LSC Principal Questionnaire Study: A Longitudinal Analysis of Data Collected Between 1997 and 2003

by

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October 2004

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INTRODUCTION

In addition to having a direct impact on teachers and their classroom practice via professional development and the adoption of high-quality instructional materials, the LSC program is intended to have a broader impact on the participating schools and districts. Data collected on the questionnaire administered to each participating school's principal provide an opportunity to examine the extent to which the LSC program has been a successful catalyst of school improvement over time. Additionally, data are also available for several school level variables often associated with growth or declines in academic progress (Bryk & Raudenbush, 1992).[1] This study makes use of questionnaire data collected from principals in the LSC projects to-date to examine the impact of the LSC on seven outcomes:

1. Principals' ratings of the school's progress in moving towards excellence in mathematics/science education;
2. Principals' ratings of the relative mathematics/science achievement of students compared to five years prior;
3. Principals' reports of the proportion of teachers participating in LSC-professional development activities;
4. Principals' reports of the proportion of teachers implementing the LSC-designated instructional materials;
5. Principals' attitudes toward reform-oriented teaching;
6. Principals' perceptions of their support for mathematics/science teaching; and
7. Principals' perceptions of the effect of resource availability on mathematics/science teaching.

School level predictor variables included school size and school socioeconomic indicators such as percentage of students classified as non-Asian minority, free/reduced-price lunch (FRL), and limited English proficient (LEP), as well as school size, community type, and whether the principal had been in the school and district since the beginning of the LSC project.

The analyses of the first four outcomes can be conceptualized as examining the impacts of the LSC on schools over time, while the analyses of the last three can be thought of as impacts on the principal over time. Thus, this report is organized by the nature of the outcome variable (i.e., impacts on school vs. impacts on principals). Further, the analyses were conducted separately for mathematics and science projects as contextual factors (e.g., state-mandated high-stakes accountability measures in mathematics but not science) may have a differential effect on the two subjects. Because the data have a nested structure, with multiple time-points nested within schools, and schools within individual LSC projects, hierarchical modeling was used to examine these outcomes.

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[1] Bryk, A.S. & Raudenbush, W.W. (1992). *Hierarchical linear models: Applications and data analysis methods.* Newbury Park, CA: Sage Publications.

SAMPLE

Between 1997 and 2003, over 17,500 questionnaires were submitted by principals as part of the LSC Core Evaluation. Projects were required to administer the full version of the principal questionnaire during their Baseline Year, Year Two, and Final Year. Since projects varied in length, their Final Year of data collection could occur in the third, fourth, fifth, or sixth year of the project. In order to maintain a truly longitudinal dataset, the data set was reduced to those cases that were clearly provided by the same principal over time.[2] Due to incomplete school information, some questionnaires were removed from these analyses, yielding a final data set that included about 6,300 questionnaires from roughly 4,100 principals, representing 85 LSC projects. Table 1 shows the number of projects targeting each subject/grade-range included in these analyses.

Table 1
Projects Targeting Each Subject/Grade-Range

	Number of Projects
K–8 Science	42
K–8 Mathematics	29
6–12 Mathematics	19
6–12 Science	7
Total	**85**†

† The sum of projects is greater than the total as some projects target more than one subject/grade-range.

On average, mathematics projects targeted about 800 teachers and science projects targeted about 1,100 teachers (see Table 2). However, project size varied widely, with the smallest project targeting only 49 teachers and the largest targeting over 4,000 teachers.

Table 2
Project Size

	Minimum	Maximum	Mean	Standard Deviation
Mathematics	49	4,079	792.91	827.90
Science	102	4,079	1,069.38	782.59

As can be seen in Table 3, about 60 percent of the principals in the data set submitted a questionnaire at one time-point. Roughly 30 percent of the principals are represented at two time-points and 10 percent are represented at three time-points.

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[2] Consistency checks were conducted to ensure that each school's records could have been provided by the same person. The checks included examining whether the number of years a principal served in a school followed a logical progression (e.g., a progression of 10, 12, and 14 years as principal of a school was considered likely to be the same person responding, while a progression of 10, 3, 8 was not).

Table 3
Number of Time-Points, by Subject

	Percent of Principals	
	Mathematics (N =1,846)	**Science (N =2,321)**
1 Time-Point	57	59
2 Time-Points	33	37
3 Time-Points	10	4

Examining the schools represented in the data set, about half were located in urban areas and one-fourth in suburban communities, with the remaining roughly split between rural areas and towns/small cities (see Table 4). About one-fourth of the schools had no students classified as limited-English proficient, 5 percent of the schools had a majority of limited-English proficient students.

Table 4
Descriptive Statistics for Categorical School Variables

	Percent of Schools	
	Mathematics (N = 1,846)	**Science (N = 2,321)**
Community type		
Rural	9	14
Town or small city	9	14
Suburban	24	27
Urban	58	44
Percent of students classified as limited-English proficient		
0 percent	23	30
1–10 percent	44	42
11–50 percent	27	22
51 or more percent	6	5

As can be seen in Table 5, school sizes varied widely, ranging from a mere 5 to over 3,000 students. About 51 percent of students in schools targeted for mathematics and 38 percent in schools targeted for science were classified as non-Asian minority. In both subjects, nearly half of the students were eligible for free/reduced-price lunch.

Table 5
Descriptive Statistics for Continuous School Variables

	Minimum	Maximum	Mean	Standard Deviation
Mathematics				
Number of students in school	16.00	3,030.00	704.91	416.19
Percent of student body classified as Non-Asian minority	0.00	100.00	50.69	34.81
Percent of students in school eligible for free/reduced-price lunch	0.00	100.00	49.69	31.08
Science				
Number of students in school	5.00	2,290.00	523.24	284.38
Percent of student body classified as Non-Asian minority	0.00	100.00	37.94	32.18
Percent of students in school eligible for free/reduced-price lunch	0.00	100.00	45.04	29.50

It should be noted that, due to different patterns of missing data on the outcome variables, in part due to changes in the principal questionnaire in various years, the number of cases utilized in each analysis varies (Appendix A).

ANALYSIS AND RESULTS

Impact of the LSC on Schools

The LSC principal questionnaire data have a nested structure with time-points nested within principals, and principals within projects. Statistical techniques that do not account for potential shared variance within groups in nested data structures can lead to incorrect estimates of the relationship between independent factors and the outcome. Hierarchical modeling is an appropriate technique for apportioning and predicting variance within and across groups in a nested data structure (Bryk & Raudenbush, 1992).

The first four outcomes studied in these analyses, those examining the impact of the LSC on schools, are measured on categorical scales. These outcomes are:

- Principals' ratings of the school's progress in moving towards excellence in mathematics/science education;
- Principals' ratings of the relative mathematics/science achievement of students compared to five years prior;
- Principals' reports of the proportion of teachers participating in LSC-professional development activities; and
- Principals' reports of the proportion of teachers implementing the LSC-designated instructional materials.

Each categorical outcome was collapsed into a four-level ordinal variable. Tables 6 and 7 show the principal ratings for each outcome by project year. Ratings in the top categories increased over time for all variables in both mathematics and science projects. By the projects' Final Year, approximately three-quarters of principals rated progress and achievement for mathematics and science programs in the top two categories.

Table 6
School Outcomes, by Project Year: Mathematics

	Percent of Principals		
	Baseline Year	Year Two	Final Year[§]
Percent of teachers participating in LSC professional development[†]			
0–20 percent	65	22	17
30–50 percent	10	14	16
60–80 percent	11	20	20
90–100 percent	14	43	48
Percent of teachers using LSC-designated instructional materials[†]			
0–20 percent	58	20	15
30–50 percent	12	14	14
60–80 percent	12	21	23
90–100 percent	18	44	48
Program progress towards excellence			
Quite Far From Ideal	5	4	2
Beginning to Improve	44	39	33
Well along in Improving	39	42	47
Approaching Ideal	13	15	18
Student achievement compared to five years ago			
Much/Somewhat Worse	5	6	4
About the Same	27	20	15
Somewhat Improved	50	54	50
Much Improved	18	21	31

† The questionnaire asked principals to approximate to the nearest 10 percent.
§ Projects' Final Year ranged from Year Three to Year Six, depending on individual project duration.

Table 7
School Outcomes, by Project Year: Science

	Percent of Principals		
	Baseline Year	Year Two	Final Year[§]
Percent of teachers participating in LSC professional development[†]			
0–20 percent	5	22	16
30–50 percent	38	19	14
60–80 percent	39	20	23
90–100 percent	17	39	47
Percent of teachers using LSC-designated instructional materials[†]			
0–20 percent	58	18	14
30–50 percent	13	16	12
60–80 percent	8	21	26
90–100 percent	20	44	49
Program progress towards excellence			
Quite Far From Ideal	11	5	4
Beginning to Improve	45	38	34
Well along in Improving	32	39	42
Approaching Ideal	12	17	20
Student achievement compared to five years ago			
Much/Somewhat Worse	4	3	4
About the Same	29	23	18
Somewhat Improved	48	52	52
Much Improved	20	22	26

† The questionnaire asked principals to approximate to the nearest 10 percent.
§ Projects' Final Year ranged from Year Three to Year Six, depending on individual project duration.

Due to limitations in modeling software, it was not feasible to include a third level of nesting in the model to control for project membership. In an attempt to control for possible project effects, a set of dummy-coded project membership variables was included at the school level. Although this process does not allow for the testing of specific project effects (i.e., whether the effect of a certain variable on the outcome varies across projects), it should factor these effects out of the analyses. Thus, for each of the ordinal outcome variables, a two-level hierarchical model (observations nested within schools) was used to investigate the relationship between the outcome variable and project year and predictor variables.

The independent variable included at the project-year (time-point) level was:

- Project year;

At the school level, the following independent variables are included:

- Number of students enrolled in the school;
- Percent of students in the school classified as non-Asian minority;
- Percent of students in the school eligible for free/reduced-price lunch;
- Percent of students in the school classified as limited-English proficient (dummy coded);
- Community type in which the school was located (dummy coded); and
- Project membership (dummy coded).
- Principal at the same school since beginning of LSC project; and
- Principal in the same district since beginning of LSC project.

Since the statistical approaches employed assume that the variables are normally distributed, all continuous predictors were examined for deviations from normality. Variables that were non-normally distributed were transformed as necessitated by the level and direction of skewness and kurtosis. The transformations are listed in Appendix B.

For the analysis of ordinal outcomes, each questionnaire was treated as an "observation" with an underlying probability distribution that the outcome would be reported in each possible category. The analysis produces estimates of the likelihood that the outcome will be reported in each category based on the project year while controlling for a number of other factors. The statistical model for analyzing ordinal outcomes is a hierarchical generalized linear model. In the model, a "log odds" transformation of the probability for each rating category is estimated. The final estimates can then be converted to probabilities for ease of interpretation.

The outcome variable was organized as follows:

Y_{ij} = X = outcome variable, for observation i in project j, where

X = L = rating in lowest category
X = S = rating in second category
X = T = rating in third category
X = H = rating in highest category

Y_{Xij} = 1, if the outcome is in or below category X
Y_{Xij} = 0, if the outcome is above category X

$P(Y_{ij} = X) = \varphi_{Xi}$ = probability that the outcome is in category X
$P(Yx_{ij} = 1) = \varphi^{*}_{Xij}$ = probability that the outcome is in or below category X

$$\varphi_{Lij} = \varphi^{*}_{Lij}$$
$$\varphi_{Lij} + \varphi_{Sij} = \varphi^{*}_{Sij}$$
$$\varphi_{Lij} + \varphi_{Sij} + \varphi_{Tij} = \varphi^{*}_{Tij}$$
$$\varphi_{Lij} + \varphi_{Sij} + \varphi_{Tij} + \varphi_{Hij} = \varphi^{*}_{Hij} = 1$$

The expected value and variance for each category of the ordinal outcome variable are:

$$E(Y_{Xij}) = \varphi^{*}_{Xij}$$
$$Var(Y_{Xij}) = \frac{\varphi^{*}_{Xij}}{1-\varphi^{*}_{Xij}}$$

A logit link function was used to transform the ordinal outcome variable to estimate three values in model:

$$\eta_{Lij} = \ln\left(\frac{\varphi^{*}_{Lij}}{1-\varphi^{*}_{Lij}}\right)$$

$$\eta_{Sij} = \ln\left(\frac{\varphi^{*}_{Sij}}{1-\varphi^{*}_{Sij}}\right)$$

$$\eta_{Tij} = \ln\left(\frac{\varphi^{*}_{Tij}}{1-\varphi^{*}_{Tij}}\right)$$

Using this transformation, η_{Xij} is the logarithm of the predicted odds (or "log-odds") of a rating in or below category X. The predicted probability can be obtained by reversing the transformation using the formula:

$$P(Y_{Xij} = 1) = \frac{1}{1+e^{(-\eta_{Xij})}}$$

From these values, the predicted probabilities for an outcome in each category can be computed.

For each ordinal outcome the following model was run:

Level 1 Model

Prob[R = 1|B] = P'(1) = P(1)
Prob[R <= 2|B] = P'(2) = P(1) + P(2) + P(3)
Prob[R <= 3|B] = P'(3) = P(1) + P(2) + P(3)
Prob[R <= 4|B] = 1.0

where

P(1) = Prob[Y(1) = 1|B]
P(2) = Prob[Y(2) = 1|B]
P(3) = Prob[Y(3) = 1|B]

log[P'(1)/(1 - P'(1)] = B0
+ B1*(Project Year)
log[P'(2)/(1 - P'(2)] = B0
+ B1*(Project Year)
+ d(2)
log[P'(3)/(1 - P'(3)] = B0
+ B1*(Project Year)
+ d(3)

Level 2 Model

B0 = G00
+ G01*(Transformed number of students)
+ G02*(Transformed percent of students classified as non-Asian minority)
+ G03*(Transformed percent of students eligible for free/reduced-price lunch)
+ G04*(Limited English proficient: 1-10 Percent)
+ G05*(Limited English proficient: 11-50 Percent)
+ G06*(Limited English proficient: 51 Percent of more)
+ G07*(Community type: rural)
+ G08*(Community type: town or small city)
+ G09*(Community type: suburban)
+ G010*(Principal in school since start of project)
+ G011*(Principal in district since start of project)
+ $\sum G_i$*(Project$_i$)
+ U0

B1 = G10
+ G11*(Transformed number of students)
+ G12*(Transformed percent of students classified as non-Asian minority)
+ G13*(Transformed percent of students eligible for free/reduced-price lunch)
+ G14*(Limited-English proficient: 1-10 Percent)
+ G15*(Limited-English proficient: 11-50 Percent)
+ G16*(Limited-English proficient: 51 or more percent)
+ G17*(Community type: rural)
+ G18*(Community type: town or small city)
+ G19*(Community type: suburban)
+ G110*(Principal in school since start of project)
+ G111*(Principal in district since start of project)

B2 = G20

B3 = G30

HLM 5.05[3] was used for all analyses, with variables entered using grand-mean centering, except for project year, which was entered uncentered. Categorical independent variables were entered as sets of dummy-coded variables. Results are presented separately for mathematics and science.

Mathematics

The estimates of fixed effects for initial status for each ordinal outcome variable in mathematics are shown in Table 8. The individual project effects were included in the model to control for project-specific differences on each outcome, but are not shown because the analysis was focused on program-wide effects. Due to the transformation of the outcome variable and the centering of dummy-coded predictor variables, the magnitude and direction of these coefficients should not be interpreted directly. The coefficients must be converted to probabilities in order to draw meaningful interpretations and conclusions. In general, a negative coefficient for a predictor of initial status indicates that respondents with high scores on the predictor variable were less likely to be at the lower levels of the outcome variable. A negative coefficient for a predictor's effect on change over time indicates an accelerated effect—respondents with high scores on the predictor were less likely to respond in the lower categories as time progressed.

The only predictor of initial status that is significant across the various outcomes is proportion of students eligible for free/reduced-price lunch. Higher proportions of FRL students predicted lower initial status for perceived program progress, percent of teachers using the LSC-designated instructional materials, and percentage of teachers participating in LSC professional development.

[3] Raudenbush, S., Bryk, A., Cheong, Y. F., & Congdon, R. Scientific Software International, 2000.

Table 8
Fixed Effects for Initial Status, by Ordinal Outcome: Mathematics

	Teacher Involvement in LSC PD	Teacher Use of LSC Materials	Progress Towards Excellence	Student Achievement
Intercept	0.03 (0.13)	-0.21 (0.14)	-1.03*** (0.09)	-2.63*** (0.17)
Threshold (2)	0.87*** (0.04)	0.89*** (0.05)	1.02*** (0.04)	2.03*** (0.10)
Threshold (3)	1.86*** (0.06)	2.04*** (0.06)	3.63*** (0.08)	4.86*** (0.13)
Number of Students	-0.03* (0.02)	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.02)
Non-Asian Minority	-0.64 (0.61)	-0.69 (0.62)	1.05* (0.04)	0.50 (0.64)
Free/Reduced-Price Lunch	1.41** (0.52)	1.79** (0.53)	0.98* (0.39)	0.45 (0.55)
Limited-English Proficient (0 percent omitted) 1–10 percent	0.22 (0.27)	-0.09 (0.27)	-0.11 (0.20)	0.16 (0.30)
11–50 percent	0.08 (0.33)	-0.31 (0.33)	-0.21 (0.20)	0.09 (0.35)
51 or more percent	0.04 (0.62)	-0.38 (0.63)	-0.36 (0.41)	0.20 (0.65)
Community Type (Urban Omitted)				
Rural	0.04 (0.62)	-0.38 (0.63)	0.31 (0.34)	-0.05 (0.43)
Suburban	-0.24 (0.33)	-0.22 (0.34)	0.18 (0.23)	-0.17 (0.35)
Town or Small City	0.09 (0.38)	0.05 (0.38)	0.23 (0.30)	0.13 (0.39)
Principal in School since Beginning of the LSC	-0.32 (0.50)	-0.27 (0.51)	-1.06* (0.45)	-0.81 (0.56)
Principal in District since Beginning of the LSC	0.10 (0.56)	0.09 (0.58)	0.49 (0.52)	-0.51 (0.62)

~ $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Project year was a significant predictor of change over time for all four ordinal outcomes with schools shifting from the lower categories to the top categories over time (Table 9). In other words, there was a greater probability of schools being in the higher categories towards the end of the project than at the beginning. The predicted probabilities of a school being in each category of the outcome variables for the mathematics programs, by project year, are shown in Figure 1. For example, in terms of the principal's perception of school progress towards excellence in mathematics education, at the Baseline Year (project year = 0), there was about a 50 percent probability that a school would be "well along in improving" or "approaching ideal." By project's Year Six, the probability of a school being "well along in improving" or "approaching ideal" climbed to roughly 70 percent.

Table 9
Fixed Effects for Change over Time, by Ordinal Outcome: Mathematics

	Teacher Involvement in LSC PD	Teacher Use of LSC Materials	Progress Towards Excellence	Student Achievement
Project Year	-0.50*** (0.04)	-0.48*** (0.04)	-0.17*** (0.03)	-0.29*** (0.04)
Number of Students	0.01** (0.01)	0.01 (.01)	0.01 (0.01)	0.01* (0.01)
Non-Asian Minority	0.39* (0.18)	0.36 (0.19)	0.11 (0.13)	-0.11 (0.18)
Free/Reduced-Price Lunch	-0.46** (0.16)	-0.58*** (0.16)	-0.05 (0.11)	-0.18 (0.17)
Limited-English Proficient (0 percent omitted)				
1–10 percent	-0.10 (0.09)	-0.02 (0.09)	0.06 (0.07)	-0.03 (0.09)
11–50 percent	-0.02 (0.10)	0.12 (0.11)	0.03 (0.08)	0.03 (0.11)
51 or more percent	-0.04 (0.18)	0.13 (0.18)	0.19 (0.12)	0.04 (0.19)
Community Type (Urban Omitted)				
Rural	0.06 (0.13)	0.17 (0.13)	-0.18 (0.11)	-0.02 (0.13)
Suburban	0.09 (0.10)	0.09 (0.10)	-0.06 (0.07)	0.01 (0.10)
Town or Small City	-0.02 (0.12)	-0.02 (0.12)	-0.17 (0.11)	-0.10 (0.12)
Principal in School since Beginning of the LSC	-0.05 (0.13)	-0.02 (0.14)	0.10 (0.12)	0.15 (0.14)
Principal in District since Beginning of the LSC	-0.10 (0.14)	-0.10 (0.14)	-0.14 (0.14)	0.04 (0.16)

~ $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

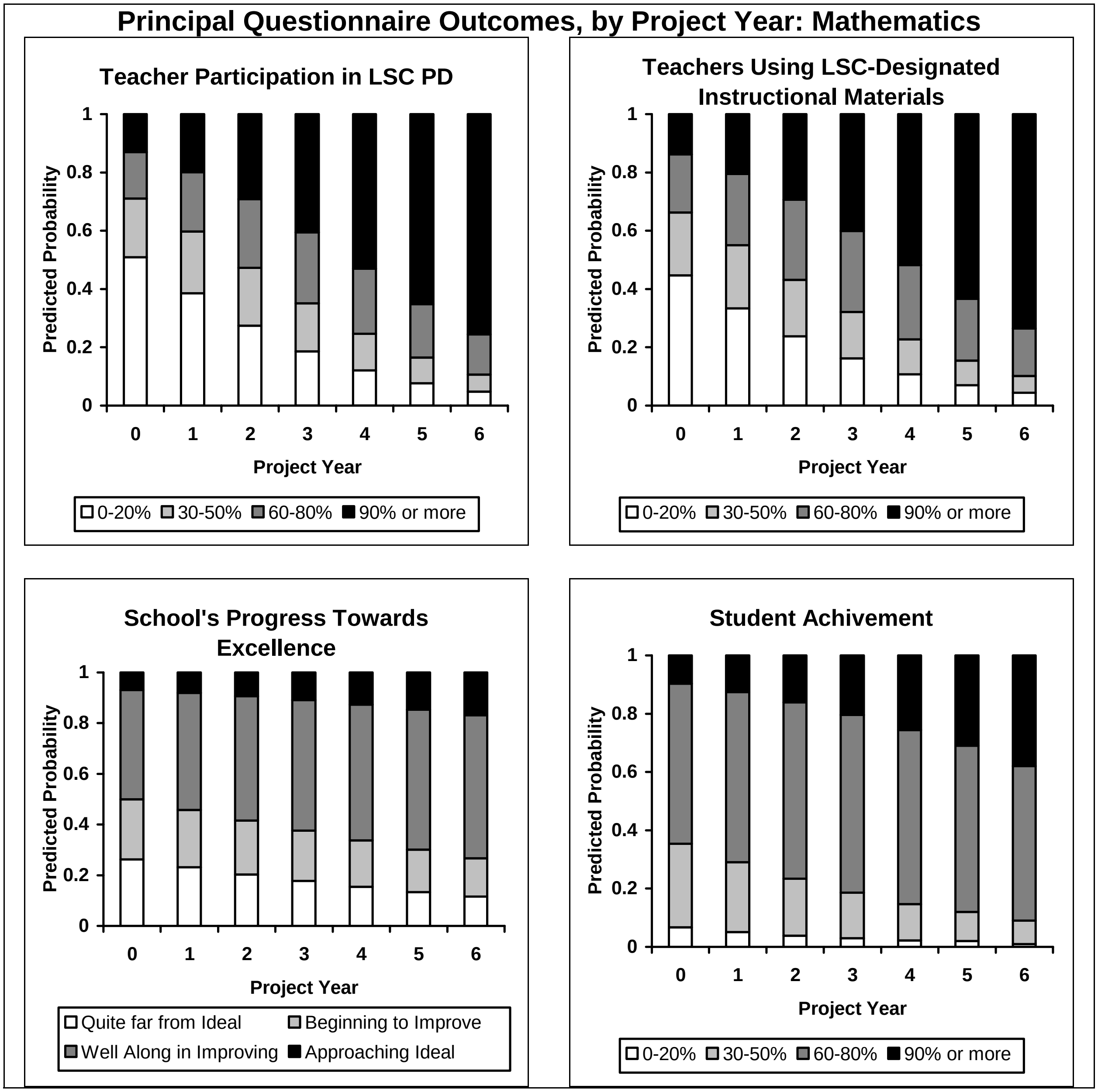

Figure 1

Change over time was moderated by several predictors. Schools with higher proportions of free/reduced-price lunch students tended to move more quickly into the higher response categories for the percent of teachers using the LSC-designated instructional materials and teacher participation in LSC professional development activities. In other words, those starting with more room for growth tended to grow more rapidly. For example, a school with 5 percent FRL students had a 52 percent probability of the principal reporting 20 percent or fewer teachers using the LSC-designated instructional materials at the start of the project. At the end of the project, such a school had only an 11 percent probability of being rated in this category. A school with 95 percent FRL students had an 80 percent probability of being rated in this category at the start of a project compared to a 19 percent probability at the end of the project.

School with higher proportions of non-Asian minorities tended to exhibit slower growth in terms of teacher participation in LSC professional development activities. For example, a school with 5 percent non-Asian minorities had a 48 percent probability of the principal indicating that 20 percent or fewer teachers were participating in LSC professional development at the start of the project and a 4 percent predicted probability of responding in this category at the end of the project. For a school with 95 percent non-Asian minorities, these probabilities became 42 and 3 percent, respectively.

Science

The estimates of fixed effects for initial status for each ordinal outcome variable for science programs are shown in Table 10. Again, the individual project effects were included in the model to control for project-specific differences on each outcome, but are not shown because the analysis was focused on program-wide effects. As noted earlier, a negative coefficient for a predictor of initial status indicates that respondents with high scores on the predictor variable were less likely to be at the lower levels of the outcome variable. A negative coefficient for a predictor's effect on change over time indicates an accelerated effect- more change as time progressed.

As in the mathematics programs, high proportions of FRL students predicted lower initial status for perceived program progress. In contrast to the mathematics programs, community type and percentage of LEP students predicted initial status for several ordinal outcomes for the science programs. Higher proportions of LEP students predicted lower initial status for perceived program progress towards excellence and perceived student achievement, but higher initial status for the proportion of teachers using the LSC-designated instructional materials. School locations in rural or suburban areas or in towns or small cities predicted higher initial status on percent of teachers using the LSC-designated instructional materials and teacher participation in LSC professional development activities than did schools in urban locations.

Table 10
Fixed Effects for Initial Status, by Ordinal Outcome: Science Programs

	Teacher Involvement in LSC PD	Teacher Use of LSC Materials	Progress Towards Excellence	Student Achievement
Intercept	-0.25 (0.15)	-0.54*** (0.16)	-0.97*** (0.09)	-3.19*** (0.20)
Threshold (2)	0.94*** (0.05)	0.87*** (0.05)	1.78*** (0.04)	2.56*** (0.12)
Threshold (3)	1.99*** (0.06)	1.99*** (0.06)	3.58*** (0.07)	5.41*** (0.14)
Number of Students	0.01 (0.01)	0.02 (0.02)	-0.05** (0.01)	-0.01 (0.02)
Non-Asian Minority	0.29 (0.54)	0.49 (0.52)	0.30 (0.42)	-0.62 (0.60)
Free/Reduced-Price Lunch	-0.31 (0.41)	0.04 (0.42)	1.28** (0.34)	0.71 (0.46)
Limited-English Proficient (0 percent omitted) 1–10 percent	-0.09 (0.22)	-0.49* (0.23)	0.27 (0.19)	0.24 (0.26)
11–50 percent	-0.23 (0.33)	-0.74* (0.34)	0.68** (0.25)	0.86* (0.38)
51 or more percent	-0.79 (0.81)	-1.69* (0.82)	1.31** (0.47)	1.59~ (0.92)
Community Type (Urban Omitted)				
Rural	-0.97* (0.37)	-0.86* (0.38)	0.13 (0.30)	0.04 (0.40)
Suburban	-0.64* (0.28)	-1.11** (0.35)	-0.12 (0.22)	-0.12 (0.32)
Town or Small City	-1.21** (0.35)	-0.30* (0.29)	-0.16 (0.27)	-0.52 (0.38)
Principal in School since Beginning of the LSC	0.08 (0.47)	0.17 (0.48)	-0.13 (0.37)	-0.51 (0.56)
Principal in District since Beginning of the LSC	-0.05 (0.55)	0.11 (0.56)	0.21 (0.44)	-0.73 (0.64)

~ $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

As in the mathematics programs, project year was a significant predictor of all four ordinal outcomes with schools moving towards the higher response categories as projects mature (see Table 11). These relationships are illustrated in Figure 2.

Table 11
Fixed Effects for Change over Time, by Ordinal Outcome: Science Programs

	Teacher Involvement in LSC PD	Teacher Use of LSC Materials	Progress Towards Excellence	Student Achievement
Project Year	-0.39*** (0.04)	-0.36*** (0.04)	-0.20*** (0.03)	-0.22*** (0.05)
Number of Students	-0.01 (0.01)	0.01 (0.01)	0.01** (0.01)	0.01 (0.01)
Non-Asian Minority	0.15 (0.14)	0.04 (0.14)	0.31** (0.12)	0.34* (0.16)
Free/Reduced-Price Lunch	0.02 (0.12)	-0.03 (0.12)	-0.15 (0.10)	-0.19 (0.13)
Limited-English Proficient (0 percent omitted)				
1–10 percent	-0.06 (0.06)	0.05 (0.06)	-0.09 (0.06)	-0.11 (0.07)
11–50 percent	0.01 (0.09)	0.11 (0.09)	-0.20*** (0.07)	-0.19~ (0.10)
51 or more percent	0.18 (0.18)	0.36* (0.19)	-0.14 (0.12)	-0.19 (0.20)
Community Type (Urban Omitted)				
Rural	0.09 (0.11)	0.02 (0.11)	-0.12 (0.09)	-0.04 (0.11)
Suburban	0.16 (0.08)	0.12 (0.08)	-0.01 (0.06)	-0.02 (0.08)
Town or Small City	0.19 (0.10)	0.18 (0.10)	-0.05 (0.08)	0.06 (0.11)
Principal in School since Beginning of the LSC	-0.05 (0.11)	-0.08 (0.11)	-0.13 (0.37)	0.07 (0.13)
Principal in District since Beginning of the LSC	-0.09 (0.12)	-0.10 (0.12)	0.21 (0.44)	0.05 (0.14)

~ $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

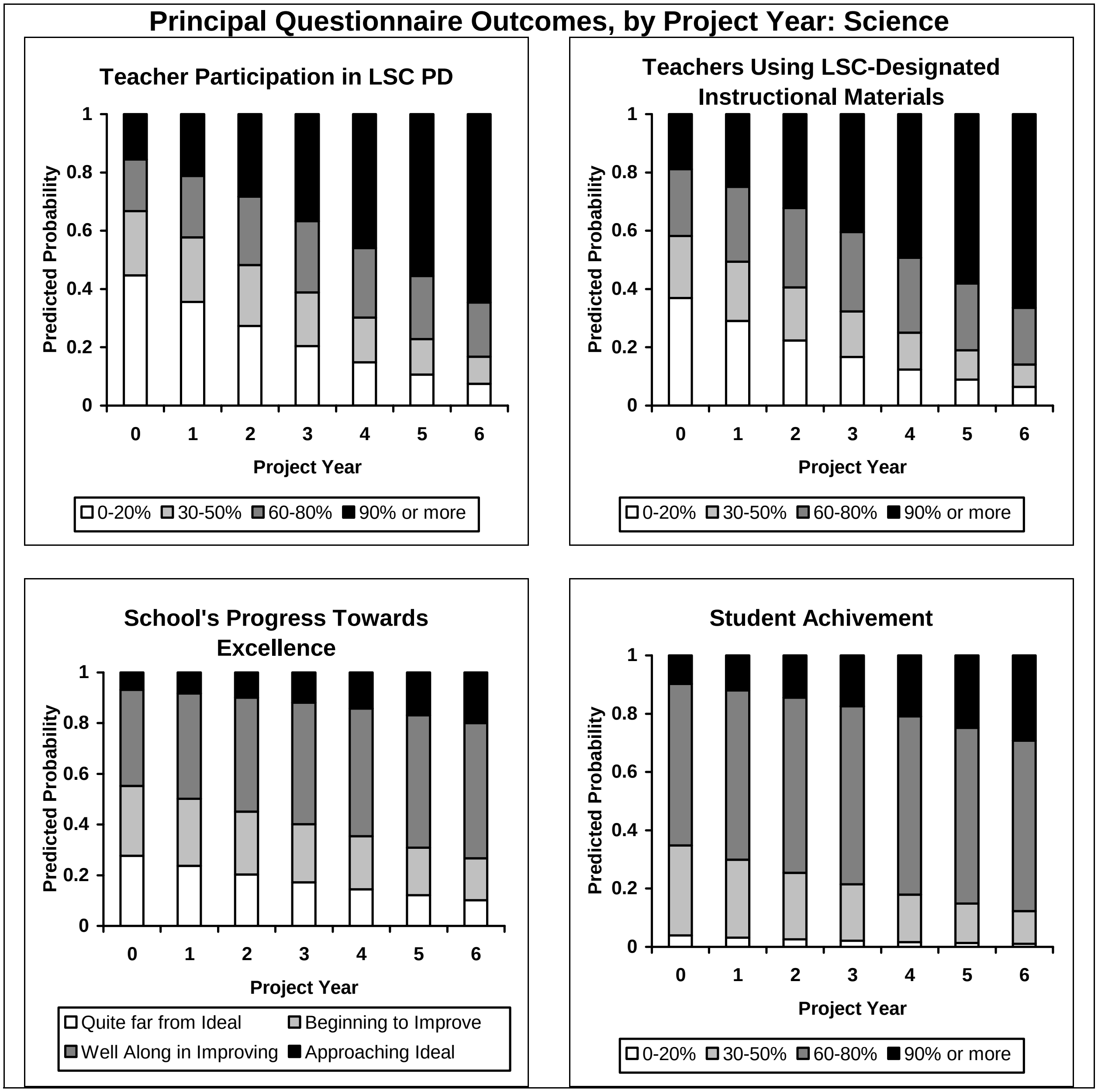

Figure 2

In addition, a number of demographic factors moderated the relationships between outcomes and project year. Schools with more students and higher proportions of non-Asian minorities exhibited less improvement in perceived program progress than did schools with fewer students and non-Asian minorities. Additionally, schools with higher proportions of non-Asian minorities exhibited less improvement in perceived student achievement.

There also appears to be a trend for schools with a higher proportion of LEP students to show an accelerated amount of growth in perceived program progress and perceived student achievement. Although these schools started at lower levels on these outcomes, there was greater room for growth. Schools with more than 50 percent LEP students showed less change in the proportion of teachers using the LSC-designated instructional materials than schools with no LEP students, but this is almost certainly due to the initially high proportion of teachers using these materials in majority LEP schools. For example, the probability of a school with a majority of LEP students having 20 percent or fewer teachers using the LSC-designated instructional materials dropped from 13 percent in a project's Baseline Year to two percent by the Final Year. In contrast, a school with no LEP students had a 37 percent probability of being in this category during a project's Baseline Year and a six percent probability during the Final Year.

Impact of LSC on Principals

In terms of the impact of the LSC on principals, the three outcome variables of interest are composite scores[4] measuring:

- Principals' attitudes toward reform-oriented teaching;
- Principals' perceptions of their support for mathematics/science teaching; and
- Principals' perceptions of the effect of resource availability on mathematics/science teaching.

These composite scores are measured on continuous scales. Composite scores were converted to "percent of total possible points" scales. As with the continuous school-level predictors, the continuous outcome variables did not meet normality requirements and needed to be transformed. The transformations are listed in Appendix B. Tables 12 and 13 show the means and standard deviations of the continuous outcome variables by project year for the mathematics and science programs. Overall, composite scores for both mathematics and science programs started very high and remained so over the life of a project.

Table 12
Mathematics Composites, by Project Year

	Mean (Standard Deviation)					
	Baseline Year		Year Two		Final Year†	
Attitudes Toward Teaching	91.12	(9.60)	89.61	(9.62)	89.13	(9.65)
Principal Support	84.99	(12.23)	83.93	(11.02)	84.01	(9.48)
Effects of Resource Availability	80.31	(15.59)	80.63	(13.90)	81.84	(13.52)

† Projects' Final Year ranged from Year Three to Year Six, depending on individual project duration.

[4] See <http://www.horizon-research.com/LSC/news/composites/composites.pdf> for definitions of the principal composites.

Table 13
Science Composites, by Project Year

	Mean (Standard Deviation)					
	Baseline Year		Year Two		Final Year†	
Attitudes Toward Teaching	89.47	(9.07)	89.39	(8.79)	89.13	(9.17)
Principal Support	80.83	(12.12)	82.50	(10.96)	83.46	(10.15)
Effects of Resource Availability	75.73	(17.95)	79.77	(16.15)	80.78	(15.70)

† Projects' Final Year ranged from Year Three to Year Six, depending on individual project duration.

Because their distributions were not normally distributed, each was transformed as necessitated by the level and direction of skewness and kurtosis. The particular transformations employed are listed in Appendix B.

For each continuous outcome, a three-level hierarchical linear model (observations nested within schools nested within projects) was used to investigate the relationship between principals' composite scores and project year and school-level predictors. The independent variables included at the observation level were:

- Project year;

At the school level, the following independent variables were included:

- Number of students enrolled in the school;
- Percent of students in the school classified as non-Asian minority;
- Percent of students in the school eligible for free/reduced-price lunch;
- Percent of students in the school classified as limited-English proficient (dummy coded); and
- Community type in which the school was located (dummy coded)
- Principal at the same school since beginning of LSC project; and
- Principal in the same district since beginning of LSC project.

At the project level, the only independent variable included was:

- Number of teachers targeted by the project.

For each continuous outcome the following model was run:

Level 1 Model

Y = P0
+ P1*(Project Year)
+ E

Level 2 Model

P0 = B00
+ B01*(Transformed number of students in school)
+ B02*(Transformed percent of students classified as non-Asian minority)
+ B03*(Transformed percent of students eligible for free/reduced-price lunch)
+ B04*(Limited-English proficient: 1-10 Percent)
+ B05*(Limited-English proficient: 11-50 Percent)
+ B06*(Limited-English proficient: 51 or more Percent)
+ B07*(Community type: rural)
+ B08*(Community type: town)
+ B09*(Community type: suburban)
+ B010*(Principal in school since beginning of project)
+ B011*(Principal in district since beginning of project)
+ R0

P1 = B10
+ B11*(Transformed number of students in school)
+ B12*(Transformed percent of students classified as non-Asian minority)
+ B13*(Transformed percent of students eligible for free/reduced-price lunch)
+ B14*(Limited-English proficient: 1-10 Percent)
+ B15*(Limited-English proficient: 11-50 Percent)
+ B16*(Limited-English proficient: 51 or more Percent)
+ B17*(Community type: rural)
+ B18*(Community type: town)
+ B19*(Community type: suburban)
+ B110*(Principal in school since beginning of project)
+ B111*(Principal in district since beginning of project)
+ R0

Level 3 Model

B00 = G000 + G001*(Transformed number of targeted teachers) + U00
B01 = G010
B02 = G020
B03 = G030
B04 = G040
B05 = G050
B06 = G060
B07 = G070
B08 = G080
B09 = G090
B10 = G100 + G101*(Transformed number of targeted teachers) + U10
B11 = G110
B12 = G120
B13 = G130
B14 = G140
B15 = G150
B16 = G160
B17 = G170
B18 = G180
B19 = G190
B20 = G200
B30 = G300

HLM 5.05 was used for all analyses, with variables entered using grand-mean centering, except for project year which was entered uncentered. Categorical variables were entered as sets of dummy-coded variables. In addition, the random effects were tested for inclusion in each model (i.e., the relationship between the level one predictor variable and the outcome variable varied across projects).

For these models, the fixed effects estimates of main effects on the initial status for the continuous outcome variables are shown in Table 14. The interpretation of the coefficients for the continuous outcomes is much more straightforward than for ordinal outcomes. For the continuous variables, positive coefficients indicate higher initial status or more growth over time in the case of variables affecting slopes.

Few predictors showed a relationship with the initial status or change over time for any of the continuous outcome variables. Principals from schools with 1–50 percent LEP students showed a slightly lower initial status in attitudes toward reform-based teaching than did principals from schools with no LEP students. Principals from schools in rural and suburban areas as wells in towns or small cities showed a lower initial status in attitudes toward reform-based teaching and in the perceived effects of resource availability than did principals in urban schools. Principals that had been in their school since the beginning of the project showed a higher initial status in the perceived effects of resource availability.

Table 14
Fixed Effects for Initial Status, by Continuous Outcome: Mathematics

	Attitudes Toward Reform-Oriented Teaching	Principal Support	Effect of Resource Availability
Intercept	1.32*** (0.01)	0.63*** (0.01)	1.13*** (0.01)
Number of Students in School	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)
Non-Asian Minority	-0.01 (0.03)	-0.03 (0.04)	-0.01 (0.04)
Free/Reduced-Price Lunch	0.03 (0.03)	-0.01 (0.02)	-0.02 (0.04)
Limited-English Proficient (0 percent omitted) 1–10 percent	-0.04** (0.02)	-0.01 (0.02)	0.01 (0.02)
11–50 percent	-0.06** (0.02)	-0.03 (0.02)	-0.04 (0.02)
51 or more percent	-0.07 (0.03)	0.03 (0.04)	0.06 (0.04)
Community Type (Urban Omitted)			
Rural	-0.10*** (0.02)	-0.06~ (0.03)	-0.11*** (0.03)
Suburban	-0.05** (0.02)	-0.03 (0.02)	-0.06** (0.02)
Town or Small City	-0.07** (0.02)	-0.07 (0.03)	-0.08** (0.03)
Principal in School since Beginning of the LSC	0.01 (0.04)	0.04 (0.04)	0.09* (0.04)
Principal in District since Beginning of the LSC	-0.01 (0.04)	0.06 (0.05)	-0.05 (0.05)
Number of Students Targeted by Project	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)

~ $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 15 shows the fixed effects estimates of main effects for change over time of the continuous outcome variables for the mathematics programs. Overall, scores on the attitudes toward reform-oriented teaching showed a very slight decline over time. However, principals in schools with higher numbers of LEP students and schools in rural areas or towns or small cities tended to score higher on this composite over time. Principals in schools in rural areas showed a very slight increase in perceptions of their support for reform-oriented teacher over time. The effect sizes for both initial status and change were, however, exceptionally small, representing a change of less than 0.10 standard deviations. The small changes in the outcome variables over time (Table 12) may be due to ceiling effects in the continuous outcome variables; scores started and remained high. Table 16 shows the standardized regression coefficients (i.e., effect size) for project year for continuous outcome variables for the mathematics programs.

Table 15
Fixed Effects for Change over Time, by Continuous Outcome: Mathematics

	Attitudes Toward Reform-Oriented Teaching	Principal Support	Effect of Resource Availability
Project Year	-0.01*** (0.01)	-0.01 (0.01)	0.01 (0.01)
Number of Students in School	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)
Non-Asian Minority	0.02* (0.01)	0.01 (0.01)	0.01 (0.01)
Free/Reduced-Price Lunch	-0.01 (0.01)	-0.01 (0.01)	0.01 (0.01)
Limited-English Proficient (0 percent omitted)			
1–10 percent	0.02** (0.01)	0.01 (0.01)	-0.01 (0.01)
11–50 percent	0.02** (0.01)	0.01 (0.01)	0.01 (0.01)
51 or more percent	0.03** (0.01)	0.01 (0.01)	-0.01 (0.01)
Community Type (Urban Omitted)			
Rural	0.03* (0.01)	0.02* (0.01)	0.01 (0.01)
Suburban	0.01 (0.01)	0.01 (0.01)	0.02** (0.01)
Town or Small City	0.02* (0.01)	0.02~ (0.01)	0.02~ (0.01)
Principal in School since Beginning of the LSC	-0.01 (0.01)	0.04 (0.04)	-0.02~ (0.01)
Principal in District since Beginning of the LSC	0.01 (0.01)	0.06 (0.06)	0.01 (0.01)
Number of Students Targeted by Project	-0.01 (0.01)	0.01 (0.01)	0.01 (0.01)

~ $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 16
Continuous Outcome Variables, Mathematics Programs:
Standardized Regression Coefficients for Project Year

	Standardized Regression Coefficient
Attitudes Toward Teaching	-0.09**
Principal Support	-0.09
Effects of Resource Availability	0.08

**$p < 0.01$

Table 17 shows HLM results for initial status for the continuous outcome variables for the science programs. Slightly higher initial status in perceived principal support was associated with a higher number of students in the school and to the school's being in a town or small city.

Table 17
Fixed Effects for Initial Status, by Continuous Outcome: Science Programs

	Attitudes Toward Reform-Oriented Teaching	Principal Support	Effect of Resource Availability
Intercept	0.06*** (0.01)	0.61*** (0.01)	0.97*** (0.02)
Number of Students in School	0.01 (0.01)	0.01* (0.01)	0.01 (0.01)
Non-Asian Minority	0.03 (0.03)	0.04 (0.04)	0.04 (0.06)
Free/Reduced-Price Lunch	0.01 (0.03)	-0.03 (0.03)	-0.04 (0.05)
Limited-English Proficient (0 percent omitted) 1–10 percent	0.01 (0.02)	0.02 (0.02)	-0.02 (0.03)
11–50 percent	0.01 (0.02)	0.02 (0.03)	-0.04 (0.04)
51 or more percent	0.05 (0.04)	0.14 (0.05)	-0.02 (0.07)
Community Type (Urban Omitted)			
Rural	-0.04 (0.02)	0.04 (0.03)	-0.02 (0.04)
Suburban	0.01 (0.02)	0.02 (0.02)	-0.05 (0.03)
Town or Small City	-0.01 (0.02)	0.06* (0.03)	-0.02 (0.04)
Principal in School since Beginning of the LSC	0.02 (0.03)	-0.01 (0.04)	-0.01 (0.06)
Principal in District since Beginning of the LSC	0.02 (0.04)	0.03 (0.05)	-0.04 (0.07)
Number of Students Targeted by Project	0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)

~ $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 18 shows the HLM results concerning change over time for the continuous outcome variables for the science programs. Scores on the attitudes toward reform-oriented teaching composite declined very slightly over time. Principals' perception of their support for reform-oriented teaching and the effects of resource availability increased very slightly over time. The increase in perceived principal support over time was offset in schools with more than 51 percent LEP students and schools in towns or small cities. As in the mathematics data, the regression coefficients describe exceptionally small effects, less than a 0.10 standard deviations change. Scores on all of the outcome variables were very high at all measurement occasions (Table 13). Table 18 shows the standardized regression coefficients for project year for continuous outcome variables for the science programs.

Table 18
Fixed Effects for Change Over Time, by Continuous Outcome: Science Programs

	Attitudes Toward Reform-Oriented Teaching	Principal Support	Effect of Resource Availability
Project Year	-0.01* (0.01)	0.01* (0.01)	0.01* (0.01)
Number of Students in School	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)
Non-Asian Minority	0.01 (0.01)	0.01 (0.01)	-0.01 (0.02)
Free/Reduced-Price Lunch	-0.01 (0.01)	-0.01 (0.01)	0.01 (0.01)
Limited-English Proficient (0 percent omitted)			
1–10 percent	0.01 (0.01)	0.01 (0.01)	0.01~ (0.01)
11–50 percent	-0.01 (0.01)	0.01 (0.01)	0.01 (0.01)
51 or more percent	-0.01 (0.01)	-0.04** (0.01)	0.01 (0.02)
Community Type (Urban Omitted)			
Rural	0.01 (0.01)	-0.01 (0.01)	0.01 (0.01)
Suburban	0.01 (0.01)	-0.01 (0.01)	0.03** (0.01)
Town or Small City	-0.01 (0.01)	-0.02** (0.01)	0.02~ (0.01)
Principal in School since Beginning of the LSC	-0.01 (0.01)	-0.01 (0.01)	0.01 (0.01)
Principal in District since Beginning of the LSC	0.01 (0.01)	0.01 (0.01)	0.02 (0.01)
Number of Students Targeted by Project	-0.01 (0.01)	-0.01~ (0.01)	0.01 (0.01)

~ $p < .10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 19
Continuous Outcome Variables, Science Programs:
Standardized Regression Coefficients for Project Year

	Standardized Regression Coefficient
Attitudes Toward Teaching	-0.09*
Principal Support	0.03*
Effects of Resource Availability	0.10*

* $p < .05$

CONCLUSIONS

These analyses indicate that the LSC appears to be achieving a number of the intended school-level impacts for both mathematics and science programs; principals were more likely to rate their schools higher as time progressed in progress toward excellence and increased student achievement. In addition, principals in both mathematics and science reported a greater proportion of teachers using the LSC-designated instructional materials and participating in LSC professional development over time. Very little change over time was observed in principals' attitudes toward reform-oriented teaching, perceptions of their support for teachers implementing the type of instruction recommended by the LSC, and the perceived effects of resource availability on mathematics/science. This lack of change is probably due to the very high initial status of these variables.

The most striking effect concerning the relationship between predictor and outcome variables was that, in some circumstances, schools starting at a lower level made up ground more ground over time than schools starting at a higher level. This effect was observed for the relationship between the percentage of FRL students and the proportion of teachers using the LSC-designated instructional materials and participating in LSC professional development for schools in mathematics LSCs. The relationship between the percentage of LEP students and perceived program progress and student achievement for schools in science LSCs showed a similar pattern. Overall, the percentage of LEP students and community type played a stronger role in the outcomes for the science LSCs than for the mathematics LSCs.

It is important to note that all of the outcomes examined in these analyses are based upon self-report data. Thus, principal reports of impacts (e.g., proportion of teachers involved in LSC professional development) may or may not be supported by other, more objective, measures (such as project records of teacher participation).

Appendix A

Number of Cases Used for HLM Analyses

Mathematics Programs			
Ordinal Outcomes	**Time-Point Level**	**Principal/School Level**	**Project Level**
Teacher Involvement in LSC PD	2037	1491	NA
Teacher Use of LSC Materials	2024	1486	NA
Progress Towards Excellence	2811	1837	NA
Student Achievement	2068	1503	NA
Continuous Outcomes			
Attitudes Toward Reform-Oriented Teaching	2684	1783	43
Principal Support	2774	1820	43
Effect of Resource Availability	2265	1577	43

Science Programs			
Ordinal Outcomes	**Time-Point Level**	**Principal/School Level**	**Project Level**
Teacher Involvement in LSC PD	2234	1824	NA
Teacher Use of LSC Materials	2223	1818	NA
Progress Towards Excellence	3329	2309	NA
Student Achievement	2257	1845	NA
Continuous Outcomes			
Attitudes Toward Reform-Oriented Teaching	3074	2163	47
Principal Support	2453	1876	47
Effect of Resource Availability	2744	2007	47

Appendix B

Transformations Used to Normalize Variables

Variable	Transformation
Predictors	
Number of students in school	Square Root (original)
Percent of student body classified as non-Asian minority	$(\text{Arcsine}(\text{Square Root}(\text{original}/100)))^{1.5}$
Percent of students in school eligible for free-reduced-price lunch	Transformed—arcsine(square root(original/100))
Outcomes	
Attitudes toward teaching	
Mathematics	Arcsine(Square Root(original/100))
Science	$\text{LN}((\text{original}/100)^{0.35}\text{-}(1\text{-original}/100)^{0.35}+5)$
Principal support	
Mathematics	$(\text{original}/100)^{3}$
Science	$(\text{original}/100)^{2.75}$
Effects of resource availability	
Mathematics	Arcsine(Square Root(original/100))
Science	Arcsine(original/100)