LSC Teacher Questionnaire Study: Indicators of Systemic Change A Longitudinal Analysis of Data Collected Between 1997 and 2006

by

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INTRODUCTION

The Local Systemic Change (LSC) program was designed to provide a substantial amount of professional development to all teachers of mathematics or science in a project's targeted schools with a substantial amount of professional development. Each district participating in an LSC project selected a set of standards-based instructional materials around which the LSC professional development program was built. Because the projects were designed as systemic change initiatives, they also were intended to promote a supportive policy environment and to cultivate support from key stakeholders for standards-based classroom practice.

For a variety of reasons the LSCs were not able to provide the intended number of hours of professional development at the level intended for all targeted teachers. However, if the LSCs achieved a measure of systemic change, discernible changes in teachers' classroom practice may still be evident on a widespread basis, either due to teachers' participation in LSC-sponsored professional development, or due to the supportiveness of the context in which the LSCs operated.

Two "indicators of systemic change" in teachers' classroom practice were selected for investigation because they could potentially be influenced both by teachers' participation in LSC professional development and by the supportiveness of the district and school context in which they worked. The first of these indicators was teachers' use of the district-designated instructional materials in their classroom instruction. Much of the LSC professional development focused on implementing standards-based instructional materials, so it was expected that there would be a positive relationship between this indicator and teachers' extent of participation in LSC professional development. Teachers' use of particular materials would also be expected to be tied to materials adoption policies and support structures for acquiring, using, and refurbishing materials. To the extent that the LSCs managed to influence these policies and develop the support from key stakeholders for implementation of the district-designated materials, an impact on this indicator among all teachers, beyond the effects of professional development, might be expected.

The second indicator of systemic change was time on science instruction in the elementary grades. Unlike secondary schools, where time on instruction is largely determined by scheduling policies, and unlike mathematics in elementary schools, where substantial time on instruction is regulated due to high-stakes testing, time on science instruction in elementary schools has typically been quite limited and up to the discretion of teachers and schools. A key challenge for LSCs targeting elementary science was increasing the amount of time spent on science instruction. The science-focused professional development of these LSCs was hypothesized to increase the amount of time that participating teachers would dedicate to their science instruction. Additionally, efforts that LSCs might have devoted to building support among key stakeholders, (e.g., superintendents, principals, and parents), and the work they may have conducted to influence policies that would encourage attention to science instruction at the elementary level, were expected to result in a greater amount of time on science instruction among all teachers.

This study makes use of longitudinal questionnaire data collected from teachers that have been targeted by the LSC projects to date. A series of three-level hierarchical generalized linear models (HGLM), with observations nested in teachers, nested in projects, was used to investigate both the systemic impact of the LSC projects and the impact of teacher participation in LSC professional development on teachers' use of the district-designated instructional materials, and, in projects targeting science in the elementary grades, teachers' time spent on science instruction.

FREQUENCY OF USE OF DISTRICT-DESIGNATED INSTRUCTIONAL MATERIALS

Sample

Between 1997 and 2006, nearly 72,000 questionnaires were submitted by teachers at multiple time points. The data set was reduced by the removal of teacher leaders (who are not representative of the typical teacher targeted by the LSCs) and teachers with incomplete questionnaire data. The final data set used in these analyses includes 33,526 questionnaires, representing 85 LSC projects.

Analysis and Results

The LSC core evaluation requires projects to collect questionnaire data from either a random sample of 300 teachers or their entire targeted population, if 350 or fewer teachers.[1] Table 1 shows the frequency of use of district-designated materials for teachers in the sample by subject and grade range.[2]

The LSC teacher questionnaire data have a nested structure, with multiple observations nested within each teacher, nested within each project. 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 (Raudenbush & Bryk, 2002[3]).

[1] Beginning with the 1999–2000 data collection year, projects also administered teacher questionnaires to a "program sample." The program sample was purposively selected to gather longitudinal data, with the size of each project's sample proportional to project size. The analyses presented in this report draw upon longitudinal data collected as part of the program sample and those collected serendipitously (teachers randomly selected at multiple time points).

[2] Unless otherwise noted, all statistics are based upon weighted data.

[3] Bryk, A. S. & Raudenbush, S.W. (2002). *Hierarchical linear models: Applications and data analysis methods. Second Edition.* Newbury Park, CA: Sage Publications.

The outcome of interest in this analysis was the frequency of teachers' use of the district-designated instructional materials in their classroom practice. This variable was measured with a single question on the LSC Teacher Questionnaire. Teachers indicated how often they used the designated materials as the basis of lessons on a five-point scale, ranging from "Never" to "All or almost all lessons." For this analysis, the two responses "Never" and "Rarely (e.g., a few times a year)" were collapsed into a single category because the use of materials a few times a year was considered to be an insignificant portion of teachers' overall classroom practice. Table 1 shows descriptive statistics for the outcome variable by the subject/grade-range of the project.

Table 1
Descriptive Statistics for Frequency of Use of District-Designated Materials

			Percent of Questionnaires			
		N	Never or Rarely	Sometimes	Often	Always
K–8 Science	Unweighted	15,407	31	19	21	28
	Weighted	90,754	30	20	22	28
K–8 Mathematics	Unweighted	12,657	27	18	24	31
	Weighted	63,059	29	19	23	29
6–12 Mathematics	Unweighted	4,122	42	16	13	29
	Weighted	13,858	42	16	13	29
6–12 Science	Unweighted	1,340	49	20	18	13
	Weighted	3,516	50	20	17	13

The purpose of the analysis was to examine the relationship between the frequency of teachers' use of the district-designated instructional materials and both the number of years the project had been in existence and the extent of teachers' participation in LSC-sponsored professional development.

A three-level hierarchical ordinal model (time points nested in teachers, nested in projects) was used to investigate these relationships. In addition, a number of teacher and school demographic factors were controlled for in these models, for example, teacher's experience level and type of community in which the school is located.

The independent variables included at the time point level were:

- Project year;
- Extent of teacher's participation in LSC professional development;
- Teacher's experience level;
- Teacher's perception of principal support;
- Teacher's perception of pedagogical preparedness; and
- Teacher's perception of content preparedness.

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

- Number of students enrolled in the teacher's school;
- Percent of students in the school classified as non-Asian minority;
- Percent of students in the school classified as limited-English proficient (LEP);
- Percent of students in the school eligible for free/reduced-price lunch (FRL); and
- Community type in which the school was located (dummy coded).

At the project level, the following predictors were included:

- Number of teachers targeted by the LSC; and
- Subject/grade-range targeted by the LSC (dummy coded).

Descriptive statistics for the time-point-level, teacher/school-level, and project-level independent variables are shown in Tables 2–7. The distributions of the continuous variables were examined for normality, revealing concerns regarding the skewness and kurtosis of some of the distributions. Transformations that yielded the best overall correction for skewness and kurtosis were applied to variables as needed. For the appropriate variables, both original and transformed values are presented in the tables.

Nearly half of the questionnaires were submitted when the teacher had participated in fewer than 20 hours of LSC professional development, but there was a wide range of extent of participation. Roughly half of the questionnaires came from teachers that had taught for 11 or more years, while about one-third indicated having five or fewer years of experience.

Almost half of the questionnaires were from teachers located in schools in urban areas, about one-fourth in schools in suburban communities, with the remainder evenly divided between schools in rural areas and schools in towns/small cities. School sizes varied widely, ranging from a low of 7 to over 3,000 students. On average, 46 percent of the students in these schools were non-Asian minority, 14 percent were classified as limited-English proficient, and 49 percent were eligible for free/reduced-price lunch.

Table 2
Descriptive Statistics for Time-Point-Level Variables

	Percent of Questionnaires (N = 33,526)	Weighted Percent of Questionnaires (N = 171,187)
Extent of Teacher Participation in LSC Professional Development		
0 hours	28	27
1–9 hours	8	10
10–19 hours	9	10
20–39 hours	13	13
40–59 hours	10	11
60–79 hours	7	7
80–99 hours	6	6
100–129 hours	8	8
130–159 hours	4	3
160–199 hours	2	2
200 or more hours	3	3
Prior Teaching Experience		
5 or fewer years	34	34
6–10 years	17	17
11 or more years	50	49
Project Year		
0	13	8
1	7	7
2	28	25
3	14	15
4	15	18
5	18	20
6	5	6

Table 3
Descriptive Statistics for Time-Point-Level Variables (Unweighted)

	Minimum	Maximum	Mean	Standard Deviation
Perception of Pedagogical Preparedness				
Original	25.00	100.00	76.97	13.47
Transformed–Box and Cox	0.06	1.00	0.61	0.20
Perception of Content Preparedness				
Original	25.00	100.00	67.21	18.18
Transformed–Box and Cox	-0.66	0.00	-0.31	0.16
Perception of Principal Support				
Original	20.00	100.00	75.98	14.13
Transformed–Divided by 100, Squared	0.04	1.00	0.60	0.21

Table 4
Descriptive Statistics for Time-Point-Level Variables (Weighted)

	Minimum	Maximum	Mean	Standard Deviation
Perception of Pedagogical Preparedness				
Original	25.00	100.00	77.15	13.57
Transformed–Box and Cox	0.06	1.00	0.61	0.20
Perception of Content Preparedness				
Original	25.00	100.00	75.75	14.41
Transformed–Box and Cox	-0.66	0.00	-0.32	0.17
Perception of Principal Support				
Original	20.00	100.00	59.46	20.82
Transformed–Divided by 100, Squared	0.04	1.00	0.61	0.20

Table 5
Descriptive Statistics for Teacher-Level Variables

	Percent of Teachers (N = 27,196)
Community type in which teacher's school is located	
Rural	13
Town or small city	17
Suburban	24
Urban	46

Table 6
Descriptive Statistics for Teacher-Level Variables

	Minimum	Maximum	Mean	Standard Deviation
***Number* of students in school**				
Original	7	3,227	662	358
Transformed (Box and Cox)	2.48	24.80	15.15	2.48
***Percent* of student body classified as Non-Asian minority**				
Original	0.00	100.00	46.44	35.63
Transformed (Natural Log)	0.00	0.69	0.35	0.25
***Percent* of students in school eligible for free/reduced-price lunch (FRL)**				
Original	0.00	100.00	48.94	31.06
Transformed (Box and Cox)	-1.11	0.00	-0.54	0.34
***Percent* of students in school classified as limited-English proficient (LEP)**				
Original	0.00	100.00	13.60	21.29
Transformed (Box and Cox)	-3.85	0.00	-2.28	1.14

Table 7
Descriptive Statistics for Project-Level Variables

	Minimum	Maximum	Mean	Standard Deviation
Number of Targeted Teachers in Project				
Original	21	2,052	752	565
Transformed-Square Root	4.58	45.30	25.40	10.40

The outcome variable for the analysis, frequency of use of district-designated materials, is an ordinal variable. For these analyses, each questionnaire was treated as an "observation" with an underlying probability distribution that the frequency of use of district-designated instructional materials would be reported in each possible category. The analysis produces estimates of the likelihood that the frequency of use of district-designated materials will be reported in each category based on the project year and extent of the teacher's participation in LSC professional development, 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 = Frequency of use of district-designated materials for lesson i in project j, where

X = NR= Frequency rating in Never or Rarely categories
X = S = Frequency rating in Sometimes category
X = O = Frequency rating in Often category
X = A = Frequency rating in All or almost all lessons category

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

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

$$\varphi_{NRij} = \varphi^*_{NRij}$$
$$\varphi_{Sij} + \varphi_{NRij} = \varphi^*_{Sij}$$
$$\varphi_{Oij} + \varphi_{Sij} + \varphi_{NRij} = \varphi^*_{Oij}$$
$$\varphi_{Aij} + \varphi_{Oij} + \varphi_{Sij} + \varphi_{NRij} = \varphi^*_{Aij} = 1$$

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 3 values in the model:

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

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

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

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 a rating in each category can be computed.

HLM 6.02[4] was used for the analysis, 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 level 3 random effects were tested for each model (i.e., the relationship between the level 1 predictor variable and the outcome variable varied across projects).

Three main models were run. The first included all control variables and project year as a predictor. (See Appendix A.) This model was developed to assess change in the outcome variable across all teachers over time.

The second model added the teacher's hours of professional development, and the teacher's perception of principal support. (See Appendix B.) This model was designed to assess the contribution of participation in LSC professional development with project year controlled. Preliminary investigation of the data suggested testing of linear, quadratic, and cubic relationships between professional development hours and the outcomes. The teacher's perception of principal support was also included at this step, because many of the LSCs conducted work with principals as a part of their initiatives. Controlling for this variable permitted a more direct focus on the relationship between professional development and the outcome.

The third model added the teacher's perceptions of pedagogical preparedness and content preparedness. (See Appendix C.) This model was designed to assess the contribution of participation in LSC professional development with project year, perception of principal support, perception of pedagogical preparedness, and perception of content preparedness controlled. The purpose of including pedagogical and content preparedness as predictors was to determine

[4] Raudenbush, S., Bryk, A., Cheong, Y. F., & Congdon, R. (2005) HLM (Version 6.02) [Computer software]. Lincolnwood, IL: Scientific Software International, Inc.

whether these intermediate outcomes explained variation in the frequency of use of district-designated instructional materials.

For these models, the fixed effects estimates of the main effects on the outcome, and the standard errors of the estimates, are shown in Table 8.

Table 8
Time-Point-, Teacher/School-, and Project-Level Fixed Effects

	Project Year Model	Project Year, Professional Development, and Principal Support Model	Project Year, Professional Development, Principal Support, and Perceptions of Preparedness Model
Intercept	-0.26*	-0.87***	-0.92***
	(0.12)	(0.10)	(0.10)
Threshold 2	1.04***	1.19***	1.21***
	(0.01)	(0.01)	(0.01)
Threshold 3	2.25***	2.51***	2.56***
	(0.02)	(0.02)	(0.02)
Project Year	-0.28***	-0.09***	-0.08**
	(0.03)	(0.02)	(0.02)
Hours of LSC Professional Development			
Linear		-6.52***	-6.42***
		(0.35)	(0.34)
Quadratic		6.21***	6.13***
		(0.41)	(0.41)
Cubic		-1.80***	-1.78***
		(0.14)	(0.13)
Teacher's Perception of Principal Support		-1.27***	-0.73***
		(0.08)	(0.08)
Teacher's Perception of Pedagogical Preparedness			-1.94***
			(0.10)
Teacher's Perception of Content Preparedness			0.58***
			(0.14)
Teacher Characteristics			
Experience Level (Intermediate Omitted)			
Novice (1–5 yr)	0.12**	-0.07	-0.10*
	(0.04)	(0.04)	(0.04)
Very Experienced (11+ yr)	0.01	0.02	0.05
	(0.04)	(0.04)	(0.04)
School Characteristics			
School Size (in hundreds of students)	0.05***	0.03*	0.03~
	(0.01)	(0.01)	(0.01)
Non-Asian Minority	-0.35	-0.23	-0.21
	(0.27)	(0.27)	(0.27)
Limited-English Proficient	-0.08*	-0.07~	-0.06
	(0.04)	(0.04)	(0.04)
Free or Reduced-Price Lunch	0.25~	0.09	0.03
	(0.15)	(0.16)	(0.16)
Community Type (Urban Omitted)			
Rural	-0.21~	-0.18	-0.20~
	(0.11)	(0.11)	(0.11)
Suburban	-0.22**	-0.25**	-0.25**
	(0.08)	(0.08)	(0.08)
Town or Small City	-0.17~	-0.11	-0.10
	(0.09)	(0.10)	(0.10)
Project Characteristics			
Number of Targeted Teachers	-0.00	0.00	0.01
	(0.01)	(0.01)	(0.01)
Project Subject/Grade Range (K–8 Science Omitted)			
K–8 Mathematics	-0.26	-0.08	-0.15
	(0.29)	(0.23)	(0.22)
6–12 Mathematics	0.04	0.40	0.41
	(0.39)	(0.32)	(0.30)
6–12 Science	0.64	0.63	0.78~
	(0.52)	(0.44)	(0.42)

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

Relationship between Frequency of Use of District-Designated Materials and Project Year

The key result of the analyses for frequency of use of district-designated materials predicted by project year is the coefficient of -0.28 for project year. This result indicates that, in general, the use of district-designated instructional materials became more frequent as project year increased. Figure 1 displays the predicted probabilities for use of district-designated instructional materials by project year.

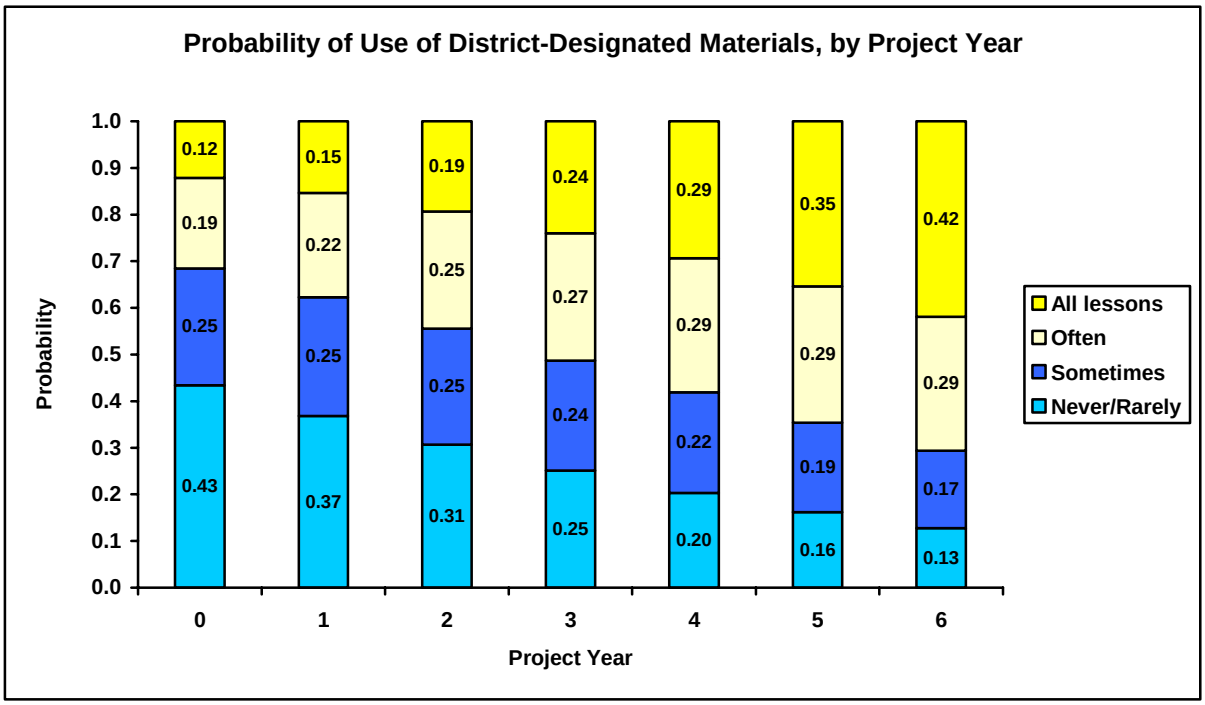

Figure 1

Two strengths of the hierarchical analysis are the inclusion of questionnaires nested within teachers, so that multiple questionnaires from the same teacher are appropriately treated as longitudinal data, and the control for project-specific effects. The increasing use of district-designated materials appears to be a longitudinal trend within teachers, and across projects, in the LSC.

One weakness of the hierarchical analysis was the inability to account for the unequal probability of inclusion of questionnaires in the sample, because the HLM software would not run with weighted estimates in this ordinal model. As a rule, teachers in smaller projects were more likely to be included, resulting in a potential bias in the analysis toward effects in smaller projects. To account for this possibility, a Chi-square test with data weighted by project size was performed.

The distribution of questionnaires included in the Chi-square analysis by project subject/grade range is summarized in Table 9. The Chi-square analysis compared the overall distribution of

reported frequency of use of district-designated materials by project year. Each questionnaire was weighted according to the probability of selection into the sample based on the size of the project from which it came, and weights were normalized to adjust the weighted sample to be equivalent in size to the unweighted sample. (See Table 10.) Significance testing for year-to-year differences in the distribution was performed using the Holm-Bonferroni adjustment for multiple comparisons in the Chi-square test. The results are presented in Table 11.

Table 9
Teachers and Projects Included in Model by Subject/Grade-Range

	***Number* of Projects**	***Number* of Teachers**	***Percent* of Teachers**	***Percent* of Teachers (weighted)**
K–8 Science	42	16,821	46	53
K–8 Mathematics	29	13,489	37	37
6–12 Mathematics	19	5,152	14	8
6–12 Science	7	1,362	4	2
Total	**85**[†]	**36,824**	**100**	**100**

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

Table 10
Frequency of Use of District-designated Materials by Project Year

		Percent of Teachers (weighted)			
	Unweighted N	**Never or Rarely**	**Sometimes**	**Often**	**All**
Year 0	4,233	63	13	11	13
Year 1	2,339	37	19	19	25
Year 2	9,277	33	17	21	29
Year 3	4,787	27	20	25	27
Year 4	5,145	26	19	23	33
Year 5	6,034	24	21	24	30
Year 6	1,711	24	24	21	30

Table 11
Chi-Square and Holm-Bonferroni Adjustment Results

	Adjusted alpha[†]	**p-value**
Year 0 v Year 1	0.0083	0.000*
Year 1 v Year 2	0.0100	0.000*
Year 2 v Year 3	0.0125	0.000*
Year 3 v Year 4	0.0167	0.000*
Year 4 v Year 5	0.0250	0.000*
Year 5 v Year 6	0.0500	0.019

[†] The overall alpha level was 0.05.
* Significant at the adjusted alpha level

The significant results in the year-to-year comparisons indicate that the distribution of teachers' reported frequency of use of district-designated instructional materials was different in each subsequent year from the baseline year up to the 5th year of LSC projects. The nature of these differences can be seen in the weighted percents in Table 10, which show increased frequency in teachers' use of district-designated materials by year up to Year Five. These results support the

conclusion of the hierarchical analysis that across all teachers and projects the frequency of use of district-designated instructional materials increased as the projects matured.

Relationship between Frequency of Use of District-Designated Materials and Professional Development

Key results of the analyses for frequency of use of district-designated materials and project year and number of hours of professional development (Table 7) are summarized in Figure 2. In general, there was a positive relationship between teachers' number of hours of participation in LSC-sponsored professional development and more frequent use of district-designated instructional materials. This relationship was over and above the effects of project year and teachers' perception of principal support, because these variables were controlled in the model.

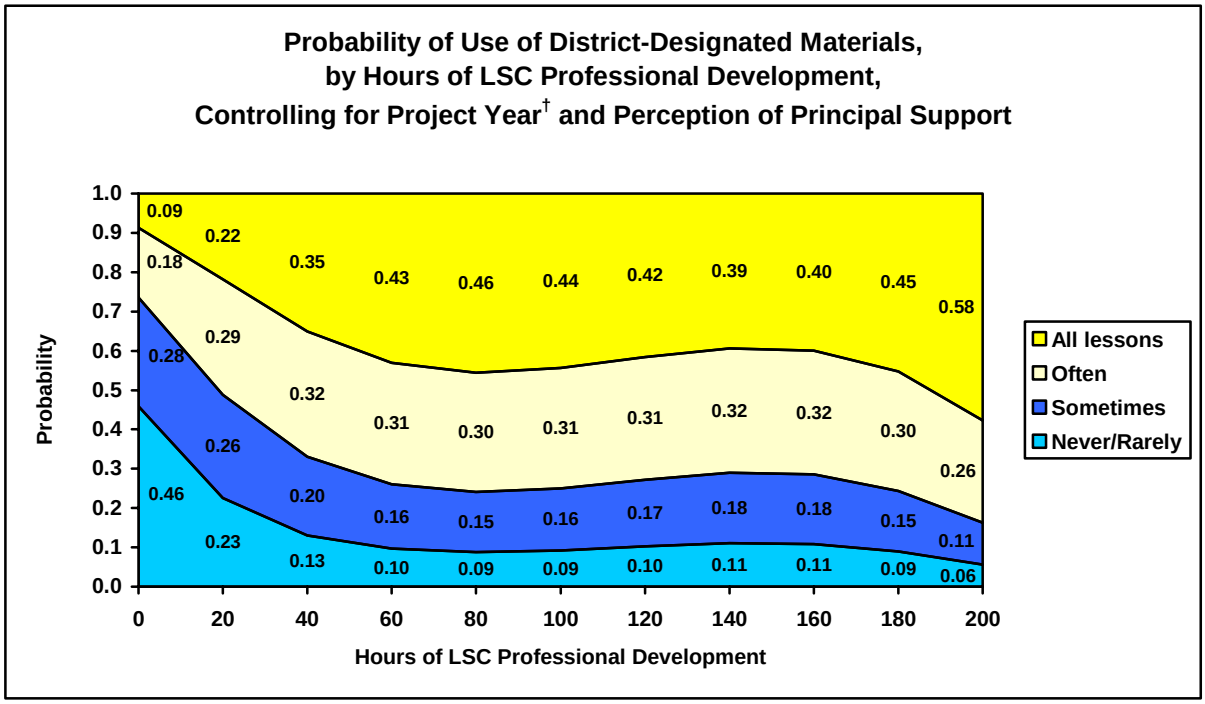

Figure 2

† Results are presented for Project Year = 5.

Converted to probabilities, a teacher with 0 hours of LSC professional development at the end of five years of an LSC project had a predicted probability of 0.46 for the "Never/Rarely" category, 0.28 for the "Sometimes" category, 0.18 for the "Often" category, and 0.09 for the "All lessons" category. For those with the mean amount of LSC professional development in this sample (46 hours), the probabilities were 0.12 for "Never/Rarely," 0.19 for "Sometimes," 0.32 for "Often," and 0.38 for "All lessons." Corresponding probabilities for teachers with one standard deviation above the mean amount of LSC professional development in this sample (100 hours) were 0.09 for "Never/Rarely," 0.16 for "Sometimes," 0.31 for "Often," and 0.44 for "All lessons."

Two other results from this model are worth noting. First, even with teachers' extent of professional development and perception of principal support controlled, the coefficient for project year remained significant. This result suggests that the district-designated instructional materials were being used somewhat more frequently over time in the targeted districts regardless of teachers' participation in LSC professional development. The predicted probability that a typical teacher would report "Never" or "Rarely" using the district-designated materials decreased from 0.30 to 0.21 between the baseline year and the 5th year of an LSC project. The corresponding increase in the predicted probability that a typical teacher would report using the district-designated materials in all lessons was from 0.16 to 0.23 between the baseline year and 5th year of a project.

Second, perception of principal support was positively related to frequency of use of district-designated materials with both project year and teachers' participation in LSC professional development controlled. This result suggests that teachers more frequently use the district-designated materials when they feel supported by their principal. In terms of probabilities, a teacher reporting an average level of perceived principal support was predicted to report use of the district-designated materials in a project's 5th year as "Never" or "Rarely" with a probability of 0.21, and as "All lessons" with a probability of 0.23. For comparison, a teacher reporting principal support one standard deviation above the mean was predicted to have the following probabilities of use of district-designated materials: 0.17 for "Never" or "Rarely," and 0.28 for "All lessons."

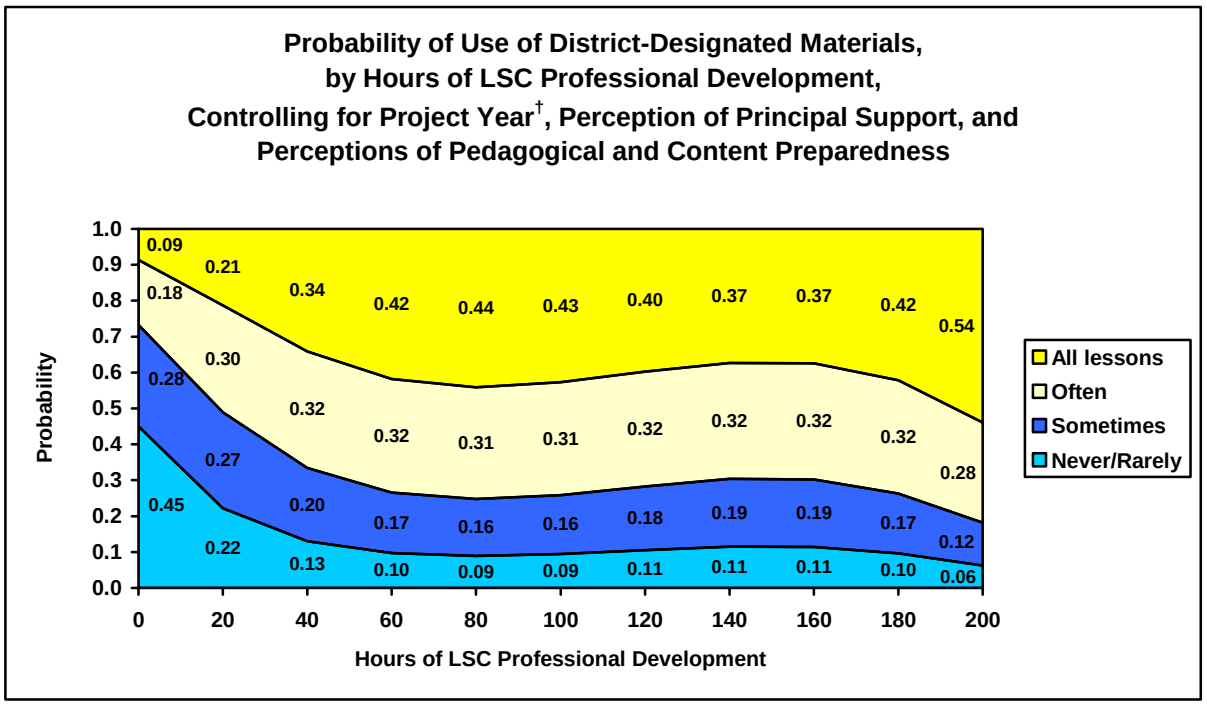

Figure 3

† Results are presented for Project Year = 5.

With perceptions of pedagogical and content preparedness controlled (in addition to project year and perception of principal support), the relationship between extent of LSC professional development and the probability of using district-designated instructional materials remained significant and positive. Converted to probabilities a teacher with 0 hours of LSC professional development at the end of five years of an LSC project had a predicted probability of 0.45 for the "Never/Rarely" category, 0.28 for the "Sometimes" category, 0.18 for the "Often" category, and 0.09 for the "All lessons" category. For those with the mean amount of LSC professional development in this sample (46 hours), the probabilities were 0.12 for "Never/Rarely," 0.19 for "Sometimes," 0.32 for "Often," and 0.37 for "All lessons." Corresponding probabilities for teachers with one standard deviation above the mean amount of LSC professional development in this sample (100 hours) were 0.09 for "Never/Rarely," 0.16 for "Sometimes," 0.31 for "Often," and 0.43 for "All lessons."

TIME ON SCIENCE INSTRUCTION IN ELEMENTARY GRADES

Sample

Between 1997 and 2006, nearly 31,000 K–5 teachers targeted by elementary grade science LSCs submitted questionnaires. The data set was reduced by the removal of teacher leaders (who are not representative of the typical teacher targeted by the LSCs) and teachers with incomplete questionnaire data. The final data set used in these analyses includes 17,583 questionnaires, representing 42 LSC projects.

The LSC core evaluation requires projects to collect questionnaire data from either a random sample of 300 teachers or their entire targeted population, if 350 or fewer teachers.[5] Because this sampling design leads to unequal probabilities of teachers being selected to receive a questionnaire, weights are used in these analyses to provide results generalizable to the targeted population of LSC teachers. Table 12 shows the raw and weighted distribution of teachers in the sample.

Table 12
Teachers and Projects Included in Model

Number of Projects	Number of Completed Questionnaires	Number of Teachers (weighted)
42	17,583	121,096

[5] Beginning with the 1999–2000 data collection year, projects also administered teacher questionnaires to a "program sample." The program sample was purposively selected to gather longitudinal data, with the size of each project's sample proportional to project size. The analyses presented in this report draw upon longitudinal data collected as part of the program sample and those collected serendipitously (teachers randomly selected at multiple time points).

Analysis and Results

The LSC teacher questionnaire data have a nested structure; with multiple observations nested within each teacher, nested within each project. 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 (Raudenbush & Bryk, 2002).

The outcome of interest in this analysis was time on science instruction in grades K–8.[6] The dependent variable was the number of minutes of instruction per week, calculated by multiplying two values reported on the teacher questionnaire: the mid-point in the range of the number of minutes in a typical science lesson and the number of science lessons per week. Minutes of Instruction was then transformed to correct for positive skewness in the distribution.

Table 13 shows descriptive statistics for the time on science instruction outcome variable.

Table 13
Descriptive Statistics for Minutes of Science Instruction per Week

	Minimum	Maximum	Mean	Standard Deviation
Original	0.00	427.5	111.29	60.92
Transformed (Box and Cox)	-1.52	81.06	31.16	12.64

A three-level hierarchical linear model (observations nested within teachers nested within projects) was used to investigate the relationship between minutes of instruction and both the number of years a project had existed and the extent of each teacher's participation in LSC-sponsored professional development. In addition, a number of teacher and school demographic factors were controlled for in these models, for example, teacher's experience level and type of community in which the school is located.

The independent variables included at the time point level were:

- Extent of teacher's participation in LSC professional development;
- Teacher's experience level;
- Teacher's perception of principal support;
- Teacher's perception of pedagogical preparedness;
- Teacher's perception of content preparedness; and
- Project year.

[6] Unless otherwise noted, all statistics for the Minutes of Instruction analysis are based upon weighted data.

At the teacher/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 classified as limited-English proficient;
- Percent of students in the school eligible for free/reduced-price lunch; and
- Community type in which the school was located.

At the project level, the following predictors were included:

- Number of teachers targeted by the LSC.

Descriptive statistics for the time-point-level independent variables are shown in Tables 14 and 15. Slightly more than half of the questionnaires came from teachers who had participated in fewer than 20 hours of LSC professional development at the time, but there was a fairly wide range of extent of participation, with 10 percent of the teachers having participated in 100 or more hours. Roughly half of the questionnaires came from teachers who had taught for 11 or more years, while almost one-third were from teachers with five or fewer years of experience.

Almost half of the questionnaires came from teachers located in schools in urban areas, over one-fourth from schools in suburban communities, and the remaining roughly divided between schools in rural areas and schools in towns/small cities. School sizes varied widely, ranging from a low of 7 to over 2000 students. On average, 39 percent of the students in these schools were non-Asian minority, 12 percent were classified as limited-English proficient, and 47 percent were eligible for free/reduced-price lunch.

Table 14
Descriptive Statistics for Time-Point-Level Variables

	Minimum	Maximum	Mean	Standard Deviation
Perception of Pedagogical Preparedness				
Original	25.00	100.00	75.77	13.70
Transformed–Box and Cox	0.06	1.00	0.59	0.20
Perception of Content Preparedness				
Original	25.00	100.00	58.53	16.99
Transformed–Box and Cox	-0.91	0.00	-0.46	0.21
Perception of Principal Support				
Original	20.00	100.00	74.32	14.55
Transformed–Divided by 100, Squared	0.04	1.00	0.57	0.21

Table 15
Descriptive Statistics for Time-Point-Level Variables

	Percent of Questionnaires
Extent of Teacher Participation in LSC Professional Development	
0 hours	31
1–9 hours	11
10–19 hours	12
20–39 hours	15
40–59 hours	10
60–79 hours	6
80–99 hours	4
100–129 hours	5
130–159 hours	2
160–199 hours	1
200 or more hours	2
Prior Teaching Experience	
5 or fewer years	29
6–10 years	17
11 or more years	53
Project Year	
0	8
1	9
2	27
3	17
4	12
5	20
6	6

Table 16
Descriptive Statistics for Teacher/School-Level Variables

	Percent of Teachers
Community type in which teacher's school is located	
Rural	12
Town or small city	18
Suburban	28
Urban	42

Table 17
Descriptive Statistics for Teacher/School-Level Variables

	Minimum	Maximum	Mean	Standard Deviation
***Number* of students in school**				
Original	7	2,290	564	256
Transformed–Box and Cox	2.94	52.69	28.24	5.72
***Percent* of student body classified as Non-Asian minority**				
Original	0.00	100.00	38.67	33.77
Transformed–Divided by 100, Square Root	0.00	1.00	0.54	0.30
***Percent* of students in school eligible for free/reduced-price lunch (FRL)**				
Original	0.00	100.00	47.26	30.43
Transformed–Box and Cox	-1.25	0.00	-0.59	0.36
***Percent* of students in school classified as limited-English proficient (LEP)**				
Original	0.00	100.00	12.14	19.64
Transformed–Box and Cox	-4.17	0.00	-2.50	1.25

Table 18
Descriptive Statistics for Project-Level Variables

	Minimum	Maximum	Mean	Standard Deviation
Number of Targeted Teachers in Project				
Original	276	2,027	1,043	534
Transformed–Square Root	16.61	45.02	31.16	8.61

HLM 6.02[7] 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 level 3 random effects were tested for each model (i.e., the relationship between the level 1 predictor variable and the outcome variable varied across projects).

Three main models were run. The first included all control variables and project year as a predictor. (See Appendix D.) This model was developed to investigate change in the outcome variable across all teachers over time.

The second model added the teacher's hours of professional development, and the teacher's perception of principal support. (See Appendix E.) This model was designed to assess the contribution of participation in LSC professional development with project year controlled. Preliminary investigation of the data suggested testing of linear, quadratic, and cubic relationships between professional development hours and the outcomes. The teacher's perception of principal support was also included at this step because many of the LSCs conducted work with principals as a part of their initiatives. Controlling for this variable

[7] Raudenbush, S., Bryk, A., Cheong, Y. F., & Congdon, R. (2005). HLM (Version 6.02) [Computer software]. Lincolnwood, IL: Scientific Software International, Inc.

permitted a more direct focus on the relationship between professional development and the outcome.

The third model added the teacher's perceptions of pedagogical preparedness and content preparedness (See Appendix F). This model was designed to assess the contribution of participation in LSC professional development with project year, perception of principal support, perception of pedagogical preparedness, and perception of content preparedness controlled.

The fixed effects estimates, and the standard errors of the estimates, for the three models are shown in Table 19.

Table 19
Time-Point-, Teacher/School-, and Project-Level Fixed Effects

	Project Year Model	Project Year, Professional Development, and Principal Support Model	Project Year, Professional Development, Principal Support, and Perceptions of Preparedness Model
Intercept	30.75***	32.48***	32.40***
	(0.94)	(0.85)	(0.79)
Project Year	0.39*	-0.19	-0.24
	(0.15)	(0.13)	(0.12)
Hours of LSC Professional Development			
Linear		12.30***	10.73***
		(1.69)	(1.56)
Quadratic		-10.64***	-9.50***
		(2.43)	(2.35)
Cubic		3.16**	2.77**
		(0.91)	(0.88)
Teacher's Perception of Principal Support		4.38***	0.11
		(0.59)	(0.48)
Teacher's Perception of Pedagogical Preparedness			5.50***
			(1.02)
Teacher's Perception of Content Preparedness			10.39***
			(1.03)
Teacher Characteristics			
Experience Level (Intermediate Omitted)			
Novice (1–5 yr)	-0.74*	-0.25	0.03
	(0.33)	(0.36)	(0.36)
Very Experienced (11+ yr)	-1.00**	-1.09**	-1.28
	(0.31)	(0.28)	(0.26)
School Characteristics			
School Size (in hundreds of students)	0.12	0.17**	0.16**
	(0.08)	(0.06)	(0.06)
Non-Asian Minority	-1.24	0.36	0.17
	(2.50)	(2.16)	(2.09)
Limited-English Proficient	0.57*	0.36~	0.41
	(0.25)	(0.21)	(0.22)
Free or Reduced-Price Lunch	-0.77	-0.23	-0.35
	(1.38)	(1.14)	(1.16)
Community Type (Urban Omitted)			
Rural	1.74	2.02*	2.63**
	(1.07)	(0.94)	(0.82)
Suburban	2.09	2.82**	2.89**
	(1.09)	(0.88)	(0.87)
Town or Small City	1.16	1.60*	2.05**
	(0.83)	(0.81)	(0.72)
Project Characteristics			
Number of Targeted Teachers	-0.11	0.09	0.06
	(0.12)	(0.09)	(0.08)

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

Relationship between Time on Science Instruction and Project Year

The results of the analysis of time on science instruction by project year are summarized in Figure 4. A positive relationship was found between the number of years an elementary science project had been in existence and the number of minutes per week teachers spent on science instruction in grades K–5.

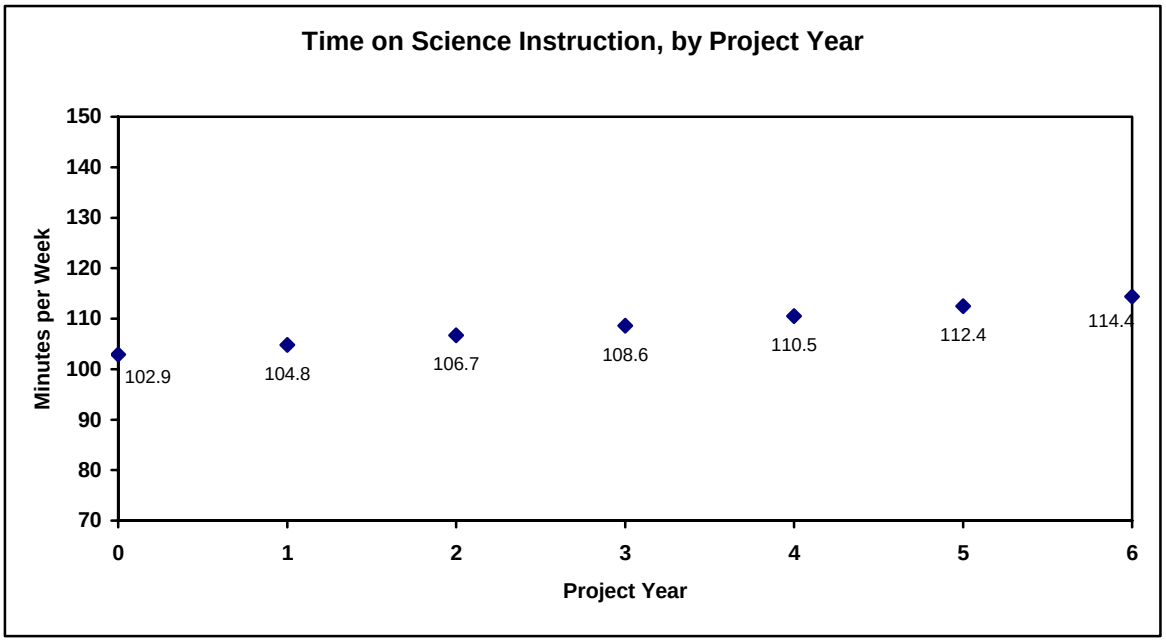

Figure 4

The analysis by project year reveals a small, but significant, increase in the time K–5 teachers spent on science instruction as projects matured. For each year a project was in existence the effect on time spent on science instruction was about 0.03 standard deviations, resulting in a predicted increase of about 9.51 minutes per week across all K–5 teachers after five years of an LSC project.

Relationship between Time on Science Instruction and Professional Development

Key results from the analysis of time on science instruction by teachers' participation in LSC professional development, controlling for project year and teachers' perception of principal support, are displayed in Figure 5. A positive relationship was found between the extent of teachers' participation in LSC professional development and the number of minutes per week teachers spent on science instruction in the elementary grades.

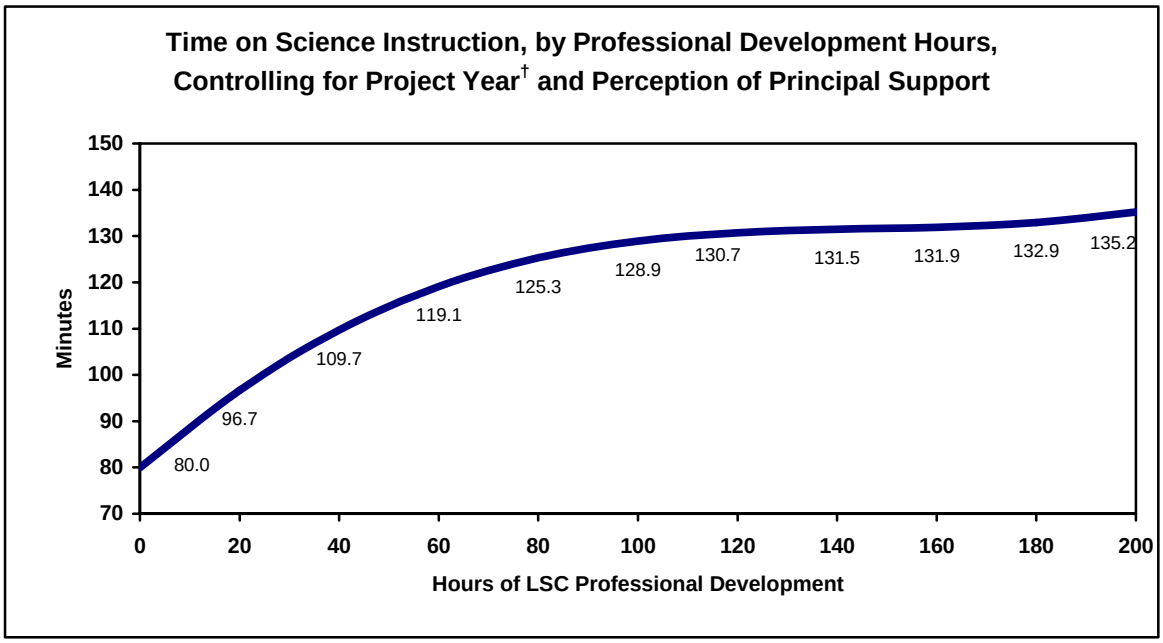

Figure 5

† Results are presented for Project Year = 5.

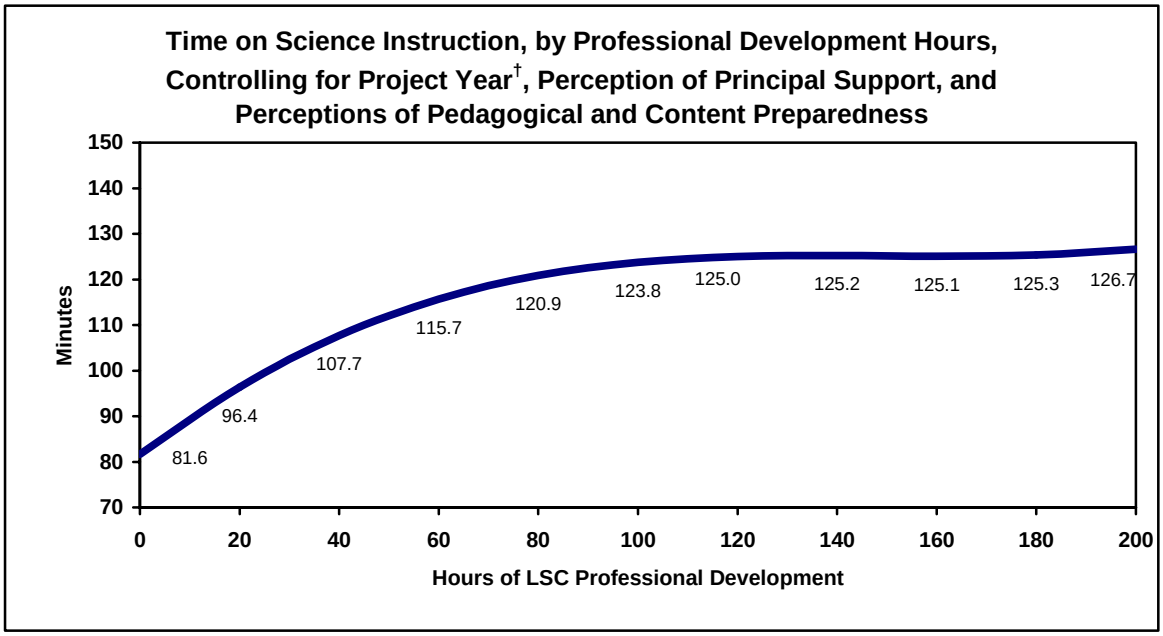

Figure 6

† Results are presented for Project Year = 5.

For a teacher who has received the mean amount of LSC professional development in this sample (35 hours), there is a medium-sized effect of 0.45 standard deviations or 26.82 minutes per week. At one standard deviation above the mean (81 hours) the effect is 0.75 standard deviations, which translates to 45.54 minutes per week more time on science instruction than a

teacher with no LSC professional development. These effects are over and above the overall change by project year or the effects of teachers' perception of principal support because these factors are controlled in the model.

Another important result from the model that includes project year, professional development, and perception of principal support is that the project year coefficient is non-significant. This result suggests that the small increase across all teachers noted in the previous model is accounted for by their participation in LSC professional development and their perception of principal support. Finally, the significant coefficient for perception of principal support indicates a positive relationship between this factor and time spent on science instruction. The effect was small, a 0.07 standard deviation change, amounting to about 4.46 additional minutes per week, in the outcome for a one standard deviation increase in perception of principal support. This effect was over and above the larger effect for participation in professional development.

With teachers' perceptions of pedagogical preparedness and content preparedness controlled (in addition to project year and perception of principal support), the relationship between the extent of teachers' LSC professional development and time spent on science instruction remained significant and positive, with an effect size of 0.48 standard deviations, equivalent to 28.78 minutes per week. (See Figure 6.) Perceptions of pedagogical preparedness and content preparedness both had significant and positive relationships with the extent of teachers' LSC professional development. A one standard deviation increase in perception of pedagogical preparedness had an effect of 0.09 standard deviations on time spent on science instruction, or 5.30 minutes per week. A one standard deviation increase in perception of content preparedness had an effect of 0.17 standard deviations on time spent on science instruction, or 10.44 minutes per week.

CONCLUSIONS

Looking across the models testing indicators of systemic change, three key findings are evident. First, there was a positive relationship between project year and both the use of district-designated materials and the time spent on science instruction in the elementary grades. This finding suggests that the LSC projects are having an overall impact on classroom instruction in the targeted schools and districts over time. For the use of district-designated materials, this effect remained even after controlling for teachers' participation in LSC professional development and their perception of principal support, suggesting a more systemic impact that might be explained by the development of a supportive context for standards-based instruction in terms of policies and stakeholder support. The trend of increased time on elementary science instruction did not remain after controlling for teachers' participation in professional development and their perception of principal support.

Second, both indicators of systemic change were positively related to teachers' participation in LSC professional development. This finding supports the central premise of the LSC that extensive and targeted professional development will have an impact on teachers' attitudes, preparedness, and practice. The modest size of these impacts, even at the highest levels of participation in LSC professional development, may be explained by unmeasured contextual

factors that limit potential impacts on teachers, or by a ceiling effect on the measurement of these outcomes. It may be, however, that the LSC program has fairly limited overall effects on teachers.

Third, even after taking project year and extent of participation in LSC professional development into account, teachers' perception of principal support was positively related to these two indicators. Although this relationship was not especially strong, it suggests that the support of school principals plays a role in teachers' decisions about their classroom practice. A number of the LSCs have included activities designed specifically to strengthen principal support for the project and for teachers participating in the project. Although it cannot be determined from these analyses whether teachers' perceptions of principal support are related to those activities, the results do suggest that working with principals to develop support for teacher change is likely an important reform strategy.

Fourth, after taking into account teachers' content and pedagogical preparedness, teachers' extent of participation in LSC professional development was positively related to frequency of use of district-designated instructional materials and K–5 teachers' time spent on science instruction. This finding suggests that changes in the use of materials and instructional time are encouraged or supported by LSC professional development over and above direct impacts of content and pedagogical preparedness.

Finally, some relationships were detected between targeted outcomes on teachers and factors such as teacher experience and the project's targeted subject/grade range. These findings suggest that projects should take these factors into account when planning, implementing, and evaluating their professional development and other interventions. Depending on teachers' backgrounds and the subject and grade range targeted by the project, participating teachers may be at somewhat different starting points. Expectations for the trajectory and extent of change among teachers may also depend on these factors. These findings do not, however, suggest that LSC professional development has been more or less effective depending on these factors.

It is important to note that the measures of teachers' frequency of use of district-designated instructional materials and K–5 teachers' time on science instruction are based upon self-report data. The nature of the data collection may raise some concerns that participants in LSC professional development tended to report greater use of the district-designated instructional materials and time on science instruction, without actually changing their practices. This concern is alleviated somewhat by the increasing values on these outcomes across a range of hours of participation in LSC professional development. It is also important to note that even though the LSC was intended to target all teachers in a jurisdiction, in practice teacher participation in the professional development tends to be voluntary, so there is a danger of selection bias in the sample (i.e., teachers who decide to participate may be the ones more likely to change). However, the longitudinal nature of these analyses minimizes this threat as much as possible without the use of random assignment. Regardless of these limitations, the results of this study appear to indicate that the LSC program is, to some extent, having the intended impacts on participating teachers and their practice through professional development, and through changes that are more systemic in nature.

Appendix A
Project Year Model for Frequency of Use of District-designated Materials

Level 1
The level 1 model for the prediction of the frequency of use of district-designated materials was:

$\log[P(Y_{NRij} = 1)/(1 - P(Y_{NRij} = 1)] = B0 + B1* (NOVTCHR) + B2*(EXPTCHR) + B3*(PROJYR)$
$\log[P(Y_{Sij} = 1)/(1 - P(Y_{Sij} = 1)] = B0 + B1* (NOVTCHR) + B2*(EXPTCHR) + B3*(PROJYR) + d(2)$
$\log[P(Y_{Oij} = 1)/(1 - P(Y_{Oij} = 1)] = B0 + B1* (NOVTCHR) + B2*(EXPTCHR) + B3*(PROJYR) + d(3)$

Level 2
Level 2 control variables were included as predictors of the level 1 intercept term and the slope for project year:

P0 = B00 + B01*(NUMST_T) + B02*(LEP_T) + B03*(NOASN_T) + B04*(FRL_T) + B05*(RURAL) + B06*(TOWN) + B07*(SUBURB) + R0
P1 = B10
P2 = B20
P3 = B30 + B31*(NUMST_T) + B32*(LEP_T) + B33*(NOASN_T) + B34*(FRL_T) + B35*(RURAL) + B36*(TOWN) + B37*(SUBURB)

Level 3
Level 3 control variables were included as predictors of the level 1 intercept term and the slope for project year:

B00 = G000 + G001(SQRTTARG) + G002 (ELEMMATH) + G003 (SECMATH) + G004 (SECSCI) + U00
B01 = G010
B02 = G020
B03 = G030
B04 = G040
B05 = G050
B06 = G060
B07 = G070
B10 = G100 + U10
B20 = G200 + U20
B30 = G300 + G301 (SQRTTARG) + G302 (ELEMMATH) + G303 (SECMATH) + G304 (SECSCI) + U30
B31 = G310
B32 = G320
B33 = G330
B34 = G340
B35 = G350
B36 = G360
B37 = G370

Appendix B
Project Year, Professional Development, and Perception of Principal Support Model for Frequency of Use of District-designated Materials

Level 1

The level 1 model for the prediction of the frequency of use of district-designated materials was:

$\log[P(Y_{NRij} = 1)/(1 - P(Y_{NRij} = 1)] = B0 + B1* (NOVTCHR) + B2*(EXPTCHR) + B3*(PROJYR) + B4*(CON9) + B5*(PDMIDPT) + B6*(PDSQR) + B7*(PDCUB)$

$\log[P(Y_{Sij} = 1)/(1 - P(Y_{Sij} = 1)] = B0 + B1* (NOVTCHR) + B2*(EXPTCHR) + B3*(PROJYR) + B4*(CON9) + B5*(PDMIDPT) + B6*(PDSQR) + B7*(PDCUB) + d(2)$

$\log[P(Y_{Oij} = 1)/(1 - P(Y_{Oij} = 1)] = B0 + B1* (NOVTCHR) + B2*(EXPTCHR) + B3*(PROJYR) + B4*(CON9) + B5*(PDMIDPT) + B6*(PDSQR) + B7*(PDCUB) + d(3)$

Level 2

Level 2 control variables were included as predictors of the level 1 intercept term and the slopes for project year, extent of participation in LSC professional development, and perception of principal support:

P0 = B00 + B01*(NUMST_T) + B02*(LEP_T) + B03*(NOASN_T) + B04*(FRL_T) + B05*(RURAL) + B06*(TOWN) + B07*(SUBURB) + U0
P1 = B10
P2 = B20
P3 = B30 + B31*(NUMST_T) + B32*(LEP_T) + B33*(NOASN_T) + B34*(FRL_T) + B35*(RURAL) + B36*(TOWN) + B37*(SUBURB)
P4 = B40
P5 = B50 + B51*(NUMST_T) + B52*(LEP_T) + B53*(NOASN_T) + B54*(FRL_T) + B55*(RURAL) + B56*(TOWN) + B57*(SUBURB)
P6 = B60 + B61*(NUMST_T) + B62*(LEP_T) + B63*(NOASN_T) + B64*(FRL_T) + B65*(RURAL) + B66*(TOWN) + B67*(SUBURB)
P7 = B70 + B71*(NUMST_T) + B72*(LEP_T) + B73*(NOASN_T) + B74*(FRL_T) + B75*(RURAL) + B76*(TOWN) + B77*(SUBURB)

Level 3

Level 3 control variables were included as predictors of the level 1 intercept term and the slope for project year and extent of professional development:

B00 = G000 + G001(SQRTTARG) + G002 (ELEMMATH) + G003 (SECMATH) + G004 (SECSCI) + U00
B01 = G010
B02 = G020
B03 = G030
B04 = G040
B05 = G050
B06 = G060
B07 = G070
B10 = G100 + U10
B20 = G200 + U20

B30 = G300 + G301 (SQRTTARG) + G302 (ELEMMATH) + G303 (SECMATH) + G304 (SECSCI) + U30
B31 = G310
B32 = G320
B33 = G330
B34 = G340
B35 = G350
B36 = G360
B37 = G370
B40 = G400 + U40
B50 = G500 + G501 (SQRTTARG) + G502 (ELEMMATH) + G503 (SECMATH) + G504 (SECSCI) + U50
B51 = G510
B52 = G520
B53 = G530
B54 = G540
B55 = G550
B56 = G560
B57 = G570
B60 = G600 + G601 (SQRTTARG) + G602 (ELEMMATH) + G603 (SECMATH) + G604 (SECSCI) + U60
B61 = G610
B62 = G620
B63 = G630
B64 = G640
B65 = G650
B66 = G660
B67 = G670
B70 = G700 + G701 (SQRTTARG) + G702 (ELEMMATH) + G703 (SECMATH) + G704 (SECSCI) + U70
B71 = G710
B72 = G720
B73 = G730
B74 = G740
B75 = G750
B76 = G760
B77 = G770

Appendix C
Project Year, Professional Development, Perception of Principal Support, and Perceptions of Pedagogical and Content Preparedness Model for Frequency of Use of District-designated Materials

Level 1

The level 1 model for the prediction of the frequency of use of district-designated materials was:

$\log[P(Y_{NRij} = 1)/(1 - P(Y_{NRij} = 1)] = B0 + B1*(NOVTCHR) + B2*(EXPTCHR) + B3*(PROJYR) + B4*(CON9) + B5*(PDMIDPT) + B6*(PDSQR) + B7*(PDCUB) + B8*(PREDCON3) + B9*(PREDCON4)$

$\log[P(Y_{Sij} = 1)/(1 - P(Y_{Sij} = 1)] = B0 + B1*(NOVTCHR) + B2*(EXPTCHR) + B3*(PROJYR) + B4*(CON9) + B5*(PDMIDPT) + B6*(PDSQR) + B7*(PDCUB) + B8*(PREDCON3) + B9*(PREDCON4) + d(2)$

$\log[P(Y_{Oij} = 1)/(1 - P(Y_{Oij} = 1)] = B0 + B1*(NOVTCHR) + B2*(EXPTCHR) + B3*(PROJYR) + B4*(CON9) + B5*(PDMIDPT) + B6*(PDSQR) + B7*(PDCUB) + B8*(PREDCON3) + B9*(PREDCON4) + d(3)$

Level 2

Level 2 control variables were included as predictors of the level 1 intercept term and the slopes for project year, extent of participation in LSC professional development, and perception of principal support:

P0 = B00 + B01*(NUMST_T) + B02*(LEP_T) + B03*(NOASN_T) + B04*(FRL_T) + B05*(RURAL) + B06*(TOWN) + B07*(SUBURB) + U0
P1 = B10
P2 = B20
P3 = B30 + B31*(NUMST_T) + B32*(LEP_T) + B33*(NOASN_T) + B34*(FRL_T) + B35*(RURAL) + B36*(TOWN) + B37*(SUBURB)
P4 = B40
P5 = B50 + B51*(NUMST_T) + B52*(LEP_T) + B53*(NOASN_T) + B54*(FRL_T) + B55*(RURAL) + B56*(TOWN) + B57*(SUBURB)
P6 = B60 + B61*(NUMST_T) + B62*(LEP_T) + B63*(NOASN_T) + B64*(FRL_T) + B65*(RURAL) + B66*(TOWN) + B67*(SUBURB)
P7 = B70 + B71*(NUMST_T) + B72*(LEP_T) + B73*(NOASN_T) + B74*(FRL_T) + B75*(RURAL) + B76*(TOWN) + B77*(SUBURB)
P8 = B80
P9 = B90

Level 3

Level 3 control variables were included as predictors of the level 1 intercept term and the slope for project year and extent of professional development:

B00 = G000 + G001(SQRTTARG) + G002 (ELEMMATH) + G003 (SECMATH) + G004 (SECSCI) + U00
B01 = G010
B02 = G020
B03 = G030

B04 = G040
B05 = G050
B06 = G060
B07 = G070
B10 = G100 + U10
B20 = G200 + U20
B30 = G300 + G301 (SQRTTARG) + G302 (ELEMMATH) + G303 (SECMATH) + G304 (SECSCI) + U30
B31 = G310
B32 = G320
B33 = G330
B34 = G340
B35 = G350
B36 = G360
B37 = G370
B40 = G400 + U40
B50 = G500 + G501 (SQRTTARG) + G502 (ELEMMATH) + G503 (SECMATH) + G504 (SECSCI) + U50
B51 = G510
B52 = G520
B53 = G530
B54 = G540
B55 = G550
B56 = G560
B57 = G570
B60 = G600 + G601 (SQRTTARG) + G602 (ELEMMATH) + G603 (SECMATH) + G604 (SECSCI) + U60
B61 = G610
B62 = G620
B63 = G630
B64 = G640
B65 = G650
B66 = G660
B67 = G670
B70 = G700 + G701 (SQRTTARG) + G702 (ELEMMATH) + G703 (SECMATH) + G704 (SECSCI) + U70
B71 = G710
B72 = G720
B73 = G730
B74 = G740
B75 = G750
B76 = G760
B77 = G770
B80 = G800 + U80
B90 = G900 + U90

Appendix D
Project Year Model for Time on Science Instruction

Level 1
The level 1 model for the prediction of time on science instruction was:

Y = P0 + P1*(NOVTCHR) + P2*(EXPTCHR) + P3*(PROJYR) + E

Level 2
Level 2 control variables were included as predictors of the level 1 intercept term and the slope for project year:

P0 = B00 + B01*(NUMST_T) + B02*(NOASN_T) + B03*(LEP_T) + B04*(FRL_T) +
B05*(RURAL) + B06*(TOWN) + B07*(SUBURB) + R0
P1 = B10
P2 = B20
P3 = B30 + B11*(NUMST_T) + B12*(NOASN_T) + B13*(LEP_T) + B14*(FRL_T) +
B15*(RURAL) + B16*(TOWN) + B17*(SUBURB)

Level 3
Project size was included as a control variable on the level 1 intercept term:

B00 = G000 + G001(SQRTTARG) + U00
B01 = G010
B02 = G020
B03 = G030
B04 = G040
B05 = G050
B06 = G060
B07 = G070
B10 = G100 + U10
B20 = G200 + U20
B30 = G300 + U30
B31 = G310
B32 = G320
B33 = G330
B34 = G340
B35 = G350
B36 = G360
B37 = G370

Appendix E
Project Year, Professional Development, and Principal Support Model for Time on Science Instruction

Level 1
The level 1 model for the prediction of time on science instruction was:

Level-1 Model

Y = P0 + P1* (NOVTCHR) + P2*(EXPTCHR) + P3*(PROJYR) + P4*(PDMIDPT) + P5*(PDSQR) + P6*(PDCUB) + P7*(SQRDCON9) + E

Level 2
Level 2 control variables were included as predictors of the level 1 intercept term and the slopes for project year, extent of participation in LSC professional development, and perception of principal support:

P0 = B00 + B01*(NUMST_T) + B02*(NOASN_T) + B03*(LEP_T) + B04*(FRL_T) + B05*(RURAL) + B06*(TOWN) + B07*(SUBURB) + R0
P1 = B10
P2 = B20
P3 = B30 + B31*(NUMST_T) + B32*(NOASN_T) + B33*(LEP_T) + B34*(FRL_T) + B35*(RURAL) + B36*(TOWN) + B37*(SUBURB)
P4 = B40 + B41*(NUMST_T) + B42*(NOASN_T) + B43*(LEP_T) + B44*(FRL_T) + B45*(RURAL) + B46*(TOWN) + B47*(SUBURB)
P5 = B50
P6 = B60
P7 = B70 + B71*(NUMST_T) + B72*(NOASN_T) + B73*(LEP_T) + B74*(FRL_T) + B75*(RURAL) + B76*(TOWN) + B77*(SUBURB)

Level 3
Project size was included as a control variable on the level 1 intercept term:

B00 = G000 + G001(SQRTTARG) + U00
B01 = G010
B02 = G020
B03 = G030
B04 = G040
B05 = G050
B06 = G060
B07 = G070
B10 = G100 + U10
B20 = G200 + U20
B30 = G300 + U30
B31 = G310
B32 = G320
B33 = G330
B34 = G340

B35 = G350
B36 = G360
B37 = G370
B40 = G400 + U40
B41 = G410
B42 = G420
B43 = G430
B44 = G440
B45 = G450
B46 = G460
B47 = G470
B50 = G500 + U50
B51 = G510
B52 = G520
B53 = G530
B54 = G540
B55 = G550
B56 = G560
B57 = G570
B60 = G600 + U60
B61 = G610
B62 = G620
B63 = G630
B64 = G640
B65 = G650
B66 = G660
B67 = G670
B70 = G700 + U70
B71 = G710
B72 = G720
B73 = G730
B74 = G740
B75 = G750
B76 = G760
B77 = G770

Appendix F
Project Year, Professional Development, Principal Support, and Perceptions of Pedagogical and Content Preparedness Model for Time on Science Instruction

Level 1
The level 1 model for the prediction of time on science instruction was:

Level-1 Model

Y = P0 + P1* (NOVTCHR) + P2*(EXPTCHR) + P3*(PROJYR) + P4*(PDMIDPT) + P5*(PDSQR) + P6*(PDCUB) + P7*(SQRDCON9) + P8*(CON3) + P9*(CON4) + E

Level 2
Level 2 control variables were included as predictors of the level 1 intercept term and the slopes for project year, extent of participation in LSC professional development, and perception of principal support:

P0 = B00 + B01*(NUMST_T) + B02*(NOASN_T) + B03*(LEP_T) + B04*(FRL_T) + B05*(RURAL) + B06*(TOWN) + B07*(SUBURB) + R0
P1 = B10
P2 = B20
P3 = B30 + B31*(NUMST_T) + B32*(NOASN_T) + B33*(LEP_T) + B34*(FRL_T) + B35*(RURAL) + B36*(TOWN) + B37*(SUBURB)
P4 = B40 + B41*(NUMST_T) + B42*(NOASN_T) + B43*(LEP_T) + B44*(FRL_T) + B45*(RURAL) + B46*(TOWN) + B47*(SUBURB)
P5 = B50
P6 = B60
P7 = B70 + B71*(NUMST_T) + B72*(NOASN_T) + B73*(LEP_T) + B74*(FRL_T) + B75*(RURAL) + B76*(TOWN) + B77*(SUBURB)
P8 = B80
P9 = B90

Level 3
Project size was included as a control variable on the level 1 intercept term:

B00 = G000 + G001(SQRTTARG) + U00
B01 = G010
B02 = G020
B03 = G030
B04 = G040
B05 = G050
B06 = G060
B07 = G070
B10 = G100 + U10
B20 = G200 + U20
B30 = G300 + U30

B31 = G310
B32 = G320
B33 = G330
B34 = G340
B35 = G350
B36 = G360
B37 = G370
B40 = G400 + U40
B41 = G410
B42 = G420
B43 = G430
B44 = G440
B45 = G450
B46 = G460
B47 = G470
B50 = G500 + U50
B51 = G510
B52 = G520
B53 = G530
B54 = G540
B55 = G550
B56 = G560
B57 = G570
B60 = G600 + U60
B61 = G610
B62 = G620
B63 = G630
B64 = G640
B65 = G650
B66 = G660
B67 = G670
B70 = G700 + U70
B71 = G710
B72 = G720
B73 = G730
B74 = G740
B75 = G750
B76 = G760
B77 = G770
B80 = G800 + U80
B90 = G900 + U90