LSC Teacher Questionnaire Study:
Indicators of Systemic Change
A Longitudinal Analysis of Data Collected Between 1997 and 2003

by

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Introduction

The 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 project selected a set of standards-based instructional materials around which to build its professional development program. 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 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 LSC-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 the policies and to develop the support from key stakeholders for implementation of the LSC-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 elementary science instruction. 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 devote 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 across 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 two- and 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 LSC-designated instructional materials, and, in projects targeting science in the elementary grades, teachers' time spent on science instruction.

Frequency of Use of LSC-designated Instructional Materials

Sample

Between 1997 and 2003, over 70,000 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 one or more questionnaires from 28,714 teachers, 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 LSC materials for teachers in the sample by subject and grade range.

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 (Bryk & Raudenbush, 1992).

The outcome of interest in this analysis was the frequency of teachers' use of the LSC-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 2 shows descriptive statistics for the outcome variable by the subject/grade-range of the project.

Table 1[2]
Descriptive Statistics for Frequency of Use of LSC Materials

	Percent of Questionnaires				
	N	**Never or Rarely**	**Sometimes**	**Often**	**Always**
K-8 Science	16821	31	19	22	28
K-8 Mathematics	13489	30	18	25	27
6-12 Mathematics	5152	42	16	14	28
6-12 Science	1362	54	20	16	10

The purpose of the analysis was to examine the relationship between the frequency of teachers' use of the LSC-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.

[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 unweighted data.

A two-level hierarchical ordinal model (time points nested in teachers with appropriate project-level data) 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; and
- Teacher's perception of principal support.

At the teacher/project 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 eligible for free/reduced-price lunch;
- Community type in which the school was located (dummy coded), and;
- Project (dummy coded).

Descriptive statistics for the time-point-level and teacher/project-level independent variables are shown in Tables 2, 3, and 4. 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 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 5 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 remaining 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 3000 students. On average, 46 percent of the students in these schools were non-Asian minority, 13 percent were classified as limited-English proficient (LEP), and 48 percent were eligible for free/reduced-price lunch.

Table 2
Descriptive Statistics for Time-Point-Level Variables

	Percent of Questionnaires (N=36,824)
Extent of Teacher Participation in LSC Professional Development	
0 hours	30
1-9 hours	9
10-19 hours	9
20-39 hours	13
40-59 hours	10
60-79 hours	7
80-99 hours	6
100-129 hours	8
130 -159 hours	4
160-199 hours	2
200 or more hours	2
Prior Teaching Experience	
5 or fewer years	32
6-10 years	16
11 or more years	51
Project Year	
0	13
1	8
2	30
3	16
4	16
5	15
6	3

Table 3
Descriptive Statistics for Teacher/Project-Level Variables

	Percent of Teachers (N=28,714)
Community type in which teacher's school is located	
Rural	11
Town or small city	16
Suburban	25
Urban	48

Table 4
Descriptive Statistics for Teacher/Project-Level Variables

	Minimum	Maximum	Mean	Standard Deviation
Number of Students in school				
Original	7	3,030	672	361
Transformed – Box and Cox	2.45	23.13	14.62	2.32
Percent of student body classified as Non-Asian minority				
Original	0.00	100.00	46.17	35.22
Transformed – Folded Natural Log	0.69	1.39	1.07	0.18
Percent of students in school eligible for free/reduced-price lunch (FRL)				
Original	0.00	100.00	48.20	31.10
Transformed – sine	0.00	0.84	0.44	0.27
Percent of students in school classified as limited-English proficient (LEP)				
Original	0.00	100.00	13.27	20.93
Transformed – Box and Cox	-4.00	8.65	1.22	3.73

The outcome variable for the analysis, frequency of use of LSC 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 LSC-designated instructional materials would be reported in each possible category. The analysis produces estimates of the likelihood that the frequency of use of LSC 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 LSC 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 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 5.05[3] 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 2 random effects were tested for each model (i.e., the relationship between the level 1 predictor variable and the outcome variable varied across projects).

Two 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

[3] Raudenbush, Stephen; Bryk, Anthony; Cheong, Yuk F.; Congdon, Richard; Scientific Software International, 2000.

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 LSC's conducted work with principals as a part of their initiatives, so controlling for this variable permitted a more direct focus on the relationship between professional development and the outcome.

The fixed-effects estimates of the main effects on the outcome are shown in Table 5. The individual project effects were included to control for project-specific differences on the outcome, but are not shown because the analysis was focused on program-wide effects rather than project-specific effects.

Table 5[4]
Time-Point- and Teacher/School-Level Fixed Effects

	Project Year Model	**Project Year, Professional Development, and Principal Support Model**
Intercept	0.07* (0.03)	-0.65*** (0.03)
Project Year (adjusted for school characteristics)		-0.15*** (0.01)
Hours of LSC Professional Development (adjusted for school characteristics) Linear		-6.61*** (0.14)
Quadratic		6.22*** (0.20)
Cubic		-1.79*** (0.07)
Teacher's Perception of Principal Support (adjusted for school characteristics)		-1.31*** (0.06)
Teacher Characteristics		
Experience Level (Intermediate Omitted)		
Novice (1–5 yr)	0.11** (0.03)	-0.07 (0.03)
Very Experienced (11+ yr)	0.00 (0.03)	0.01 (0.03)
School Characteristics		
School Size (in hundreds of students)	0.02 (0.01)	0.03* (0.01)
Non-Asian Minority	-0.88** (0.28)	-0.63* (0.29)
Limited-English Proficient	-0.05*** (0.01)	-0.04*** (0.01)
Free or Reduced-Price Lunch	0.91*** (0.15)	0.49** (0.16)
Community Type (Urban Omitted)		
Rural	0.30** (0.09)	0.11 (0.10)
Suburban	0.00 (0.07)	-0.08 (0.07)
Town or Small City	0.29*** (0.08)	0.10 (0.08)

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

[4] Note that project-specific effects were controlled at Level 2 but these coefficients are not reported in the table.

Relationship between Frequency of Use of LSC Materials and Project Year

The key result of the analyses for frequency of use of LSC Materials predicted by project year is the coefficient of -0.37 for project year. This result indicates that, in general, the use of LSC-designated instructional materials became more frequent as project year increased. Figure 1 displays the predicted probabilities for use of LSC-designated instructional materials by project year.

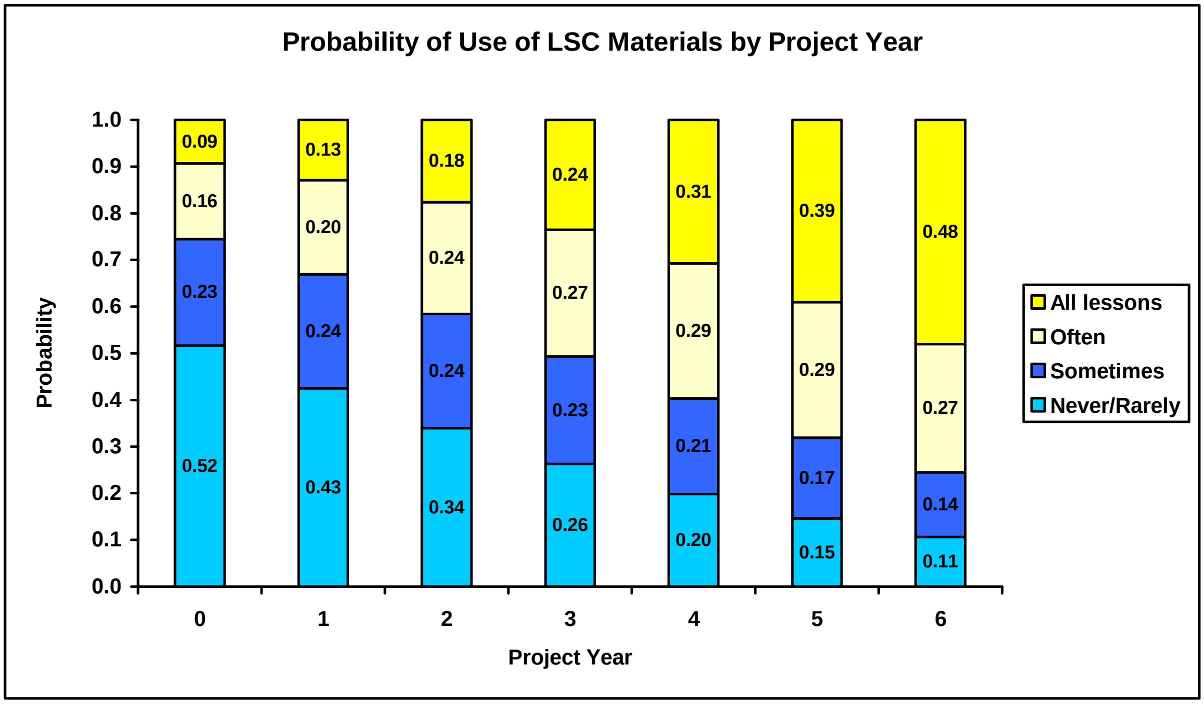

Figure 1

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 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 does not compute weighted estimates in ordinal models. 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 6. The Chi-square analysis compared the overall distribution of reported frequency of use of LSC-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 7.) 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 8.

Table 6
Teachers and Projects Included in Model by Subject/Grade-Range

Subject/Grade-Range	Number of Projects	Number of Teachers	Percent of Teachers
K–8 Science	42	16,821	46
K–8 Mathematics	29	13,489	37
6–12 Mathematics	19	5,152	14
6–12 Science	7	1,362	4
Total	**85**[†]	**36,824**	**100**

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

Table 7
Frequency of Use of LSC Materials by Project Year

		Percent of Teachers (weighted)			
	Unweighted N	Never or Rarely	Sometimes	Often	All
Year 0	3072	61	13	12	13
Year 1	1260	43	19	18	21
Year 2	6576	35	18	21	26
Year 3	5620	30	21	25	24
Year 4	4866	31	20	22	27
Year 5	5085	26	23	23	28
Year 6	1338	26	23	23	27

Table 8
Chi-Square and Holm-Bonferroni Adjustment Results

	Adjusted alpha[†]	p-value
Year 0 v Year 1	0.0083	.000*
Year 1 v Year 2	0.0100	.000*
Year 2 v Year 3	0.0125	.000*
Year 3 v Year 4	0.0167	.000*
Year 4 v Year 5	0.0250	.000*
Year 5 v Year 6	0.0500	0.990

[†] 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 LSC-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 7, which show increased frequency in teachers' use of LSC materials by year up to Year 5. These results support the conclusion of the hierarchical analysis that across all teachers and projects the frequency of use of LSC-designated instructional materials increases as projects mature.

Relationship between Frequency of Use of LSC Materials and Professional Development

Key results of the analyses for frequency of use of LSC Materials and project year and number of hours of professional development (Table 5) 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 LSC -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.

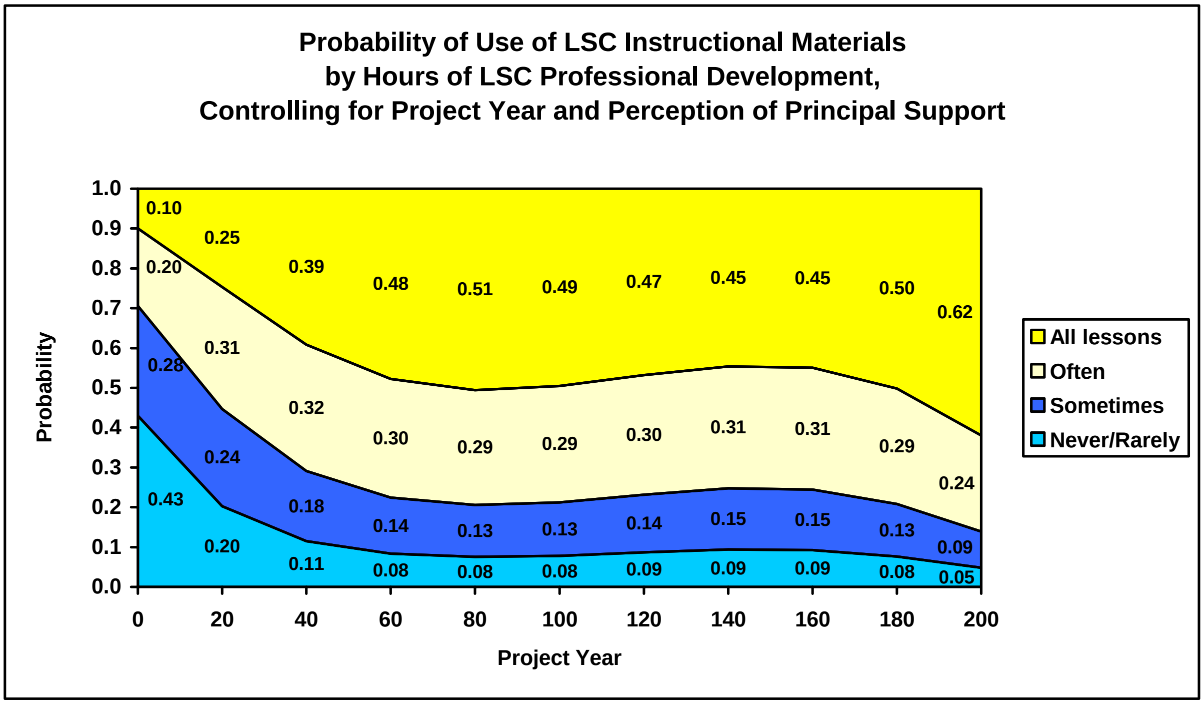

Figure 2

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 0.43 for the Never/Rarely category, 0.28 for the Sometimes category, 0.20 for the Often category, and 0.10 for the All lessons category. For those with the mean amount of LSC professional development in this sample (42 hours), the probabilities were 0.11 for Never/Rarely, 0.17 for Sometimes, 0.32 for Often, and 0.40 for All lessons. Corresponding probabilities for teachers with one standard deviation above the mean amount of LSC professional development in this sample (93 hours) were 0.08 for Never/Rarely, 0.13 for Sometimes, 0.29 for Often, and 0.50 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 LSC-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 LSC materials decreased from 0.34

to 0.20 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 LSC materials in All lessons was from 0.14 to 0.25 between the baseline year and 5th year of a project.

Second, perceptions of principal support were positively related to frequency of use of LSC materials with both project year and teachers' participation in LSC professional development controlled. This result suggests that teachers more frequently use the LSC materials when they feel supported by their principal. In terms of probabilities, a teacher reporting an average level of principal support was predicted to report use of the LSC materials in Never or Rarely with a probability of 0.20, and in All lessons with a probability of 0.26. For comparison, a teacher reporting principal support one standard deviation above the mean was predicted to have the following probabilities of use of LSC materials: 0.16 for Never or Rarely, and 0.31 for All lessons.

Time on Instruction in Science in Elementary Grades

Sample

Between 1997 and 2003, over 34,700 K-5 teachers targeted by elementary grades 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 data from nearly 20,876 teachers, some with multiple questionnaires over time, 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 9 shows the raw and weighted distribution of teachers in the sample.

Table 9
Teachers and Projects Included in Model

Number of Projects	Number of Completed Questionnaires	Weighted Number of Teachers
42	20,876	113,102

Analysis and Results

[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).

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 (Bryk & Raudenbush, 1992).

The outcome of interest in this analysis was time on science instruction. 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 10 shows descriptive statistics for the time on science instruction outcome variable.

Table 10
Descriptive Statistics for Minutes of Science Instruction per Week

	Minimum	Maximum	Mean	Standard Deviation
Minutes of Instruction				
Original	0.00	427.5	114.27	63.10
Transformed (Box and Cox)	-1.47	89.00	34.04	14.20

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; and
- Project year.

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 at 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:

- Project Size

Descriptive statistics for the time-point-level independent variables are shown in Tables 11 and 12. 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 5 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 (LEP), and 47 percent were eligible for free/reduced-price lunch.

Table 11
Descriptive Statistics for Time-Point-Level Variables

	Percent of questionnaires
Extent of Teacher Participation in LSC Professional Development	
0 hours	33
1-9 hours	11
10-19 hours	11
20-39 hours	14
40-59 hours	10
60-79 hours	7
80-99 hours	5
100-129 hours	5
130 -159 hours	2
160-199 hours	1
200 or more hours	2
Prior Teaching Experience	
5 or fewer years	27
6-10 years	16
11 or more years	56
Project Year	
0	11
1	8
2	29
3	18
4	12
5	18
6	3

Table 12
Descriptive Statistics for Teacher/School-Level Variables

	Percent of teachers
Community type in which teacher's school is located	
Rural	11
Town or small city	18
Suburban	29
Urban	42

Table 13
Descriptive Statistics for Teacher/School-Level Variables

	Minimum	Maximum	Mean	Standard Deviation
Number of Students in school				
Original	7	2,290	575	258
Transformed – Log	-0.49	1.52	0.43	0.27
Percent of student body classified as Non-Asian minority				
Original	0.00	100.00	39.07	33.60
Transformed – Folded Natural Log	0.69	1.39	1.05	0.14
Percent of students in school eligible for free/reduced-price lunch (FRL)				
Original	0.00	100.00	46.99	30.53
Transformed – Sine	-1.00	1.00	-0.02	0.71
Percent of students in school classified as limited-English proficient (LEP)				
Original	0.00	100.00	12.47	20.04
Transformed – Box and Cox	-4.17	8.42	0.94	3.76
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 5.05[6] 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 one predictor variable and the outcome variable varied across projects).

Two main models were run. The first included all control variables and project year as a predictor. (See Appendix C.) 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 D.) 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 LSC's conducted work with principals as a part of their initiatives, so controlling for this variable permitted a more direct focus on the relationship between professional development and the outcome.

The fixed effects for the two models are shown in Table 14 .

[6] Raudenbush, Stephen; Bryk, Anthony; Cheong, Yuk F.; Congdon, Richard; Scientific Software International, 2000.

Table 14
Time-Point-, Teacher/School-, and Project-Level Fixed Effects

	Project Year Model	Project Year, Professional Development, and Principal Support Model
Intercept	33.15*** (0.74)	34.71*** (0.63)
Project Year (adjusted for school characteristics)	0.52** (0.16)	-0.05 (0.16)
Hours of LSC Professional Development (adjusted for school characteristics) Linear		12.55*** (1.66)
Quadratic		-10.96*** (2.45)
Cubic		-1.79*** (0.07)
Teacher's Perception of Principal Support (adjusted for school characteristics)		3.37** (0.90)
Teacher Characteristics		
Experience Level (Intermediate Omitted)		
Novice (1–5 yr)	-0.66* (0.31)	-0.16 (0.35)
Very Experienced (11+ yr)	-0.93** (0.32)	-0.83* (0.31)
School Characteristics		
School Size (in hundreds of students)	3.06*** (0.83)	3.64*** (0.88)
Non-Asian Minority	-3.35 (2.42)	-0.92 (2.48)
Limited-English Proficient	0.01 (0.08)	-0.01 (0.08)
Free or Reduced-Price Lunch	0.11 (0.25)	0.20 (0.27)
Community Type (Urban Omitted)		
Rural	2.20** (0.81)	1.95* (0.84)
Suburban	1.48* (0.62)	1.93** (0.64)
Town or Small City	1.85* (0.72)	2.07** (0.75)
Project Characteristics		
Number of Targeted Teachers	-0.14 (0.08)	-0.11 (0.07)

~ 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 3. 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.

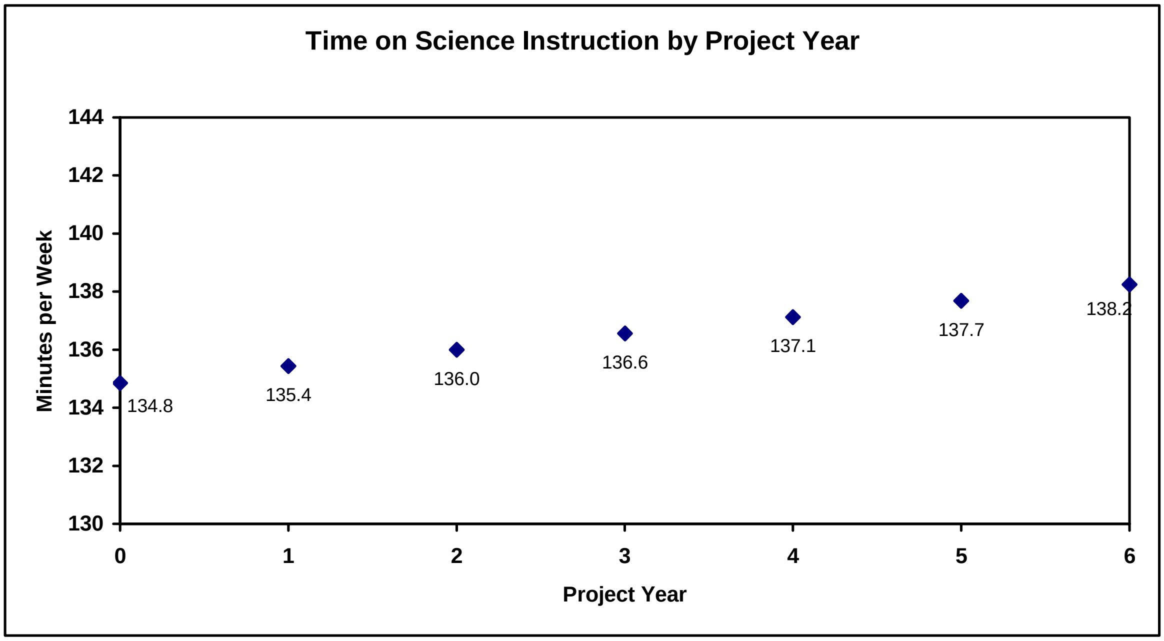

Figure 3

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 0.04 standard deviations, resulting in a predicted increase of about 2.83 minutes per week across all K-5 teachers after 5 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 4. 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.

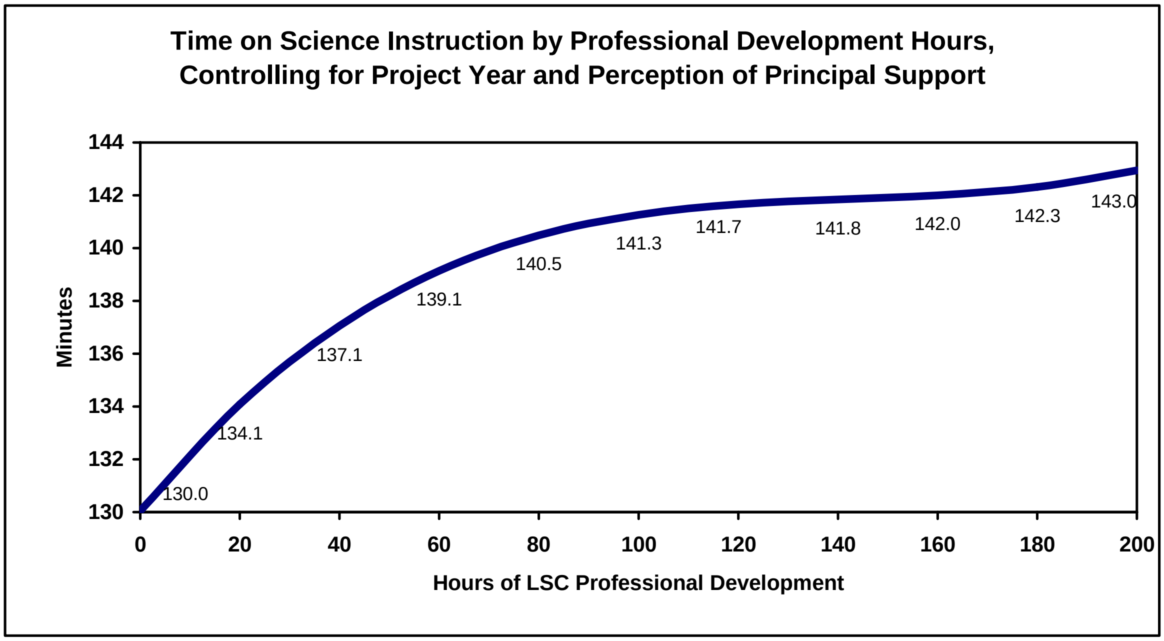

Figure 4

For a teacher who has received the mean amount of LSC professional development in this sample (34 hours), there is a medium-sized effect of 0.40 standard deviations or 6.21 minutes per week. At 1 standard deviation above the mean (79 hours) the effect is 0.66 standard deviations, which translates to 10.35 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 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 teachers' perception of principal support indicates a positive relationship between this factor and time spent on science instruction. The effect was small, a 0.06 standard deviation change, amounting to about 1 additional minute per week, in the outcome for a 1 standard deviation increase in perceived principal support. This effect was over and above the larger effect for participation in professional development.

Conclusions

Looking across the models, three key findings are evident. First, there was a positive relationship between project year and both the use of LSC 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 LSC 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.

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 LSC-designated instructional materials and K-5 teachers' time on science instruction are based upon self-report data. 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 better teachers). 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 are encouraging and appear to indicate that the LSC program is having the intended impacts on participating teachers and their practice, and is, to some extent, having impacts on classroom practice that are more systemic in nature.

Appendix A

Project Year Model for Frequency of Use of LSC Materials

Level 1

The level 1 model for the prediction of the frequency of use of LSC 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:

B0 = G00 + G01*(NUMST_T) + G02*(LEP_T) + G03*(NOASN_T) + G04*(FRL_T) + G05*(RURAL) + G06*(TOWN) + G07*(SUBURB) + SUM G0n(project ID dummy code) + U0

B1 = G10

B2 = G20

B3 = G30 + G31*(NUMST_T) + G32*(LEP_T) + G33*(NOASN_T) + G34*(FRL_T) + G35*(RURAL) + G36*(TOWN) + G37*(SUBURB)

Appendix B
Project Year, Professional Development, and Principal Support Model
for Frequency of Use of LSC Materials

Level 1
The level 1 model for the prediction of the frequency of use of LSC Materials was:

$\log[P(Y_{NRij} = 1)/(1 - P(Y_{NRij} = 1)]$ = B0 + B1* (NOVTCHR) + B2*(EXPTCHR) +
B3*(PROJYR) + B4*(PDMIDPT) + B5*(PDSQR) + B6*(PDCUB) + B7*(SQRDCON9)
$\log[P(Y_{Sij} = 1)/(1 - P(Y_{Sij} = 1)]$ = B0 + B1* (NOVTCHR) + B2*(EXPTCHR) + B3*(PROJYR) +
B4*(PDMIDPT) + B5*(PDSQR) + B6*(PDCUB) + B7*(SQRDCON9) + d(2)
$\log[P(Y_{Oij} = 1)/(1 - P(Y_{Oij} = 1)]$ = B0 + B1* (NOVTCHR) + B2*(EXPTCHR) + B3*(PROJYR)
+ B4*(PDMIDPT) + B5*(PDSQR) + B6*(PDCUB) + B7*(SQRDCON9) + 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:

B0 = G00 + G01*(NUMST_T) + G02*(LEP_T) + G03*(NOASN_T) + G04*(FRL_T) +
G05*(RURAL) + G06*(TOWN) + G07*(SUBURB) + SUM G0n(project ID dummy code) +
U0
B1 = G10
B2 = G20
B3 = G30 + G31*(NUMST_T) + G32*(LEP_T) + G33*(NOASN_T) + G34*(FRL_T) +
G35*(RURAL) + G36*(TOWN) + G37*(SUBURB)
B4 = G40 + G41*(NUMST_T) + G42*(LEP_T) + G43*(NOASN_T) + G44*(FRL_T) +
G45*(RURAL) + G46*(TOWN) + G47*(SUBURB)
B5 = G50 + G51*(NUMST_T) + G52*(LEP_T) + G53*(NOASN_T) + G54*(FRL_T) +
G55*(RURAL) + G56*(TOWN) + G57*(SUBURB)
B6 = G60 + G61*(NUMST_T) + G62*(LEP_T) + G63*(NOASN_T) + G64*(FRL_T) +
G65*(RURAL) + G66*(TOWN) + G67*(SUBURB)
B7 = G70 + G71*(NUMST_T) + G72*(LEP_T) + G73*(NOASN_T) + G74*(FRL_T) +
G75*(RURAL) + G76*(TOWN) + G77*(SUBURB)

Appendix C
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 and the slope for project year:

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

Appendix D
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)

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 + B51*(NUMST_T) + B52*(NOASN_T) + B53*(LEP_T) + B54*(FRL_T) + B55*(RURAL) + B56*(TOWN) + B57*(SUBURB)
P6 = B60 + B61*(NUMST_T) + B62*(NOASN_T) + B63*(LEP_T) + B64*(FRL_T) + B65*(RURAL) + B66*(TOWN) + B67*(SUBURB)
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 and the slope s for project year, extent of participation in LSC professional development, and perception of principal support:

B00 = G000 + G001(SQRTTARG) + U00
B01 = G010
B02 = G020
B03 = G030
B04 = G040
B05 = G050
B06 = G060
B07 = G070

B10 = G100
B20 = G200
B30 = G300 + G301(SQRTTARG) + U30
B31 = G310
B32 = G320
B33 = G330
B34 = G340
B35 = G350
B36 = G360
B37 = G370
B40 = G400 + G401(SQRTTARG) + U40
B41 = G410
B42 = G420
B43 = G430
B44 = G440
B45 = G450
B46 = G460
B47 = G470
B50 = G500 + G501(SQRTTARG) + U50
B51 = G510
B52 = G520
B53 = G530
B54 = G540
B55 = G550
B56 = G560
B57 = G570
B60 = G600 + G601(SQRTTARG) + U60
B61 = G610
B62 = G620
B63 = G630
B64 = G640
B65 = G650
B66 = G660
B67 = G670
B70 = G700 + G701(SQRTTARG) + U70
B71 = G710
B72 = G720
B73 = G730
B74 = G740
B75 = G750
B76 = G760
B77 = G770