IMPLEMENTATION OF SCHOOL INSTRUCTIONAL IMPROVEMENT AND STUDENT GROWTH IN MATH: TESTING A MULTILEVEL LONGITUDINAL MODEL

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ABSTRACT

NCLB policies in the United States focus schools' efforts on implementing effective instructional processes to improve student outcomes. This study looks more specifically at how schools are perceived to be implementing state required curricula and benchmarks and developing teaching and learning processes that support the teaching of state standards and influence student learning. This longitudinal, multilevel study focuses on how the implementation of standards-based learning and monitoring of student progress affects students' likelihood to attain proficiency in math over time. All 5th-grade students enrolled in a western United States public school district who attended the same school in both 3rd- and 5th-grades and had complete 3rd- and 5th-grade test results for mathematics (11,345 students, 79% of all Grade 5 students, in 172 schools). A multilevel value-added model (hierarchical logistic regression) was used to estimate the extent to which school processes influenced math outcomes at single and at multiple points in time. The results of this study identify effective schools and practices and illustrate the relationship between schools' academic organization and students' growth; they show that organizational processes do impact student learning over schools' contextual features. The quality of schools' implementation of the required Standards Based Learning curriculum is strongly related to students' likelihood to be proficient in math. Implications for practice: Build human and social capital by focusing on school process variables for school improvement. Because school leaders have relatively greater control over organizational processes, they can proactively focus on identifying needs, providing staff professional development and follow-up support, and implementing and evaluating changes. Growth models and case studies may provide more information about learner outcomes in math over time.

Keywords: School Improvement, Elementary, Mathematics, Assessment, Hierarchical Logistic Regression.

INTRODUCTION

The education community and the public have lived with the policies and ramifications of the federal No Child Left Behind (NCLB) Act of 2001 for eight years now. During this time, we have seen both positive and negative effects of this policy on school accountability. Positive effects include a greater concern with school accountability (e.g., monitoring student adequate yearly progress, teacher certification and professional qualifications) and reduction of gaps in student learning due to student social background. Negative effects include a narrowing of the curriculum to focus on reading and math skills at the expense of other important curricular areas, as well as a rather superficial definition of school effectiveness as whether or not a school meets "Adequately Yearly Progress" (AYP) targets each year. In many cases, AYP may have less to do with direct school efforts and more to do with where students "sit" with respect to proficiency targets at the beginning of each school year—that is, schools where students are closer to proficiency targets at the beginning of the year have an advantage in meeting targets relative to schools where students are more substantially below state proficiency benchmarks.

Given increased concern with school accountability, the purpose of this paper is to examine whether school effectiveness, as defined in terms of NCLB as adequate yearly progress, is related to stronger or weaker school process variables. In other words, if AYP outcomes were

shown related to school process variables (i.e., after accounting for differences in student background and school composition)—variables over which schools have some control—this would lend greater credibility to the process of monitoring school outcomes and processes than if AYP achievement results have little to do with variables that schools have some control over and more to do with differences in student demographics. Providing information describing differences in the implementation of state-mandated, standards-based curricula in elementary schools and uncovering differences, which may be within schools' control, may be an important first step in developing accurate and equitable ways of comparing schools in terms of their educational effectiveness.

Background of the Study

The effects of NCLB policies have narrowed the focus of school effectiveness and accountability to the academic outcomes produced, without regard for the amount of effort schools must expend (e.g., resource allocation, restructuring, staff development) to produce required outcomes. Under NCLB, state accountability systems assess students' attainment of established performance standards without consideration of how their background, their prior educational success, or conditions within the schools they attend may affect their learning outcomes. In some contexts, school personnel face relatively greater challenges (e.g., students' readiness to learn, socioeconomic English language proficiency, or staff instability) in producing required outcome levels than in others. In addition, an individual student's academic improvement over time is not recognized.

Several issues related to effective measurement-driven reform emerge. One of the first is acknowledging that it can take more energy and effort to produce academically proficient students in some schools than in others. Second, variability between groups contributes to the potential volatility of school scores when successive groups of students are compared (Linn & Haug, 2002). In addition, because of the almost exclusive focus on outcomes under NCLB, there has been little effort directed toward understanding how schools may "add value" to their students' education in both academic and extracurricular ways.

Continuing inequities in the educational experiences and achievement outcomes for students of different racial-ethnic and social class backgrounds have been a primary concern for educational reform for several decades (Haney, 2001). Because NCLB has focused attention on the equity of outcomes for all students, the effect of NCLB policies has narrowed the focus of school effectiveness and accountability to the academic outcomes produced, without regard for the amount of effort schools must expend to produce required outcomes. State accountability systems assess students' attainment of established performance standards without consideration of how their background, their prior educational success, or conditions within the schools they attend may affect their learning outcomes. It is clear, however, that in some contexts, school personnel face relatively greater challenges (e.g., students' readiness to learn, English language proficiency, or staff instability) in producing required outcome levels than in others. In addition, the current AYP approach to school accountability does not recognize that individual students may make considerable academic improvement over time but the school can still fall short of meeting the standard.

Several issues related to effective measurement-driven reform emerge. One of the first is acknowledging that it can take more energy and effort to produce academically proficient students in some schools than in others. Second, variability between groups contributes to the potential volatility of school scores when successive groups of students are compared (Linn & Haug, 2002). Third, because of the almost exclusive focus on outcomes under NCLB, there has been little effort directed toward understanding how schools may "add value" to their students' education in both academic and extracurricular ways. Most important, although the current APY approach may identify schools that do not meet state standards, there is little information in that assessment that can help schools reform their educational practices in ways that will lead to improved outcomes.

Identifying Ways Schools Can Improve Outcomes

Because of the high stakes associated with monitoring school academic progress in recent years, increased attention has been directed toward studying how schools can change to become more instructionally effective in educating students. Districts have considerable incentives to identify promising practices that can increase student achievement.

Social Distribution of Learning

Previous research has found that student learning within schools is socially distributed according to students' social backgrounds and previous academic preparation. These variables can affect how students are assigned to teachers and their access to curriculum (Cicourel & Mehan, 1983; Lee & Bryk, 1989; Mehan, 1992; Oakes, 1985). Such stratification processes affect student learning through providing differential opportunities to learn (Barr & Dreeban, 1983; Bidwell & Karsada, 1980), including the quality of curriculum content, teaching, achievement expectations, and the social relationships to which students are exposed. Prior research on school effects suggests that some schools are better than others in reducing the social distribution of learning (e.g., Lee & Bryk, 1989).

Instructional Improvement

Another line of research has focused attention on improvement of schools' instructional practices and how this may interact with student learning (e.g., Page, 1987; Van Houtte, 2004). Student academic success is highly influenced by both teachers and access to the school's curriculum. Instructional improvement has been defined variously as the successful implementation of a program, changes in teacher behavior, transformation of the school's culture, an alteration of a school structure, or an increase in student learning or school effectiveness (Clark, Lotto & Atuto, 1984; Firestone & Corbett, 1988; Fullan, 1982; Louis et al., 1999).

School Leadership

School leadership has been identified as playing a central role in facilitating changes in schools' curricular and instructional processes, by providing direction and support, and sustaining those changes over time by linking the internal and external environments of the school (Firestone & Corbett, 1988; Fullan, 2001; Heck & Hallinger, 2005; Louis et al., 1999). Taken as a whole, studies on schools' instructional improvement have helped identify the process of improvement, but they have been less successful in actually demonstrating how specific changes in school processes affect student outcomes (Hall & Hord, 1987; Ouston, 1999; Teddlie & Reynolds, 2000).

Research Focus

Given the concern with identifying ways that schools can improve in order to become more effective, the focus of this research is to test a longitudinal, multilevel model regarding the relationship between school implementation of a required state curricular and instructional mandate (i.e., requiring the implementation of standards-based learning and monitoring of student progress) and students' likelihood to attain proficiency in math over time. The study looks more specifically at how schools are perceived to be implementing state required curricula and benchmarks and developing teaching and learning processes that support the teaching of state standards. Within schools, the study controls for a number of differences in outcomes due to students' backgrounds.

Between schools, the study examines how, after controlling for features of student background and schools' contexts (e.g., student composition, structures), the implementation of curriculum focused on teaching to educational standards (e.g., curricular organization and implementation, monitoring student progress, teacher-student interactions in classrooms) may have (i) direct consequences for students' likelihood to be proficient in math at the end of the study and, further, (ii) may moderate the strength of within-school slope coefficients describing students' proficiency trajectories (i.e., the relationship between students' initial proficiency status in math and their current proficiency status in math). This latter type of school effect on a within-school student relationship (referred to as a cross-level interaction) concerns the potential effects that phenomena at one level of a data hierarchy have on relationships at another level.

Research Questions

- Are staff and parent perceptions about the quality of schools' implementation of required standards-based learning curriculum related to students' likelihood to be proficient in math?

The first hypothesis proposes that, controlling for student academic and social background and school context, in schools where parents, staff, and students perceive the implementation of standards-based curriculum to be stronger students will be more likely to be proficient at the end of the study, compared to students in schools with more average or below average implementation.

- Does better implementation of standards-based learning curriculum moderate (i.e., increase or decrease) the relationship between students' previous proficiency status and their ending proficiency status in math?

The second hypothesis proposes that students' change in math will be increased over time in schools that report having above average implementation of standards-based learning than in schools that report having more average or below average implementation of standards-based curricula.

Method

Population

The participants in the study included all 5th grade students enrolled during SY 2003–2004 in public schools in a western U.S. state. There were 14,414 Grade 5 students enrolled in 199 schools during SY 2003–2004.

Final Sample

Several steps were taken to arrive at the final sample used in this study. First, only students attending the same school in Grades 3 and 5 were included. Therefore, participants included in the study needed to have been enrolled in a public school as a 3rd grade student and in the same school as a 5th grade student. Second, students needed to have completed state standards-based test results for mathematics for both grades. These data were used to estimate students' progress over time. A school with only one Grade 5 student meeting the criteria for inclusion, charter schools, and special schools (i.e., schools that serve only disabled or incarcerated students) were excluded. After applying these criteria, 11,345 of the total set of 5th grade students (79%) in 172 schools were included in this three-year longitudinal study.

The characteristics of the 21% of the students who were excluded from the study due to not meeting the aforementioned criteria were not examined. These students may have transferred to another school between Grades 3 and 5 or they may not have participated in the test-taking at one or both of the grades. Common characteristics of these students may include high absentee rates or membership in highly transient families. Although the number was relatively small, the inclusion of these students may have produced slightly different student outcomes and adjustments for scores within schools.

Variables in the Model

The variables were selected for inclusion in this study based on Creemers' (1994) model of school effectiveness as well as those indicators found in the literature to be empirically linked with educational outcomes. Creemers' framework suggests four categories of variables affect student achievement: (i) context (e.g., SES); (ii) school (e.g., structure, resources, and processes); (iii) classroom (e.g., instructional grouping strategies and quality of teaching); and (iv) student (e.g., family background and previous learning). This scheme is consistent with multilevel analysis techniques that address the nested structure of data in educational settings. When variables are specified at the appropriate levels within and between schools, the estimation of relationships between the dependent and independent variables is more valid.

School Contextual Variables

Variables included school enrollment size, student composition (a composite measuring percentage of low SES students, percentage of minority students, and percentage of students receiving English language support), staff stability (percentage of teachers working at the school for five years), and principal stability (i.e., having the same principal over the course of the study).

Standards-Based Learning (SBL) Implementation

Evaluation of schools' progress in implementing

standards-based instruction was measured by several survey items (i.e., filled out by teachers and 5th grade parents and students at each school) defining the quality of the school's curriculum. This survey was administered between the first and second measure of student outcomes in this study.

The items paraphrased from the survey include the school's curricula (i.e., school provides challenging, coherent, relevant, and meaningful curricula for each student that fulfills the school's purpose and results in student achievement of content and performance standards), its instruction (i.e., staff uses research-based knowledge about teaching and learning; staff designs and implements a variety of learning experiences that meet the needs and learning styles of students; staff designs and implements learning experiences that engage students in inquiry and problem solving, addresses content and performance standards, is consistent with school-wide learner outcomes), and its assessment procedures (i.e., teacher and student use of assessment is frequent and integrated into the teaching and learning process; assessment results are used to measure each student's progress toward the achievement of state content and performance standards and school-wide learning outcomes; these assessment results are the basis for regular evaluation and improvement of schools' curricula and instruction). The alpha for the construct was 0.91.

Student Background Variables

Background variables included gender, ethnicity, language background, special education status, and initial proficiency level in math (coded 1= met, 0 = not met).

Math Proficiency

Math proficiency on each occasion was determined by student performance on a state-mandated test of math skills. The tests consist of constructed-response items and standardized test items from the Stanford Achievement Test (Edition 9). The math test consists of five strands measured by 52 items (i.e., number and operation; measurement; geometry and spatial sense; patterns, functions and algebra; data analysis, statistics, and probability).

Data Analysis: Multilevel Modeling

Data were analyzed using multilevel level modeling of longitudinal categorical outcomes and the HLM 6 software program (Raudenbush et al., 2004). Because the assessment of student progress involves the collection of data on students within schools, it is important to utilize analytic methods that are appropriate to the level of data collection (student or school). In the past, researchers had considerable difficulty analyzing data where students are nested in classrooms or schools. Applying the single-level regression model to hierarchical data produces several analytic difficulties. Bryk and Raudenbush (1992) describe some of these difficulties, including a forced choice over the proper unit of analysis, tradeoffs in measurement precision (whether variables are analyzed at the individual or group level), limitations in ways the model's parameters are estimated (i.e., because intercepts and slopes must be considered as fixed for the sample), and violations related to errors in the prediction equation (e.g., errors should be independent, normally distributed, and have constant variance).

Where similarities among individuals are present (i.e., there are clustering effects), multilevel models provide a more accurate assessment of the properties of schools than single-level regression models. This is primarily because of their greater efficiency in calculating standard errors. Because significance tests are calculated as the ratio of a parameter to its standard error, ignoring the presence of clustering effects can lead to false inferences about the significance level of model parameters (i.e., due to biased standard errors), as well as possible missed insights about the processes being studied. It is important to keep in mind that the error components of hierarchical data structures are more complex (i.e., they are neither independent nor necessarily normally distributed) because the errors within each unit are dependent and common to every individual within the unit (Bryk & Raudenbush, 1992).

Multilevel analyses therefore provide both technical and

conceptual benefits; that is, they reflect the way in which the data were collected and allow the variation in an outcome to be partitioned into different components (i.e., at the individual and school levels). This allows the development of sub-models which explain variance at different levels of the data hierarchy. For example, variables related to the school (e.g., size and teacher stability) should be estimated with respect to the number of schools in the study, as opposed to the number of individuals within the schools. Similarly, information about students should be associated with the number of students and not the number of schools.

Multilevel analyses also promote the development of more complex questions about the data, such as how students' probability of being proficient is distributed across schools. Studies using these analyses can answer questions about the distribution of individual-level slopes (effects of student variables such as SES) on school outcomes. This facilitates the development of school-level models that explain variation in the individual-level slopes across schools.

Although early multilevel models were restricted to outcomes that were continuous (and normally distributed), the general approach has been expanded to include a variety of models for categorical and ordinal outcomes. Under such conditions, the use of a standard multilevel model is inappropriate because the dependent variable is not normally distributed (i.e., it has only limited values; in this case, a student either met or did not meet the standard), the level-1 random effects do not have homogeneous variance, and predicted values of the outcome (which in a typical regression model could take on any real value) can only take on a few values (Raudenbush et al., 2004). For example, if the outcome is binary (coded 0, 1), the predicted values cannot meaningfully be less than zero or greater than one. Raudenbush et al. suggest that appropriate models must constrain the predicted values to lie within the interval of zero to one.

Testing Randomly-Varying Parameters

There are two primary randomly-varying parameters examined in this study. First, it is assumed that students' ending proficiency status (Grade 5) varies randomly across the set of schools. Second, it is assumed that the slope relationship between students' earlier proficiency status and their end proficiency status will vary randomly across schools. This latter type of effect is known as a slopes-as-outcomes model (Bryk & Raudenbush, 1992). In both cases, it is proposed that the implementation of standards-based learning will enhance both randomly-varying parameters. School-improvement parameters were tested at the $p < .10$ level.

Results

Table 1 presents the results of the multilevel model. Within schools, student SES, language status, special education status and most ethnicity dummy-coded variables were significant in explaining ending proficiency status. Regarding school variables in the table, context variables (i.e., enrollment size, teaching staff stability, student composition) were found not to affect students' likelihood to be proficient in this sample.

Testing Specific Hypotheses

Hypothesis 1

Results of the study provided support for both hypotheses proposed. Regarding H1 (i.e., stronger implementation of standards-based learning (SBL) practices will be positively related to greater student likelihood to attain proficiency

Between Schools	Logit	SE	Odds Ratio	T-Ratio	df	P-value
Model for Ending School Proficiency						
School Mean	-1.53	0.06	0.22	-27.339	166	0.000
H1: Standards Implementation	0.11	0.06	1.12	1.750	166	0.081
Enrollment	-0.00	0.00	1.00	-1.497	166	0.136
School Composition	-0.04	0.07	0.96	-0.520	166	0.603
Staff Stability	-0.38	0.39	0.68	-0.973	166	0.332
Same Principal	0.24	0.12	1.27	2.033	166	0.043
Model for Previous Math Ending Proficiency Slope						
Previous Math Proficiency	2.90	0.08	18.14	36.75	168	0.000
H2: Standards Implementation	0.13	0.08	1.14	1.67	168	0.099
School Composition	0.03	0.09	1.03	0.34	168	0.737
Within Schools Student Background						
Low SES	-0.50	0.06	0.60	-8.332	11335	0.000
English Language Learner	-0.55	0.12	0.57	-4.575	11335	0.000
Special Education	-1.04	0.12	0.35	-8.702	11335	0.000
Female	0.25	0.05	1.28	4.871	11335	0.000
Japanese	0.13	0.08	1.13	1.609	11335	0.107
Chinese	0.62	0.13	1.87	4.650	11335	0.000
Filipino	-0.05	0.08	0.96	-0.571	11335	0.568
Hawaiian	-0.45	0.07	0.64	-6.107	11335	0.000
Samoan	-1.27	0.23	0.28	-5.517	11335	0.000

Table 1. Variables Explaining Ending Status in Math Proficiency

in math at the end of the study), the results suggested that stronger SBL implementation was related to higher likelihood of school attainment of AYP (odds ratio = 1.12, p < .10). Importantly, the results were observed after controlling for student background within schools and for school-level controls (e.g., student composition, enrollment, staff stability). More specifically, students in schools 1-SD above the grand mean in SBL implementation were more likely to be proficient in math than their peers in schools at the grand mean in terms of implementation of SBL. The odds ratio can be interpreted as a 1-SD in quality of SBL implementation would be related to about a 12% increase in likelihood for students to be proficient in math.

Although it was not the primary focus of the research, it should also be noted that having the same principal in the school over the three-year period was also positively related to greater likelihood for students to be proficient in math (odds ratio = 1.27, p < .05). This suggests students in schools with the same principal over time had about a 27% increased likelihood of attaining proficiency in math compared with students in schools that experienced principal turnover. The relationship between principal stability and improvement is displayed in Figure 1. This pattern of results supports the thesis that leadership from formal sources such as the principal may be important in implementing reforms that are directed at changing teacher behavior (e.g., Leithwood et al., 2004).

Hypothesis 2

Regarding H2, Table 1 also suggests students' initial proficiency status in math affected their ending status in math positively (after controlling for student composition). It should be noted that students who were previously proficient in math have a big advantage over students who were not previously proficient (odds ratio = 18.14, p < .01). At the school level, stronger implementation of standards was related to an increased likelihood for students to be proficient at the end of the study, given their earlier proficiency status. More specifically, students in schools 1-SD above the grand mean in SBL implementation who were proficient in math initially had an increased likelihood of being proficient in math at the end of the study of about 14% (odds ratio = 1.14, p < .10) over their peers in schools with more average SBL implementation. Stated differently, the implementation of stronger curricular and instructional processes increased students' proficiency trajectories in math.

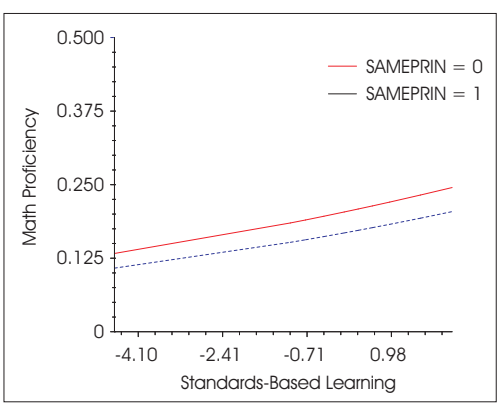

Figure 1. Comparing Students' Likelihood to be Proficient in Schools with the Same (coded 1) or Different Principals Over Time

Discussion and Implications

Given demands to increase outcomes for all students resulting from NCLB, research that examines how schools can improve their instructional processes is important for providing strategies that can improve student outcomes. Research unpacking the relationship between schools' academic organization and its impact on students' growth is important for identifying and implementing strategies to improve schools academically (e.g., Firestone & Louis, 1999). This is because school leaders have relatively greater control over these organizational processes than they do over schools' contextual features.

First, the findings provide preliminary support for the view that mandated curricular changes are implemented differently across schools. This study therefore provides some initial data indicating how differential implementation of curriculum reform affects student outcomes. Further, it suggests promising paths (e.g., upgrading school curriculum and instructional processes) that can result in increased student growth and ending outcomes. In this study, stronger perceptions about the school's efforts to implement required standards-based instruction and processes to monitor student academic progress (1) were associated with a greater likelihood of students' attaining proficiency status in math at the end of

the study, and (2) were related to enhanced student proficiency trajectories over time. More specifically, the study identified a contingent effect on students' learning trajectories in math due to differences in academic organization between schools.

These latter findings are encouraging, as they imply schools can engage in planned efforts to strengthen instructional programs, and these efforts have positive effects on students' proficiency ending levels and their changing proficiency status over time. The results, therefore, suggest that monitoring school processes, such as the implementation of mandated curricular and assessment changes, can be an important means of validating how school processes may add value to student outcomes. More specifically, in these data, at the school level student composition was less related to ending proficiency status and change in proficiency status over time than a key curriculum implementation variable.

Second, the findings also add something new in terms of the possible relationship that principal stability may play in efforts to undertake school curricular reform. More specifically, the study provided evidence that principal stability may be an important variable in enhancing the implementation of school processes related to modifying schools' curricula (Heck & Hallinger, 2005). Though the reason is not apparent from these data, this finding is likely because of the school-wide effort it takes to upgrade the quality of the schools' math curricula and teachers' classroom instructional practices (e.g., identify needs, provide staff professional development, implement and evaluate standards-based instruction or curricular changes). Although findings related to the positive impact of principal stability in enhancing school improvement over time requires verification in further studies, this result should be of interest to policymakers who manage the assignment of principals to schools. Incentives for principal stability might be one way of increasing principal stability in some types of "school improvement" settings.

Further research can be directed toward ways that enhance the school's implementation of curriculum mandates, and the role of school leadership in this process may result in increased likelihood of students meeting achievement targets over time. Although the study suggested a relationship between average implementation of curriculum change and student outcomes, this represents only a proxy indicator of what types of changes individual teachers might have made in their classrooms. Obtaining accurate information about what teachers do in classrooms to facilitate learning and what school leaders do to support teachers' efforts to implement new curricula should contribute to a more complete understanding about how school instructional changes affect student learning under a variety of organizational conditions.

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