1](#) details the measures included in the study from teacher and student surveys.

Leadership measures

We measured principal leadership with two measures – instructional leadership and teacher–principal trust. The instructional leadership survey items asked teachers about their principal’s leadership on various aspects such as promoting the school vision and supporting classroom instruction. A measure of teacher–principal trust also informed the overall measure of principal leadership. We measured teacher leadership with a measure of the extent of their influence in decision making on various aspects of school organization such as instruction and planning. A complete list of items corresponding with each of the leadership measures is provided in [Appendix 1](#).

School organizational processes

Professional capacity was measured with two factors – professional learning community (PLC) and professional development (PD) in CPS (see [Appendix 1](#) for the specific items in each measure). We used the definition of Kruse et al. (1995) of PLC, which outlines five core practices: reflective dialogue, teacher collaboration, deprivatized practice, shared norms, and new teacher socialization. Our measures for each of these aspects are similar to those developed by Bryk et al. (1999) in their study of PLC in Chicago elementary schools. The measure of PD reflects the quality and coherence of learning opportunities for teachers. Learning climate measured teachers’ expectations of students and how safe these students felt in schools. Parent–teacher trust served as a proxy factor for measuring parent–community ties. We measured classroom instruction with four subfactors: student class participation, classroom disorder, quality of student discussion, and critical thinking in student assignments. These four measures were collected from student surveys. Previous work using data from Chicago surveys have studied the validity of these measures and linked them to student outcomes such as test scores and grades (Allensworth, Gwynne, Pareja, Sebastian, & Stevens, 2014; Bryk et al., 2010; Lee, Robinson, & Sebastian, 2012; Sebastian & Allensworth, 2012).

The Chicago Consortium uses the Rasch model (Wright & Masters, 1982) to create leadership and organizational-process measures from teacher and student survey items (Consortium on Chicago School Research [CCSR], 2004). The original items are on Likert scales (see [Appendix 1](#)), and Rasch modeling uses this information to produce linear measures. Details on the construction of these scales have been discussed in prior work (Bryk et al., 2010). Using Rasch modeling, researchers at the Chicago Consortium have examined each scale for unidimensionality, construct and internal validity, reliability, and how well the Rasch models fit the data (Luppescu & Ehrlich, 2012). The scales are anchored so that measures are comparable across different survey administrations. We

report the reliabilities of each measure in [Appendix 1](#). Before we included these measures in our final structural equation model, we aggregated each measure to the school level using a three-level hierarchical linear model (HLM) and used the Empirical Bayes (EB) residuals from these HLM models (see [Appendix 2](#)). HLM provides an alternative to using simple averages of the survey measures and takes into account the nested nature of the data (students and teachers nested within schools), and also weights the information by sample size and consistency of responses. The EB residuals are centered, such that a zero score on a measure indicates a school with an average score on that particular measure.

The overall principal leadership measure was created by combining measures of instructional leadership and teacher–principal trust. We used a simple mean of EB residuals from the HLM models of instructional leadership and teacher–principal trust to obtain an overall measure of principal leadership. An overall measure of professional community was similarly created by averaging the school-level measures (obtained from EB residuals) for reflective dialogue, innovation, collective responsibility, teacher collaboration, and socialization. A measure for the quality of programs in the school was created by combining measures indicating program coherence and the quality of professional development. The measure of climate combined separate measures of teacher safety and college expectations for students. We used prior work using CPS data and these specific measures from CCSR surveys to inform the creation of these latent factors (Sebastian & Allensworth, 2012; Sebastian, Allensworth, & Stevens, 2014; Sebastian et al., 2016). We also conducted confirmatory factor analysis (CFA) to see if combining these measures was justified (CFA loadings are included in [Appendix 1](#)). Measures of teacher influence and teacher–parent trust were individual measures that were used directly in the SEM model. Under the Bryk et al. (2010) model, professional community and quality of programs together inform one of the five essential supports – professional capacity. However, prior work using CFA and SEM to examine the five essential supports at the high school level found that professional community and program quality were better retained as separate but correlated measures (Sebastian & Allensworth, 2012). [Tables 2](#) and [3](#) present the descriptive statistics of the school-level leadership, organizational, and contextual variables and correlations among them.

Table 2. Variable descriptive statistics.

| Name | Mean | SD | Min | Max |
|-------------------------------|-------|------|-------|-------|
| Principal Leadership (PRINC) | −0.02 | 0.60 | −1.44 | 1.81 |
| Teacher Influence (INFL) | −0.01 | 0.66 | −1.43 | 1.58 |
| Professional Community (PLC) | −0.01 | 0.68 | −1.78 | 1.97 |
| Professional Development (PD) | −0.02 | 0.47 | −1.14 | 1.29 |
| Learning Climate (CLIM) | 0.03 | 1.49 | −2.21 | 3.47 |
| Teacher Parent Trust (TRPA) | 0.00 | 0.57 | −1.34 | 1.80 |
| Classroom Instruction (CLASS) | −0.01 | 0.25 | −0.51 | 0.62 |
| Average Poverty (MSCON) | 0.17 | 0.52 | −1.07 | 1.05 |
| Average SES (MSSOC) | 0.00 | 0.53 | −1.50 | 1.07 |
| School Achievement (MEXP) | 13.97 | 1.81 | 11.67 | 21.90 |
| School Size (MSIZE) | 8.66 | 7.08 | 0.43 | 41.71 |

PRINC = principal leadership, INFL = teacher influence, PLC = professional learning community, PD = professional development, CLIM = learning climate, TRPA = teacher–parent trust, CLASS = classroom instruction, MSCON = school average of neighborhood poverty concentration, MSSOC = school average of neighborhood socioeconomic status (SES), MEXP = school average of student incoming achievement, MSIZE = school size/100.

Table 3. Correlation among variables.

| | Name | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----|-------------------------------|-----|------|------|------|------|------|------|------|-----|-----|
| 1 | Principal Leadership (PRINC) | | | | | | | | | | |
| 2 | Teacher Influence (INFL) | .58 | | | | | | | | | |
| 3 | Professional Community (PLC) | .55 | .72 | | | | | | | | |
| 4 | Professional Development (PD) | .78 | .67 | .78 | | | | | | | |
| 5 | Learning Climate (CLIM) | .42 | .71 | .69 | .59 | | | | | | |
| 6 | Teacher Parent Trust (TRPA) | .49 | .63 | .66 | .64 | .89 | | | | | |
| 7 | Classroom Instruction (CLASS) | .30 | .61 | .58 | .43 | .66 | .52 | | | | |
| 8 | Average Poverty (MSCON) | .04 | -.06 | -.02 | .00 | -.35 | -.33 | .16 | | | |
| 9 | Average SES (MSSOC) | .03 | -.11 | -.11 | -.04 | .11 | .18 | .00 | -.18 | | |
| 10 | School Achievement (MEXP) | .20 | .38 | .16 | .20 | .69 | .69 | .26 | -.57 | .37 | |
| 11 | School Size | .02 | -.25 | -.22 | -.05 | -.17 | -.05 | -.50 | -.42 | .06 | .23 |

PRINC = principal leadership, INFL = teacher influence, PLC = professional learning community, PD = professional development, CLIM = learning climate, TRPA = teacher–parent trust, CLASS = classroom instruction, MSCON = school average of neighborhood poverty concentration, MSSOC = school average of neighborhood socioeconomic status (SES), MEXP = school average of student incoming achievement, MSIZE = school size/100.

Student achievement

We estimated student achievement growth based on student performance on the Educational Planning and Assessment System (EPAS), a series of three standardized tests: EXPLORE, PLAN, and ACT. These tests are part of an integrated series of tests developed by ACT (2008). They measure student proficiency in English, math, science, and reading and also provide a composite score which is a simple average of the four subjects. We used the composite score in each of these tests as the outcome. Between 2006–2007 and 2012–2013, students in CPS took the EXPLORE in 9th grade, PLAN in 10th grade, and ACT in the 11th grade. The scales of these tests are comparable, which allows us to track student achievement growth in CPS high schools. ACT provides college readiness benchmarks based on these tests. For example, the benchmark scores showing likely readiness for college in mathematics are 18, 19, and 22 on the EXPLORE, PLAN, and ACT tests, respectively (ACT, 2009). Students in CPS took the EXPLORE and PLAN tests in the fall semester while ACT takes place in the spring semester. The student achievement data for this study included 191,826 students from 145 CPS high schools.

Analytical model

We adopted a two-level structural equation model (SEM) for the data analysis with a focus on how school-level (Level 2) leadership is related to school-average student achievement growth. Before we ran the final SEM model, we merged the leadership and organizational factors survey measures that were obtained from HLM EB residuals with the student achievement data. In the SEM model, as shown in Figure 3, we modeled principal leadership and teacher leadership as two separate measures while also specifying a directional path from principal leadership to teacher leadership. In this model, teacher leadership is considered as a mediator between principal leadership and school organizational processes. Principal leadership also directly links with the same organizational processes which predict student achievement growth through classroom instruction. To control for school context, we regressed all leadership, organizational, and outcome (student achievement growth) variables on four contextual factors – school-average neighborhood poverty concentration, average socioeconomic status of students, average incoming achievement, and school size.

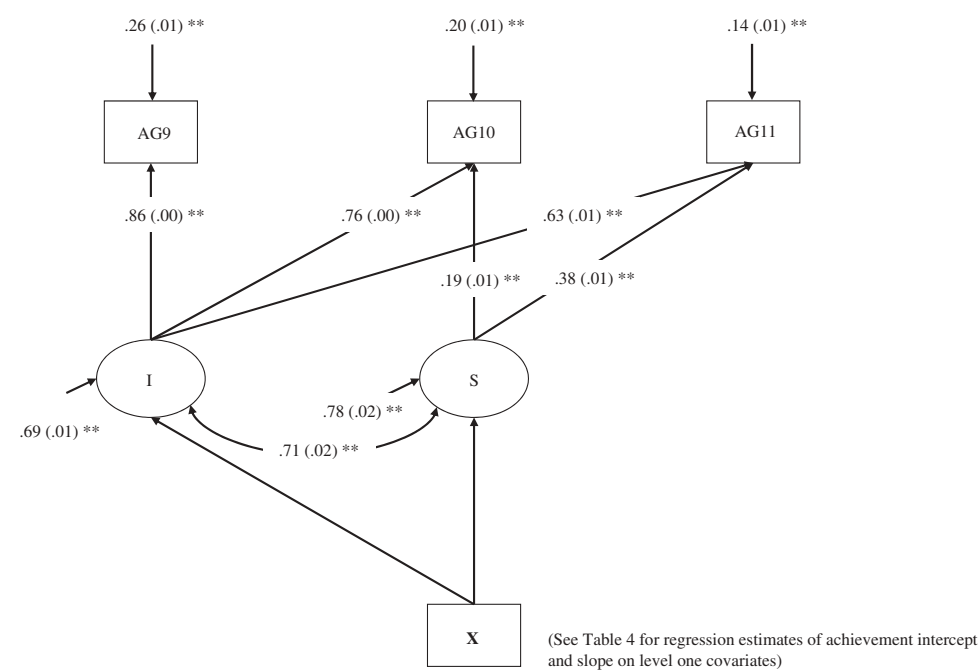


Figure 2. SEM model Level 1 (within-school) results.
* $p \leq .05$, ** $p \leq .01$; standard error in parentheses; AG9 = Achievement Grade 9, AG10 Achievement Grade 10, AG11 = Achievement Grade 11, I = student achievement intercept, S = student achievement growth, X = Level 1 control variables (see Table 4).

At Level 1, our SEM model estimates a linear growth model of student achievement based on students' test scores on their achievement in Grade 9 through Grade 11 (see Figure 2). In this growth model, we controlled for student neighborhood poverty concentration, socioeconomic status,⁵ special education needs, race, gender, whether the student was ever retained or transferred, while estimating the student achievement growth. The intercept and slope from the Level 1 growth model, representing the expected performance of a 9th-grade student on the 9th-grade test and the growth made on subsequent tests, respectively, were allowed to vary (or be random) at Level 2, the school level. At Level 2, variation in the intercept and slope (growth) from the Level 1 growth model was treated as our outcomes. While we have reason to expect that schools vary in how incoming 9th graders perform, we are more interested in their subsequent growth and how school factors are related to this growth. The SEM model was conducted using the Mplus 7 software program (Muthén & Muthén, 1998–2010).

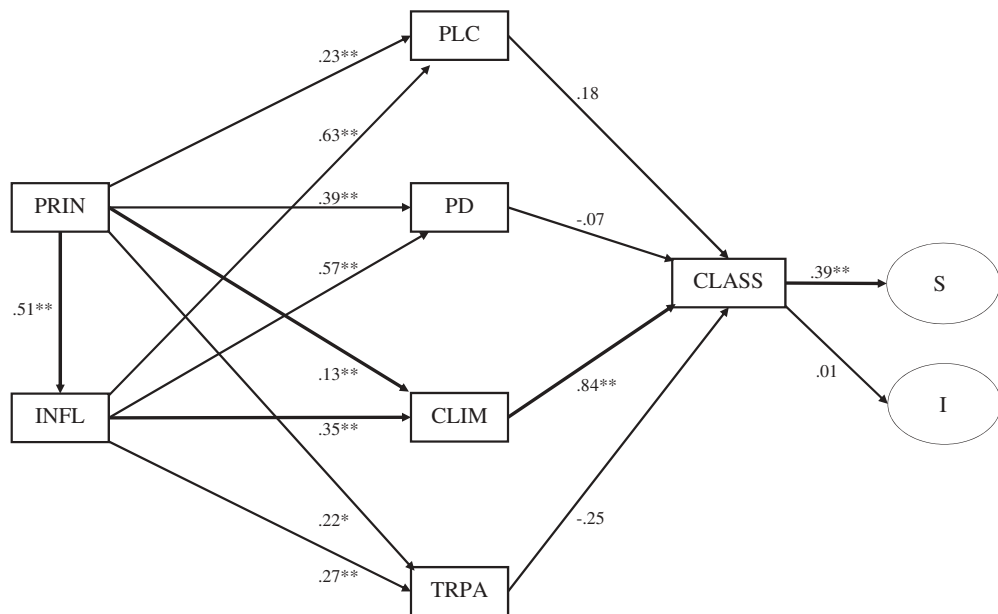
Results

Figure 2 and Table 4 describe the Level 1 (growth model) results of our SEM analysis. The two columns in Table 4 report the standardized coefficients of student-level covariates on student achievement intercept and growth. Most of them are significantly related to

Table 4. Regression coefficients of SEM Level 1 variables.

| | Level One Intercept and Growth (Slope) | | | |
|-----------|--|-------|--------|-------|
| | Intercept | | Growth | |
| | (I) | | (S) | |
| SCON | -.02** | (.01) | -.04** | (.01) |
| SSOC | .01 | (.01) | .04* | (.02) |
| SPED | -.42** | (.01) | -.01 | (.01) |
| BLACK | -.30** | (.03) | -.50** | (.04) |
| NATIVE | -.01** | (.00) | -.02** | (.01) |
| ASIAN | -.02** | (.01) | .01 | (.01) |
| LATINO(A) | -.21** | (.02) | -.36** | (.03) |
| MALE | -.05** | (.01) | .12** | (.01) |
| OLDGRADE | -.19** | (.01) | -.19** | (.01) |
| COHORT | .04** | (.01) | .18** | (.02) |
| ERETAIN | .00 | (.01) | -.08** | (.01) |

* $p \leq .05$, ** $p \leq .01$; standard error in parentheses; I = student achievement intercept, S = student achievement growth, SCON = neighborhood poverty concentration, SSOC = neighborhood socioeconomic status, SPED = special education needs, OLDGRADE = whether a student is older for his/her grade, COHORT = which year a student joined CPS as a freshman, ERETAIN = whether a student was ever retained.

**Figure 3.** SEM model Level 2 (between-school) results.

* $p \leq .05$, ** $p \leq .01$; standard error in parentheses; CFI = .98, TLI = .95, RMSEA = .02; PRIN = principal leadership, INFL = teacher influence, PLC = professional learning community, PD = professional development, CLIM = learning climate, TRPA = teacher–parent trust, CLASS = classroom instruction, S = student achievement growth, I = student achievement intercept. The four mediating variables PLC, PD, CLIM, and TRPA were allowed to be correlated. We present the regression coefficients of control variables in Tables 4 and 5.

student achievement, with the exception of special education status and Asian ethnicity for achievement growth.

Figure 3 and Table 5 present the Level 2 or school-level SEM results. Typically, values of the comparative fit index (CFI) and Tucker Lewis index (TLI) larger than .95 and the root

Table 5. Regression coefficients of SEM Level 2 control variables.

| | Level Two Variables | | | | | | | | |
|-------|---------------------|-----------------|----------------|---------------|-----------------|----------------|-----------------|-----------------|----------------|
| | PRINC | INFL | PLC | PD | CLIM | TRPA | CLASS | (I) | (S) |
| MSCON | .26** (.10) | -.02 (.07) | -.14 (.08) | -.04 (.06) | -.17** (.06) | -.09 (.06) | .33** (.08) | .13** (.03) | -.16 (.08) |
| MSSOC | -.07 (.10) | -.27** (.07) | .00 (.06) | .02 (.06) | -.07 (.04) | -.01 (.06) | .02 (.06) | .03* (.01) | .03 (.07) |
| MEXP | .36** (.11) | .46** (.06) | -.20* (.09) | -.10 (.08) | .53** (.08) | .54** (.08) | .06 (.12) | 1.05** (.02) | .45** (.12) |
| MSIZE | .06 (.10) | -.36** (.07) | -.08 (.07) | .04 (.05) | -.28** (.05) | -.16* (.07) | -.22** (.07) | -.00 (.01) | -.06 (.06) |

* $p \leq .05$, ** $p \leq .01$; standard error in parentheses; PRINC = principal leadership, INFL = teacher influence, PLC = professional learning community, PD = professional development, CLIM = learning climate, TRPA = teacher–parent trust, CLASS = classroom instruction; I = student achievement intercept; S = student achievement growth, MSCON = school average of neighborhood poverty concentration, MSSOC = school average of neighborhood socioeconomic status, MEXP = school average of student incoming achievement, MSIZE = school size/100.

mean square error of approximation (RMSEA) smaller than .06 are criteria that determine model fit (Hu & Bentler, 1999). The three indices from our SEM results (CFI = .98, TLI = .95, and RMSEA = .02) suggest a good model fit. There are two main findings from the SEM model. First, teacher leadership/influence partially mediated the relationship between principal leadership and student achievement growth, and second, principal leadership was also directly related to student achievement (independent of teacher influence). Table 6 shows the indirect effect of each pathway and the overall effect of eight different paths. The total indirect effect of principal leadership on student achievement growth was .08 ($p \leq .01$). Mplus reports these tables as indirect/direct effects, but the word “effects” here only denotes a relationship and does not mean a causal connection.

Teacher leadership as an influential mediator

As we show in Figure 3, teacher leadership was modeled as a mediator between principal leadership and all four organizational processes: The relationships between teacher leadership and professional development, professional learning community, parent–community ties, as well as learning climate were all statistically significant. The standardized coefficients ranged from .27 ($p < .01$) for the association between teacher leadership and parent–community ties to .67 ($p < .01$) for teacher leadership and

Table 6. Standardized indirect relationship between principal leadership and student achievement growth.

| Principal Leadership ↓ | To | Student Achievement Growth | Indirect Relationship | |
|------------------------------------|-----------------------------------|--------------------------------|-----------------------|---------------------------|
| | → Learning Climate | → Classroom Instruction | ↑ | .04* (.02) |
| | → Teacher–Parent Trust | → Classroom Instruction | ↑ | -.03 (.02) |
| | → Professional Learning Community | → Classroom Instruction | ↑ | .02 (.01) |
| | → Professional Development | → Classroom Instruction | ↑ | -.02 (.02) |
| → Teacher Leadership | → Learning Climate | → Classroom Instruction | ↑ | .06* (.03) |
| → Teacher Leadership | → Teacher–Parent Trust | → Classroom Instruction | ↑ | -.01 (.01) |
| → Teacher Leadership | → Professional Learning Community | → Classroom Instruction | ↑ | .02 (.02) |
| → Teacher Leadership | → Professional Development | → Classroom Instruction | ↑ | -.01 (.01) |
| Total Indirect Relationship | | | | .08** (.03) |

* $p \leq .05$, ** $p \leq .01$; standard error in parentheses.

professional learning community. The association between teacher leadership and professional development was .57 ($p < .01$), and the association between teacher leadership and learning climate was .35 ($p < .01$). However, only the indirect pathway linking principal and teacher leadership that involved learning climate ultimately translated to better student learning outcomes.

Principal direct role

Principal leadership was significantly related to all organizational processes; the coefficients were .23 ($p < .01$) for professional learning community, .39 ($p < .01$) for professional development, .13 ($p < .01$) for learning climate, and .22 ($p < .05$) for parent–community ties (see [Figure 3](#)). Here again, only principal leadership’s direct relationship with learning climate translated to better student learning outcomes. In sum, the two indirect pathways relating principal leadership with student achievement growth are:

- (1) Principal Leadership → Learning Climate → Classroom Instruction → Student Achievement Growth;
- (2) Principal Leadership → Teacher Leadership → Learning Climate → Classroom Instruction → Student Achievement Growth.

We therefore found that principal leadership had a direct relationship with school learning climate and student achievement, over and above the pathway through teacher leadership. Recall that Sebastian et al. (2016) did not find evidence for a direct pathway of principal leadership (not involving teacher leadership) that connected principal leadership and achievement in a study of Chicago elementary schools. The mediating role of teacher leadership and the importance of school learning climate is comparable in both studies.

Discussion

The past four decades of school leadership research have shown that leadership matters for student learning. Nevertheless, there has been little clarity on how that influence works – what principals do that is most likely to lead to student learning gains, and whether the mechanisms through which they exhibit influence on student learning might differ based on school grade levels. In urban high schools similar to the CPS context, where principals have many challenges to resolve, it is particularly important to know what specific practices/pathways lead to better learning. These practices can help principals prioritize their responsibilities by indicating where to put their efforts and how.

Although leaders may employ varying approaches to promote school improvement, this study finds that effective principal and teacher leadership places an emphasis on learning climate – school safety and teacher’s expectations – in high schools, as well as elementary schools. This is in contrast to other mediating processes that principals might otherwise consider equally important, including the teachers’ professional development, professional learning community, and relationships with parents. This is a critical distinction at a time when policies around teacher evaluation are encouraging principals to spend more of their

efforts evaluating and coaching individual teachers; such efforts might not be productive if they take principals' focus and efforts away from addressing issues of school-wide climate. That learning climate emerges as the dominant feature distinguishing which schools show achievement gains across school levels highlights the significance of assuring the safety and high expectations of students from elementary to high schools. School safety (Cornell & Mayer, 2010; Gronna & Chin-Chance, 1999; Varjas, Henrich, & Meyers, 2009) and low expectations (Diamond, Randolph, & Spillane, 2004; McKown & Weinstein, 2008; Rist, 1970) are long-standing issues that affect urban schools more than others. Furthermore, students with relatively disadvantaged socioeconomic status (SES) and from ethnic minority groups are more likely to experience teachers' lower expectations, leading to lower achievement (McKown & Weinstein, 2008; Rist, 1970). The importance of learning climate has been discussed since the earliest studies of school leadership. For example, Edmonds (1979) found that effective urban schools have strong leadership and a strong climate of student expectations. Further, learning climate is a key organizational construct of all major leadership and school organizational theoretical frameworks (Hitt & Tucker, 2016). The present study adds to the empirical evidence on the importance of learning climate by examining climate within a holistic framework of school organization that includes other organizational processes.

One difference in the results from this study in comparison to what was found in elementary schools (Sebastian et al., 2016) is that effective leadership at the high school level involves both direct and indirect (via teacher leadership) pathways to improve the school learning climate. In the elementary school context, the direct pathway from principal leadership to learning climate was not significant. As discussed in the literature review, high schools face unique challenges regarding safety, discipline, and student behavior issues that are different from those faced by elementary schools. Expectations for students could also take on different meaning at the elementary schools than at the high school level where expectations go beyond academic and behavior expectations at the classroom level, but also involve college, career, and transition to adulthood outcomes. Therefore, it could be that principals need to approach learning climate both via promoting teacher influence on climate-related policies and also directly assuming responsibility for these functions. The measure of teacher leadership used in this study includes both formal, informal, and everyday interactions among school leaders.

Our study adds to the substantial research evidence indicating the importance of school safety (see Chen & Weikart, 2008; Cornell & Mayer, 2010; Henrich, Schwab-Stone, Fanti, Jones, & Ruchkin, 2004; Milam, Furr-Holden, & Leaf, 2010) and teachers' expectations of students (see Jussim & Harber, 2005, for a comprehensive review). Therefore, a key takeaway from this study is that principals in large urban high schools in contexts similar to CPS seem to benefit from prioritizing their efforts in improving learning climate, and enabling teachers to assist in these efforts by increasing their leadership capacity towards climate-related processes. The fact that teacher leadership emerges as an important mediator suggests that successful principals rarely address issues of climate alone, but that a key role of the principal in high schools is to guide teachers and give them the authority to address common issues around safety and school expectations together. These models also show that teacher leadership does not exist in a vacuum, but is intrinsically tied to principal leadership. Principals provide the structures for teachers to improve the learning climate of the school, guiding and

supporting their work, and monitoring the success of their efforts. Such efforts seem to have the greatest potential for improving student achievement, relative to other aspects of school organization.

Study limitations

Before concluding, we acknowledge a few limitations of our data and analytical model. The use of population data from students and teachers in CPS allows us to make valid inferences about linkages between school leadership and organizational constructs in the CPS district, and similar urban high school environments. However, the results are not generalizable to other school districts and contexts. Next, information from teacher and student surveys were averaged across multiple years, and therefore the SEM analysis can be considered as cross-sectional. Mediation models using cross-sectional data can lead to biased estimates of the direct and indirect effects (Maxwell & Cole, 2007; Maxwell, Cole, & Mitchell, 2011). While longitudinal information was available to conduct growth models for survey data, it was difficult to link multiple growth models of each leadership and organizational measure to student achievement within a single SEM model. This study can be considered as an examination of relationships between average leadership and organizational factors between 2007 and 2013 and how they linked to student achievement growth during the same period. The Consortium surveys are also anonymous; no teacher identification was available for us to link students with teachers. This required us to aggregate the survey measures at the school level instead of directly linking them with student achievement through teacher identification. Moreover, we were not able to account for teachers' experience and tenure status in our SEM models. Another limitation is also related to data availability. Although the leadership roles of both assistant principals and instructional coaches are well recognized in educational research (Neumerski, 2013), our data do not provide measures of those two types of leadership. Further, our teacher leadership measure indicates teacher influence only in decision making. While influence in decision making is an essential aspect of teacher leadership, it does not include teacher leadership roles in direction setting, guiding professional development, establishing community ties, and motivating peer teachers. Despite these limitations, our study reveals important similarities and differences across school levels in the pathways between school leadership and student learning. We also provide empirical evidence to show the importance of teacher leadership, as separate but related systems along with principal leadership, in the context of urban high schools.

Notes

1. Teacher influence over key school decision-making processes was examined as a measure of teacher leadership.
2. The other two leadership frameworks reviewed by Hitt and Tucker (2016) were the Ontario Leadership Framework (OLF) and the Learning Centered Leadership Framework (LCL).
3. We still include the influence of other contextual variables such as student demographic characteristics, prior achievement, and school size as control variables.
4. Combining student and teacher survey information is an added strength of this study; most prior studies of school leadership rely on a single source of information – usually teacher surveys.

5. Neighborhood poverty concentration and socioeconomic status are two variables from the U.S. Census Bureau's tracking of the percentage of people living under poverty in a neighborhood, and the socioeconomic status of the neighborhood.

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Appendices

Appendix 1. Survey measure reliability

| | CFA Loading | Measures | Items |
|--------------------------|----------------|---|--|
| Leadership | 0.97 | Principal Instructional Leadership Reliability = .91 | The principal: Makes clear to the staff his or her expectations for meeting instructional goals; Communicates a clear vision for our school; Sets high standards for teaching; Understands how children learn; Sets high standards for student learning; Presses teachers to implement what they have learned in professional development; Knows what's going on in my classroom |
| (Source: Teacher Survey) | 0.92 | Teacher–Principal Trust Reliability = .89 | The principal has confidence in the expertise of the teachers; I trust the principal at his or her word; It's OK in this school to discuss feelings, worries, and frustrations with the principal; The principal takes a personal interest in the professional development of teachers; The principal looks out for the personal welfare of the faculty members; The principal places the needs of children ahead of personal and political interest |
| (Source: Teacher Survey) | | Teacher Influence Reliability = .80 | How much influence do teachers have over school policy in each of the areas below: Hiring new professional personnel; Planning how discretionary school funds should be used; Determining books and other instructional materials used in classrooms; Establishing the curriculum and instructional program; Determining the content of in-service programs; Setting standards for student behavior |
| Learning Climate | 0.85 | Expectations for Postsecondary Education Reliability = .79 | Teachers expect most students in this school to go to college; Teachers at this school help students plan for college outside of class time; The curriculum at this school is focused on helping students get ready for college; Most of our students have the capacity to do college-level work; Most of the students in this school are planning to go to college; Teachers in this school feel that it is a part of their job to prepare students to succeed in college |
| (Source: Teacher Survey) | 0.99 | School Safety Reliability = .89 | To what extent is each of the following a problem at your school: Physical conflicts among students; Robbery or theft; Vandalism; Gang activity; Disorder in classrooms; Disorder in hallways; Student disrespect of teachers; Threats of violence toward teachers |
| Professional Community | 0.91 | Collective Responsibility Reliability = .91 | How many teachers in this school: Help maintain discipline in the entire school, not just their classroom; Take responsibility for improving the school; Set high standards for themselves; Feel responsible to help each other do their best; Feel responsible that all students learn; Feel responsible for helping students develop self-control; Feel responsible when students in this school fail |

(Continued)

(Continued).

| | CFA Loading | Measures | Items |
|-----------------------------|----------------|---|---|
| (Source: Teacher Survey) | 0.91 | Collaborative Practice Reliability = .73 | How often have you: Observed another teacher's classroom to offer feedback; Observed another teacher's classroom to get ideas for your own instruction; Gone over student assessment data with other teachers to make instructional decisions; Worked with other teachers to develop materials or activities for particular classes; Worked on instructional strategies with other teachers during common planning time |
| | 0.67 | Teacher Innovation Reliability = .89 | How many teachers in this school: Are really trying to improve their teaching; Are willing to take risks to make this school better; Are eager to try new ideas; All teachers are encouraged to "stretch" and "grow"; In this school, teachers are continually learning and seeking new ideas; In this school, teachers have a "can do" attitude |
| | 0.92 | Reflective Dialogue Reliability = .78 | Teachers in this school regularly discuss assumptions about teaching and learning; Teachers talk about instruction in the teachers' lounge, faculty meetings, etc.; Teachers in this school share and discuss student work with other teachers; How often have you had conversations with colleagues on; What helps students learn the best; Development of new curriculum; The goals of this school; Managing classroom behavior |
| | 0.58 | New Teacher Socialization Reliability = .57 | Experienced teachers invite new teachers into their rooms to observe, give feedback, etc.; A conscious effort is made by faculty to make new teachers feel welcome here |
| | 0.84 | Professional Development Quality Reliability = .81 | Teachers are left completely on their own to seek out professional development; Most of what I learn in professional development addresses the needs of the students in my classroom; Most professional development topics are offered in the school once and not followed up; Overall, my professional development experiences this year have; Been sustained and coherently focused, rather than short-term and unrelated; Included enough time to think carefully about, try, and evaluate new ideas; Been closely connected to my school's improvement plan; Included opportunities to work productively with colleagues in my school; Included opportunities to work productively with teachers from other schools |
| (Source: Teacher Survey) | 0.96 | Program Coherence Reliability = .79 | Once we start a new program, we follow up to make sure that it's working; We have so many different programs in this school that I can't keep track of them all; Many special programs come and go at this school; You can see real continuity from one program to another at this school; Curriculum, instruction, and learning materials are well coordinated across the different grade levels at this school; There is consistency in curriculum, instruction, and learning materials among teachers in the same grade level at this school |

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(Continued).

| | CFA Loading | Measures | Items |
|---|----------------|--|--|
| Teacher–Parent Trust (Source: Teacher Survey) | | Teacher–Parent Trust Reliability = .79 | For the students you teach this year, how many of their parents: Support your teaching efforts; Do their best to help their children learn; How many teachers at this school feel good about parents' support for their work; How many teachers at this school feel good about parents' support for their work? Please mark the extent to which you disagree or agree with each of the following: Teachers and parents think of each other as partners in educating children; Staff at this school work hard to build trusting relationships with parents. To what extent do you feel respected by the parents of your students? To what extent do you feel respected by the parents of your students? |
| Classroom Instruction (Source: Student Survey) | 1.00 | Course Clarity Reliability = .88 | 1. I learn a lot from feedback on my work; 2. It's clear to me what I need to do to get a good grade; 3. The work we do in class is good preparation for the test; 4. The homework assignments help me to learn the course material; 5. I know what my teacher wants me to learn in this class |
| | 0.70 | Student Engagement Reliability = .91 | 1. I usually look forward to this class; 2. I work hard to do my best in this class; 3. Sometimes I get so interested in my work I don't want to stop; 4. The topics we are studying are interesting and challenging |
| | 0.90 | Challenging Classwork Reliability = .91 | How often do your students do the following: 1. This class really makes me think; 2. I'm really learning a lot in this class; 3. Expects everyone to work hard; 4. Expects me to do my best all the time; 5. Wants us to become better thinkers, not just memorize things In your class, how often: 6. Are you challenged? 7. Do you have to work hard to do well? 8. Does the teacher ask difficult questions on tests? 9. Does the teacher ask difficult questions in class? |
| | 0.90 | Teacher Personalism Reliability = .90 | The teacher for this class: 1. Helps me catch up if I am behind; 2. Is willing to give extra help on schoolwork if I need it; 3. Notices if I have trouble learning something; 4. Gives me specific suggestions about how I can improve my work in this class; 5. Explains things in a different way if I don't understand something in class |

Appendix 2. Empirical Bayes residuals of survey measures HLM

The leadership measures including instructional leadership, and teacher leadership, and all the mediating measures are estimated with the same model with no control variables at Level 1:

$$\text{Level 1 : } Y_{ijk} = \pi_{0jk} + e_{ijk} \quad (1)$$

Meanwhile, we control the *year* (2008–2009, 2011–2012, and 2012–2013) of survey measures at Level 2:

$$\text{Level2 : } \pi_{0jk} = \beta_{00k} + \sum_{n=1}^n \beta_{0nk}(\text{Year})_{0jk} + r_{0jk} \quad (2)$$

$$\text{Level3 : } \beta_{00k} = \gamma_{000} + \sum_{n=1}^n \gamma_{00n}(Z)_{00k} + \mu_{00k} \quad (3)$$