

Professional Development Observation Study

by

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In 1995 the National Science Foundation initiated the Local Systemic Change (LSC) through Teacher Enhancement program to improve instruction in science, mathematics, and technology. Through the LSC program, 88 individual projects were funded, typically in 1 of 4 targeted areas—K–8 science, K–8 mathematics, 6–12 mathematics, or 6–12 science—though some projects targeted 2 of these 4 areas (e.g., K–12 mathematics, or K–8 science and mathematics). LSC projects were expected to provide 130 hours of professional development to each targeted teacher over the course of its funding, with the emphasis on preparing teachers to implement exemplary science and mathematics instructional materials and lessons in their classes.¹

As part of the core evaluation, all LSC evaluators were required to observe a sample of their project's professional development sessions each year.² Evaluators utilized a common instrument for rating the features and quality of the observed sessions, the Professional Development Observation Protocol (PDOP). The accumulated protocols provide a large set of data on professional development that allow for the investigation of whether certain features are important predictors of the quality of the professional development. Specifically, questions that can be investigated with these data are:

- Has LSC professional development improved as projects mature?
- Is providing professional development around the instructional materials teachers are expected to implement a promising strategy?
- Does the type of professional development provider (e.g., scientist/mathematician, teacher leader, university education faculty) predict session quality?
- What professional development strategies (e.g., lecture/discussion, engaging participants in problem-solving) appear to be most effective?
- Are seminars/study-groups/mentoring more effective than workshops?

This study utilizes hierarchical linear modeling to explore these questions. Model One examines the relationship between quality of professional development and project maturity. Models Two, Three, and Four examine relationships between session quality ratings and features of the professional development. Since professional development can have any of a number of purposes these models are examined for each independently. The professional development purposes for which these relationships are examined are:

- Creating a vision of effective instruction;
- Increasing mathematics/science content knowledge of the participants;
- Understanding student thinking/learning about mathematics/science content;
- Learning pedagogical/classroom management strategies;
- Learning how to use specific instructional materials in the classroom;

¹ Prior to 1999, the requirement for K–8 projects was 100 hours.

² Lead Evaluators were required to attend training on the use of the observation protocol to ensure consistent application of the rating scales across projects.

- Promoting/exploring reflective practice;
- Building professional networks among educators; and
- Strategies/issues/roles of teacher leaders, principals, or others in leadership positions.

For each purpose, Models Two, Three, and Four are constructed, relating session quality to a key feature of the professional development. Model Two examines the effects of various types of professional development providers, Model Three examines the types of activities used in the session (problem solving, listening to a formal presentation, etc.), and Model Four examines the approaches used (workshop, study group, etc.).

Sample

Between 1997 and 2003, over 2,400 observations of professional development sessions were submitted as part of the core evaluation of the LSC. In total, these analyses utilized data from 2,185 of the observed sessions.³ Project evaluators were required to observe 5–8 professional development sessions each year after the Baseline Year. (Two observations were required in the Baseline Year.) In some instances, evaluators submitted more than the required number of observations, resulting in some projects being represented more heavily in the data set than others. Typically, design weights are used to adjust for unbalanced sampling. Unfortunately, the type of analyses utilized in this study does not allow for the use of design weights; however, as discussed later in this report, the effect of this unbalanced sampling appears to be minimal.

Table 1 shows the frequency with which the observed sessions targeted the various professional development purposes. The most common purposes in the observed sessions were training teachers to use the LSC-designated instructional materials and deepening teachers' mathematics/science content knowledge. Professional development sessions targeting leadership strategies and building professional networks were observed least frequently.⁴

Table 1
Observed Sessions Targeting Various Professional Development Purposes

	Number of Sessions	Percent of Sessions[†]
Learning how to use specific instructional materials in the classroom	952	44
Increasing mathematics/science content knowledge of the participants	893	41
Learning pedagogical/classroom management strategies	707	32
Creating a vision of effective instruction	652	30
Understanding student thinking/learning about mathematics/science content	640	29
Promoting/exploring reflective practice	440	20
Building professional networks among educators	307	14
Strategies/issues/roles of teacher leaders, principals, or other leadership positions	304	14

[†] Percents do not sum to 100 as sessions could have multiple purposes.

³ Although the LSC core evaluation began in 1995, the instruments evolved over the first few years. Observations prior to 1997 were dropped due to inconsistent instrument items. A small group of observations from the remaining years were dropped due to incomplete data.

⁴ Evaluators were asked to observe professional development sessions that were representative of the project's activities; the distribution of purposes in the observed sessions should reflect the frequency in the programs overall.

Descriptive statistics for the data set as a whole are shown in the body of this report. The models utilize different subsets of the data set; therefore, descriptive statistics for each individual model can be found in Appendices A–D.

The distribution of professional development sessions by subject and grade range is shown in Table 2. Elementary science sessions were observed most frequently while sessions for secondary science were observed least frequently; these frequencies are not surprising given the relative number of projects funded within each subject/grade-range.

Table 2
Sessions by Subject/Grade Range

	Number of Projects	Number of Sessions	Percent of Sessions
K–8 Mathematics	29	521	24
K–8 Science	45	1,131	52
6–12 Mathematics	19	381	17
6–12 Science	7	152	7
Total †	85	2,185	100

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

As can be seen in Table 3, evaluators judged the majority of observed professional development sessions to be high in quality. Only eight percent of the sessions were rated low in quality.

Table 3
Distribution of Capsule Ratings

Five-Point Scale	Percent of Sessions	Three-Point Scale	Percent
Level 1: Ineffective Professional Development	2	Low Rating	8
Level 2: Elements of Effective Professional Development	6		
Level 3: Beginning stages of Effective Professional Development	35	Medium Rating	35
Level 4: Accomplished, Effective Professional Development	35	High Rating	57
Level 5: Exemplary Professional Development	22		

Observers also provided information on a number of session characteristics, including the number and background of session facilitators, the number of participants, and the professional development approaches and activities utilized in the session. As can be seen in Table 4, sessions were typically led by one or two professional development providers, people who came from a wide variety of backgrounds. Ninety percent of the observed sessions were part of a workshop, institute, or course; 11 percent were classified as study groups or instances of coaching/mentoring. The number of participants attending the sessions varied, although few sessions included more than 50 people. Half of the sessions incorporated the LSC-designated instructional materials into the professional development.

Table 4
Session Characteristics

	Percent of Sessions
Project Year	
Baseline	6
Year One	19
Year Two	26
Year Three	23
Year Four	16
Year Five	7
Year Six	2
Type of Professional Development Provider[†]	
Regular Full-time or Part-time classroom teachers	43
Teachers on special assignment	32
District Mathematics/Science Supervisors and/or Other District Personnel	18
University mathematics/science education faculty	19
Business Industry Mathematicians/Scientists and/or University Mathematics/Science Faculty	17
Other non-district personnel	23
Type of Professional Development Approach	
Workshop/institute/course seminar	90
Study groups/"kit clubs"/discussion groups/school-based meetings/ Coaching/Mentoring	11
Type of Professional Development Activity[†]	
Engaged in discussions/seminars/reporting out	78
Engaged in problem solving/investigation focusing on disciplinary content, pedagogy and/or reform issues	62
Listened to a formal presentation	40
Number of Professional Development Providers	
One	38
Two	34
Three	14
Four or more	14
Number of Participants	
1–10	23
11–20	36
21–50	34
51 or more	8
Utilized LSC-Designated Instructional Materials	
Yes	50
No	50

[†] Percents do not sum to 100 as multiple categories could apply to each session.

Analysis and Results

The LSC professional development observation data have a nested structure, with multiple observed sessions within each LSC 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, 1992⁵).

⁵ Bryk, A.S., & Raudenbush, S.W. (1992). *Hierarchical Linear Models: Applications and data analysis methods*. Newbury Park, CA: Sage Publications.

Model One examines the relationship between project maturity and quality of session ratings. Model Two looks at the relationship between the types of professional development providers leading a session and the rating of session quality. Model Three analyzes the relationship between the type of activity utilized within the session and the session's quality. Finally, Model Four examines the relationship between the professional development approaches and ratings of session quality. All four models utilize a two-level hierarchical linear model (HLM), with sessions nested within projects.

Because of the small number of sessions led by certain types of professional development providers, some types of professional development providers were categorized into the same group. Specifically, university mathematics/science faculty and business/industry mathematicians/scientists were grouped together into a scientist/mathematician group. Similarly, district mathematics/science supervisors were grouped with "other district personnel" (non teacher leaders) to form a district administrator group. Thus, the professional development provider categories used in the analyses are:

- Regular full-time or part-time classroom teacher(s);
- Teacher(s) on special assignment;
- District administrators: mathematics/science supervisor(s) and/or other district personnel;
- Scientists/mathematicians: university mathematics/science faculty and/or business/industry mathematicians/scientists;
- University mathematics/science education faculty; and
- Other non-district personnel.

The activities used in the professional development session were categorized into three variables:

- Listening to a formal presentation;
- Engaging in discussions/seminars/reporting out; and
- Engaging in problem solving/investigation focusing on disciplinary content, pedagogy, and/or reform issues.

The two professional development approaches examined were:

- Workshop/institute/course seminar; and
- Study groups/"kit clubs"/discussion groups/school-based meetings/coaching/mentoring.

The number of professional development providers and participants at the session, the projects' targeted subject/grade-range, and the number of teachers targeted by the project were included in these analyses as well.

Regression analysis assumes that the variables utilized are multivariate normal. Because the distribution of the number of teachers targeted by projects deviated substantially from a normal distribution, the variable was transformed using a square root transformation. Table 5 displays summary data for both the original and the transformed variable.

Table 5
Project Characteristics

	Minimum	Maximum	Mean	Standard Deviation
Number of targeted teachers				
Original	21.00	2052.00	747.63	565.30
Transformed—Square Root	4.58	45.30	25.30	10.43

Conceptually, each session was treated as an event with a probability of receiving a low (1 or 2 capsule rating), medium (3 capsule rating), or high (4 or 5 capsule rating) rating for the overall session quality that is related to characteristics of the session and project. The analysis produces estimates that can be translated into predicted probabilities that a session will receive a particular rating given the specific characteristics of the session and project.

The outcome variable for each analysis, lesson capsule rating, is an ordinal variable. For these analyses, the lesson is conceptualized as an event with an underlying distribution of probabilities that its capsule rating will be in each category. The analysis produces estimates of the likelihood that a session will be rated in each category based on the independent variables in the model. 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:

$$\begin{aligned}
 Y_{ij} &= X = \text{Capsule rating for session } i \text{ in project } j \\
 X = L &= \text{Capsule rating in Low category (1a, 1b, 2)} \\
 X = M &= \text{Capsule rating in Medium category (3 low, 3 solid, 3 high)} \\
 X = H &= \text{Capsule rating in High category (4, 5)}
 \end{aligned}$$

$$Y_{Xij} = 1, \text{ if the capsule rating is in or below category } X$$

$$Y_{Xij} = 0, \text{ if the capsule rating is above category } X$$

$$P(Y_{ij} = X) = \varphi_{Xi} = \text{probability that the capsule rating is in category } X$$

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

$$\begin{aligned}
 \varphi_{Lij} &= \varphi^*_{Lij} \\
 \varphi_{Mij} + \varphi_{Lij} &= \varphi^*_{Mij} \\
 \varphi_{Hij} + \varphi_{Mij} + \varphi_{Lij} &= \varphi^*_{Hij} = 1
 \end{aligned}$$

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

$$E(Y_{Xij}) = \varphi^*_{Xij}$$

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

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

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

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

Using this transformation, η_{Xij} is the logarithm of the predicted odds (or “log-odds”) of a session being rated in or below category X. Since the estimated outcomes are the log odds of a capsule rating in or below each category, the predicted probability of a rating in or below each category for any session 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 5.05⁶ was used for all analyses. All independent variables were entered using grand-mean centering; categorical variables were entered as sets of dummy-coded variables. One limitation of estimating hierarchical generalized linear models is the inability to use sample design weights. However, the lack of consistent random variation across projects for any of the variables included at the session level suggests that the unweighted data provided reasonable estimates, despite the unequal sampling probabilities of sessions across projects.

Model One: Project Maturity and Session Quality

A two-level hierarchical linear model, with professional development sessions nested within projects, was used to investigate the relationship between ratings of quality of professional development sessions and project maturity. The model also took into account whether the session utilized the LSC-designated instructional materials and controlled for session characteristics such as the total number of providers and participants.

The variables included at the session level were:

- Number of professional development providers;

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

- Number of participants;
- Use of LSC-designated instructional materials; and
- Project year.

At the project level, the following control variables were included:

- Subject/grade-range targeted by the LSC; and
- Number of teachers targeted by the LSC.

Descriptive statistics for the variables used in Model One are provided in Appendix A.

The following model was run:

$$\begin{aligned} \eta_{Lij} = & B_{0j} \\ & + B_{1j}*(\text{Use of LSC-designated instructional materials}) \\ & + B_{2j}*(\text{Number of providers: One}) \\ & + B_{3j}*(\text{Number of providers: Two}) \\ & + B_{4j}*(\text{Number of providers: Three}) \\ & + B_{5j}*(\text{Number of participants: 1-10}) \\ & + B_{6j}*(\text{Number of participants: 11-20}) \\ & + B_{7j}*(\text{Number of participants: 21-50}) \\ & + B_{8j}*(\text{Project year}) \end{aligned}$$

$$\begin{aligned} \eta_{Mij} = & B_{0j} \\ & + B_{1j}*(\text{Use of LSC-designated instructional materials}) \\ & + B_{2j}*(\text{Number of providers: One}) \\ & + B_{3j}*(\text{Number of providers: Two}) \\ & + B_{4j}*(\text{Number of providers: Three}) \\ & + B_{5j}*(\text{Number of participants: 1-10}) \\ & + B_{6j}*(\text{Number of participants: 11-20}) \\ & + B_{7j}*(\text{Number of participants: 21-50}) \\ & + B_{8j}*(\text{Project year}) \\ & + d(2) \end{aligned}$$

$$B_{0j} = G_{00} + G_{01}*(\text{Project Size}) + G_{02}*(\text{K-8 Mathematics}) + G_{03}*(\text{6-12 Mathematics}) + G_{04}*(\text{6-12 Science}) + U_{0j}$$

$$B_{1j} = G_{10}$$

$$B_{2j} = G_{20}$$

$$B_{3j} = G_{30}$$

$$B_{4j} = G_{40}$$

$$B_{5j} = G_{50}$$

$$B_{6j} = G_{60}$$

$$B_{7j} = G_{70}$$

$$B_{8j} = G_{80}$$

As can be seen in Table 6, project year is a significant predictor of session quality. It is important to note that the magnitude and direction of the regression coefficients should not be interpreted directly. Due to the transformation of the outcome variable and the centering of dummy-coded predictor variables, the coefficients must be converted to probabilities in order to draw meaningful interpretations and conclusions.

Table 6
Regression Coefficients and Standard Errors for Model One:
Project Maturity and Session Quality

	Overall Capsule Rating
Number of Sessions	2,111
<i>Intercept</i>	-2.30*** (0.15)
<i>Threshold</i>	2.44*** (0.09)
Session Characteristics	
<i>Number of professional development providers (4 or more omitted)</i>	
One	0.43** (0.16)
Two	0.32* (0.16)
Three	0.10 (0.19)
<i>Number of participants (51 or more omitted)</i>	
1-10	0.07 (0.21)
11-20	-0.22 (0.20)
21-50	-0.17 (0.20)
<i>Use of LSC-designated instructional materials (No omitted)</i>	
Yes	-0.12 (0.09)
<i>Project Year</i>	-0.22*** (0.04)
Project Characteristics	
<i>Project Subject/Grade Range (K-8 Science omitted)</i>	
K-8 Mathematics	-0.24 (0.25)
6-12 Mathematics	-0.01 (0.33)
6-12 Science	0.72 (0.46)
<i>Square Root of the Number of Teachers Targeted by the LSC</i>	
+1 standard deviations	0.03* (0.01)

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

Table 7 displays predicted probabilities that a session would receive a rating of low, medium, or high at different stages of a project. Sessions during a project's Baseline Year have a 0.47 probability of receiving a high quality rating, compared to 0.58 and 0.72 in Year Two and Year Five, respectively.

Table 7
Predicted Session Quality, by Project Year

	Predicted Probability		
	Project Year		
	Baseline Year	Year Two	Year Five
Low	0.09	0.06	0.03
Medium	0.44	0.36	0.24
High	0.47	0.58	0.72

[~] p < 0.10; * p < 0.05; ** p < 0.01; *** p < 0.001

Model Two: Type of Professional Development Provider

For each session purpose, a two-level hierarchical linear model, with professional development sessions nested within projects, was used to investigate the relationship between the professional development sessions' ratings of overall quality and the type of professional development providers leading each professional development session. The models also took into account whether the session utilized the LSC-designated instructional materials and controlled for session characteristics such as the total number of providers and participants.

The variables included at the session level were:

- Number of professional development providers;
- Number of participants;
- Use of LSC-designated instructional materials; and
- Type of presenter(s)/facilitator(s)
 - Regular full-time or part-time classroom teacher(s);
 - Teacher(s) on special assignment;
 - District mathematics/science supervisor(s) and/or other district personnel;
 - University mathematics/science faculty and/or business industry scientists;
 - University mathematics/science education faculty; or
 - Other non-district personnel.

At the project level, the following control variables were included:

- Subject/grade-range targeted by the LSC; and
- Number of teachers targeted by the LSC.

Descriptive statistics for the variables used in Model Two, by professional development purpose, are provided in Appendix B.

For each professional development purpose, the following model was run:

$$\eta_{L,ij} = B_{0j} + B_{1j}*(\text{Use of LSC-designated instructional materials}) + B_{2j}*(\text{Providers: Regular full-time or part-time teachers}) + B_{3j}*(\text{Providers: Teachers on special assignment}) + B_{4j}*(\text{Providers: University mathematics/science faculty or business industry mathematicians/scientists})$$

- + B_{5j}*(Providers: Other non-district personnel)
- + B_{6j}*(Providers: District mathematics/science supervisor or other district personnel)
- + B_{7j}*(Providers: University mathematics/science education faculty)
- + B_{8j}*(Number of providers: One)
- + B_{9j}*(Number of providers: Two)
- + B_{10j}*(Number of providers: Three)
- + B_{11j}*(Number of participants: 1-10)
- + B_{12j}*(Number of participants: 11-20)
- + B_{13j}*(Number of participants: 21-50)

$$\eta_{Mij} = B_{0j} + B_{1j}*(\text{Use of LSC-designated instructional materials}) + B_{2j}*(\text{Providers: Regular full-time or part-time teachers}) + B_{3j}*(\text{Providers: Teachers on special assignment}) + B_{4j}*(\text{Providers: University mathematics/science faculty or business industry mathematicians/scientists}) + B_{5j}*(\text{Providers: Other non-district personnel}) + B_{6j}*(\text{Providers: District mathematics/science supervisor or other district personnel}) + B_{7j}*(\text{Providers: University mathematics/science education faculty}) + B_{8j}*(\text{Number of providers: One}) + B_{9j}*(\text{Number of providers: Two}) + B_{10j}*(\text{Number of providers: Three}) + B_{11j}*(\text{Number of participants: 1-10}) + B_{12j}*(\text{Number of participants: 11-20}) + B_{13j}*(\text{Number of participants: 21-50}) + d(2)$$

$$B_{0j} = G_{00} + G_{01}*(K-8 \text{ Mathematics}) + G_{02}*(6-12 \text{ Mathematics}) + G_{03}*(6-12 \text{ Science}) + G_{04}*(\text{Project Size}) + U_{0j}$$

$$\begin{aligned} B_{1j} &= G_{10} \\ B_{2j} &= G_{20} \\ B_{3j} &= G_{30} \\ B_{4j} &= G_{40} \\ B_{5j} &= G_{50} \\ B_{6j} &= G_{60} \\ B_{7j} &= G_{70} \\ B_{8j} &= G_{80} \\ B_{9j} &= G_{90} \\ B_{10j} &= G_{100} \\ B_{11j} &= G_{110} \\ B_{12j} &= G_{120} \\ B_{13j} &= G_{130} \end{aligned}$$

As can be seen in Table 8, which shows the number of sessions, regression coefficients, and standard errors by professional development purpose, few of the independent variables are significant predictors of session quality. It is important to note that the magnitude and direction of the regression coefficients should not be interpreted directly. Due to the transformation of the outcome variable and the centering of dummy-coded predictor variables, the coefficients must be converted to probabilities in order to draw meaningful interpretations and conclusions. Probabilities for variables of interest that were significant predictors of session quality are shown in Tables 9–12.

Table 8
Regression Coefficients and Standard Errors for Model Two (Providers),
by Professional Development Purpose

	Creating a Vision of Effective Instruction	Deepening Teacher Content Knowledge	Understanding Student Thinking	Learning Pedagogical Strategies	Learning to Use Instructional Materials	Promoting Reflective Practice	Building Professional Networks	Strategies in Leadership Roles
Number of Sessions	621	869	627	674	922	424	294	295
<i>Intercept</i>	-3.08*** (0.20)	-2.95*** (0.18)	3.07*** (0.20)	-2.98*** (0.19)	-2.73*** (0.17)	-3.47*** (0.28)	-3.21*** (0.31)	-3.31*** (0.32)
<i>Threshold</i>	2.38*** (0.17)	2.37*** (0.14)	2.28*** (0.17)	2.38*** (0.16)	2.42*** (0.12)	2.57*** (0.24)	2.53*** (0.27)	2.61*** (0.27)
Session Characteristics								
<i>Number of professional development providers (4 or more omitted)</i>								
One	0.80* (0.38)	0.34 (0.36)	0.50 (0.39)	0.73~ (0.40)	0.18 (0.36)	-0.51 (0.50)	-0.37 (0.54)	0.08 (0.55)
Two	0.68* (0.33)	0.03 (0.30)	0.69* (0.34)	0.92* (0.35)	0.07 (0.32)	-0.48 (0.44)	0.08 (0.48)	0.06 (0.47)
Three	0.08 (0.36)	0.04 (0.31)	0.04 (0.38)	0.62~ (0.37)	0.11 (0.32)	-0.36 (0.47)	-0.12 (0.50)	-0.57 (0.51)
<i>Number of participants (51 or more omitted)</i>								
1-10	-0.72~ (0.43)	-0.61 (0.41)	-0.19 (0.42)	-0.86* (0.41)	-0.03 (0.45)	0.12 (0.53)	0.32 (0.56)	0.94 (0.58)
11-20	-1.00* (0.39)	-0.57 (0.39)	-0.54 (0.40)	-0.93* (0.38)	-0.11 (0.43)	0.06 (0.50)	-0.02 (0.49)	0.08 (0.53)
21-50	-0.86* (0.38)	-0.53 (0.38)	-0.16 (0.39)	-0.99** (0.37)	-0.26 (0.43)	0.36 (0.46)	0.04 (0.47)	0.23 (0.49)
<i>Use of LSC-designated instructional materials (No omitted)</i>								
Yes	-0.09 (0.19)	-0.43** (0.16)	-0.16 (0.19)	-0.08 (0.18)	-0.39* (0.16)	0.14 (0.24)	0.30 (0.28)	0.20 (0.32)
<i>Presenters/facilitators for this particular session included:</i>								
Classroom teachers	-0.20 (0.26)	0.19 (0.22)	0.19 (0.26)	0.21 (0.25)	0.01 (0.22)	-0.16 (0.34)	-0.07 (0.36)	-0.47 (0.44)
Teachers on special assignment	0.10 (0.25)	-0.18 (0.22)	0.18 (0.25)	0.12 (0.25)	-0.21 (0.22)	-0.51 (0.32)	0.25 (0.39)	0.31 (0.43)
District personnel	0.37 (0.29)	-0.10 (0.28)	-0.10 (0.31)	0.14 (0.27)	-0.00 (0.26)	-0.52 (0.37)	0.06 (0.36)	0.10 (0.37)
Mathematicians/scientists	-0.21 (0.33)	0.13 (0.23)	-0.21 (0.33)	-0.20 (0.32)	0.10 (0.25)	0.12 (0.37)	-0.51 (0.41)	-0.08 (0.45)
Education faculty	-0.28 (0.30)	-0.34 (0.24)	-0.93** (0.33)	-0.13 (0.31)	-0.53* (0.27)	-1.43** (0.45)	-0.49 (0.46)	-0.18 (0.41)
Other non-district personnel	-0.22 (0.28)	-0.13 (0.24)	-0.21 (0.28)	-0.02 (0.27)	0.06 (0.24)	-0.91* (0.40)	0.36 (0.38)	-0.01 (0.38)
Project Characteristics								
<i>Project Subject/Grade Range (K-8 Science omitted)</i>								
K-8 Mathematics	0.34 (0.35)	-0.24 (0.32)	-0.09 (0.33)	0.15 (0.33)	-0.10 (0.35)	0.26 (0.42)	0.17 (0.53)	0.60 (0.51)
6-12 Mathematics	0.96* (0.47)	-0.06 (0.40)	0.63 (0.43)	0.47 (0.45)	-0.01 (0.46)	0.87 (0.63)	0.35 (0.68)	0.50 (0.74)
6-12 Science	1.70** (0.58)	0.31 (0.55)	1.04~ (0.58)	0.86 (0.61)	0.44 (0.63)	1.86** (0.71)	1.00 (0.77)	2.54* (1.01)
<i>Square Root of the Number of Teachers Targeted by the LSC</i>								
+1 standard deviations	0.04* (0.02)	0.01 (0.02)	0.03 (0.02)	0.05** (0.02)	0.02 (0.02)	0.04~ (0.02)	0.03 (0.03)	0.08** (0.03)

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

Across all of the purposes, the type of professional development provider is a significant predictor of session quality in only a few instances. As can be seen in Table 9, sessions including university mathematics/science education faculty were likely to receive higher ratings than sessions without university mathematics/science education faculty in three of the eight purposes: learning to use instructional materials, promoting reflective practice, and understanding student thinking.

Table 9
Predicted Probabilities, by Whether the Session Facilitators
Included University Mathematics/Science Education Faculty

	Low	Medium	High
Learning to Use Instructional Materials			
With Education Faculty *	0.04	0.28	0.68
Without Education Faculty	0.07	0.38	0.56
Promoting Reflective Practice			
With Education Faculty **	0.01	0.10	0.89
Without Education Faculty	0.04	0.31	0.66
Understanding Student Thinking			
With Education Faculty *	0.02	0.15	0.82
Without Education Faculty	0.05	0.30	0.65

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

Sessions focusing on promoting reflective practice tended to have higher ratings when their facilitators included “other non-district personnel” (e.g., personnel from museums or curriculum publishers). Sessions with “other non-district personnel” as one of the providers had a 0.84 probability of receiving a high rating for this purpose, compared to a 0.68 probability when the session did not include this type of provider (see Table 10).

Table 10
Predicted Probabilities, by Whether the Session
Facilitators Included “Other Non-District Personnel”

	Low	Medium	High
Promoting Reflective Practice			
With Other Non-District Personnel*	0.01	0.15	0.84
Without Other Non-District Personnel	0.04	0.29	0.68

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

Tables 11 and 12 display the predicted probabilities for other significant findings in the Model Two analyses. Sessions focused on two purposes, creating a vision of effective instruction and learning pedagogical strategies, were more likely to receive high ratings when they contained 1–10, 11–20, and 21–50 participants than when they included 51 or more participants. Similarly, for these two purposes, sessions facilitated by one, two, or three providers tended to have lower ratings than sessions facilitated by four or more providers. For these two purposes, it appears that the ratio of presenters to participants may be a key predictor of quality.

Table 11
Predicted Probabilities,
Model Two Number of Participants

	Low	Medium	High
Creating a Vision of Effective Instruction			
1–10 Participants [~]	0.05	0.35	0.65
11–20 Participants*	0.04	0.29	0.71
21–50 Participants*	0.04	0.32	0.68
51 or More Participants [‡]	0.09	0.53	0.47
Learning Pedagogical Strategies			
1–10 Participants*	0.05	0.36	0.64
11–20 Participants*	0.05	0.34	0.66
21–50 Participants**	0.04	0.33	0.77
51 or More Participants [‡]	0.11	0.57	0.43

[‡] Referent Group

[~] p < 0.10; * p < 0.05; ** p < 0.01; *** p < 0.001

Table 12
Predicted Probabilities,
Model Two Number of Providers

	Low	Medium	High
Creating a Vision of Effective Instruction			
Facilitated by One Provider *	0.06	.40	.60
Facilitated by Two Provider *	0.05	.37	.63
Facilitated by Three Providers	0.06	.25	.75
Facilitated by Four or More Providers [‡]	0.03	.23	.77
Learning Pedagogical Strategies			
Facilitated by One Provider [~]	0.05	0.37	0.63
Facilitated by Two Provider *	0.06	0.42	0.58
Facilitated by Three Providers [~]	0.11	0.35	0.65
Facilitated by Four or More Providers [‡]	0.03	0.22	0.78

[‡] Referent Group

[~] p < 0.10; * p < 0.05; ** p < 0.01; *** p < 0.001

Model Three: Activities Utilized in the Professional Development Session

As in Models One and Two, a two-level hierarchical linear model, with professional development sessions nested within projects, was used to investigate the relationship between the professional development sessions' capsule rating of quality and the types of activities used in the professional development session for each purpose category. Session factors such as the number of providers and participants were controlled for in these models as well.

Descriptive statistics for the variables used in Model Three, by professional development purpose, are provided in Appendix C.

The variables included at the session level were:

- Number of professional development providers;
- Number of participants;
- Use of LSC-designated instructional materials; and
- Professional development activities

- Listened to a formal presentation
- Engaged in discussions/seminars/reporting out
- Engaged in problem solving/investigation focusing on disciplinary content, pedagogy, and/or reform issues.

At the project-level, the following control variables were included:

- Subject/grade-range targeted by the LSC; and
- Number of teachers targeted by the LSC.

For each professional development purpose, the following model was run:

$$\begin{aligned} \eta_{Lij} = & B_{0j} \\ & + B_{1j}*(\text{Use of LSC-designated instructional materials}) \\ & + B_{2j}*(\text{Activities: Listening to formal presentations}) \\ & + B_{3j}*(\text{Activities: Engaging in discussions/seminars/reporting out}) \\ & + B_{4j}*(\text{Activities: Engaging in problem solving/investigation focusing on disciplinary content,} \\ & \quad \text{pedagogy, and/or reform issues}) \\ & + B_{5j}*(\text{Number of providers: One}) \\ & + B_{6j}*(\text{Number of providers: Two}) \\ & + B_{7j}*(\text{Number of providers: Three}) \\ & + B_{8j}*(\text{Number of participants: 1-10}) \\ & + B_{9j}*(\text{Number of participants: 11-20}) \\ & + B_{10j}*(\text{Number of participants: 21-50}) \end{aligned}$$

$$\begin{aligned} \eta_{Mij} = & B_{0j} \\ & + B_{1j}*(\text{Use of LSC-designated instructional materials}) \\ & + B_{2j}*(\text{Activities: Listening to formal presentations}) \\ & + B_{3j}*(\text{Activities: Engaging in discussions/seminars/reporting out}) \\ & + B_{4j}*(\text{Activities: Engaging in problem solving/investigation focusing on disciplinary content,} \\ & \quad \text{pedagogy, and/or reform issues}) \\ & + B_{5j}*(\text{Number of providers: One}) \\ & + B_{6j}*(\text{Number of providers: Two}) \\ & + B_{7j}*(\text{Number of providers: Three}) \\ & + B_{8j}*(\text{Number of participants: 1-10}) \\ & + B_{9j}*(\text{Number of participants: 11-20}) \\ & + B_{10j}*(\text{Number of participants: 21-50}) \\ & + d(2) \end{aligned}$$

$$B_{0j} = G_{00} + G_{01}*(K-8 \text{ Mathematics}) + G_{02}*(6-12 \text{ Mathematics}) + G_{03}*(6-12 \text{ Science}) + G_{04}*(\text{Project Size}) + U_{0j}$$

$$\begin{aligned} B_{1j} &= G_{10} \\ B_{2j} &= G_{20} \\ B_{3j} &= G_{30} \\ B_{4j} &= G_{40} \\ B_{5j} &= G_{50} \\ B_{6j} &= G_{60} \\ B_{7j} &= G_{70} \\ B_{8j} &= G_{80} \\ B_{9j} &= G_{90} \\ B_{10j} &= G_{100} \end{aligned}$$

The number of sessions, regression coefficients, and standard errors for each purpose are shown in Table 13. Unlike the previous set of models examining the type of professional development providers, across the various purposes, there is a consistent pattern of relationships between the type of professional development activity and evaluator ratings of the quality of the session. The predicted probabilities for these variables, and other significant predictors of quality, are shown in Tables 14–16.

Table 13
Regression Coefficients and Standard Errors for Model Three (Activities),
by Professional Development Purpose

	Creating a Vision of Effective Instruction	Deepening Teacher Content Knowledge	Understanding Student Thinking	Learning Pedagogical Strategies	Learning to Use Instructional Materials	Promoting Reflective Practice	Building Professional Networks	Strategies in Leadership Roles
<i>Number of Sessions</i>	620	869	626	673	921	422	294	295
<i>Intercept</i>	-3.14*** (0.21)	-2.99*** (0.18)	-3.06*** (0.20)	-3.03*** (0.19)	-2.75*** (0.17)	-3.40*** (0.27)	-3.26*** (0.30)	-3.42*** (0.33)
<i>Threshold</i>	2.42*** (0.17)	2.41*** (0.14)	2.29*** (0.17)	2.42*** (0.16)	2.45*** (0.13)	2.53*** (0.24)	2.54*** (0.27)	2.72*** (0.28)
Session Characteristics								
<i>Number of professional development providers (4 or more omitted)</i>								
One	0.91** (0.30)	0.34 (0.27)	0.43 (0.31)	0.55~ (0.30)	0.26 (0.28)	0.09 (0.35)	-0.20 (0.40)	0.09 (0.44)
Two	0.78** (0.30)	0.13 (0.27)	0.76* (0.31)	0.90** (0.31)	0.18 (0.28)	-0.01 (0.36)	0.25 (0.40)	0.08 (0.42)
Three	0.20 (0.35)	0.02 (0.30)	0.06 (0.38)	0.66~ (0.36)	0.13 (0.31)	0.06 (0.43)	-0.03 (0.48)	-0.68 (0.49)
<i>Number of participants (51 or more omitted)</i>								
1-10	-0.64 (0.42)	-0.35 (0.41)	0.23 (0.41)	-0.60 (0.41)	0.19 (0.45)	0.53 (0.51)	0.62 (0.55)	1.41* (0.59)
11-20	-1.02** (0.39)	-0.35 (0.39)	-0.17 (0.39)	-0.68~ (0.38)	0.13 (0.43)	0.26 (0.48)	0.15 (0.49)	0.30 (0.53)
21-50	-0.83* (0.38)	-0.38 (0.38)	0.06 (0.38)	-0.78* (0.38)	0.01 (0.44)	0.60 (0.45)	0.46 (0.47)	0.45 (0.50)
<i>Use of LSC-designated instructional materials (No omitted)</i>								
Yes	-0.08 (0.19)	-0.42** (0.16)	-0.10 (0.19)	-0.10 (0.18)	-0.37* (0.16)	0.25 (0.23)	0.43 (0.27)	0.27 (0.33)
<i>Major activities included:</i>								
Listened to a formal presentation	0.47* (0.21)	0.46** (0.17)	0.47* (0.20)	0.47* (0.19)	0.36* (0.16)	0.30 (0.26)	0.51~ (0.30)	1.02** (0.32)
Engaged in discussions/ seminars/reporting out	-0.39 (0.27)	-0.50** (0.19)	-0.25 (0.25)	-0.51* (0.24)	-0.47* (0.19)	0.03 (0.40)	-0.33 (0.42)	-0.39 (0.45)
Engaged in problem solving/ investigation focusing on disciplinary content, pedagogy, and/or reform issues	-0.51* (0.20)	-0.32~ (0.19)	-0.59** (0.21)	-0.45* (0.19)	-0.47** (0.16)	-0.31 (0.24)	-0.63* (0.28)	-0.35 (0.31)
Project Characteristics								
<i>Project Subject/ Grade Range (K-8 Science omitted)</i>								
K-8 Mathematics	0.26 (0.36)	-0.27 (0.31)	-0.09 (0.32)	0.15 (0.33)	-0.10 (0.34)	0.13 (0.41)	0.27 (0.50)	0.61 (0.51)
6-12 Mathematics	0.77 (0.48)	0.00 (0.41)	0.70~ (0.42)	0.61 (0.46)	0.11 (0.45)	0.60 (0.60)	0.69 (0.64)	0.50 (0.75)
6-12 Science	1.78** (0.61)	0.14 (0.56)	1.02~ (0.57)	0.91 (0.62)	0.40 (0.62)	1.58* (0.68)	1.43* (0.71)	2.33* (1.02)
<i>Square Root of the Number of Teachers Targeted by the LSC</i>								
+1 standard deviations	0.04~ (0.02)	0.01 (0.02)	0.03~ (0.02)	0.05** (0.02)	0.02 (0.02)	0.04~ (0.02)	0.05~ (0.02)	0.07** (0.03)

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

In 7 of the 8 purposes, sessions including listening to a formal presentation tended to be rated less highly than sessions not including a formal presentation. The probabilities of sessions receiving a low, medium, or high rating, by the inclusion of a formal presentation, are shown in Table 14.

Table 14
Predicted Probabilities, by Whether the
Session Included Formal Presentations

	Low	Medium	High
Deepening Teacher Content Knowledge			
Formal Presentations **	0.06	0.37	0.57
No Formal Presentations	0.04	0.28	0.68
Creating a Vision of Effective Instruction			
Formal Presentations *	0.05	0.34	0.61
No Formal Presentations	0.03	0.25	0.71
Learning to Use Instructional Materials			
Formal Presentations *	0.07	0.41	0.52
No Formal Presentations	0.05	0.34	0.61
Building Professional Networks			
Formal Presentations ~	0.05	0.34	0.61
No Formal Presentations	0.03	0.24	0.73
Learning Pedagogical Strategies			
Formal Presentations *	0.06	0.36	0.58
No Formal Presentations	0.04	0.27	0.69
Understanding Student Thinking			
Formal Presentations *	0.06	0.32	0.62
No Formal Presentations	0.04	0.24	0.72
Strategies in Leadership Roles			
Formal Presentations **	0.05	0.41	0.54
No Formal Presentations	0.02	0.22	0.76

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

On the other hand, sessions that engaged participants in discussions or problem solving activities tended to receive higher ratings than sessions without either of these two activities. Sessions including seminars/discussions tended to be more highly rated than sessions not including seminars/discussions for 3 of the 8 purposes (see Table 15): deepening teachers' mathematics/science content knowledge, learning pedagogical strategies, and learning to use the LSC-designated instructional materials.

Table 15
Predicted Probabilities,
by Whether the Session Included Discussions

	Low	Medium	High
Deepening Teacher Content Knowledge			
Discussions**	0.04	0.29	0.67
No Discussions	0.07	0.38	0.55
Learning to Use Instructional Materials			
Discussions*	0.05	0.35	0.60
No Discussions	0.08	0.43	0.48
Learning Pedagogical Strategies			
Discussions*	0.04	0.29	0.67
No Discussions	0.07	0.38	0.55

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

As can be seen in Table 16, sessions including problem solving activities tended to receive higher ratings than those that did not include such activities for 6 of the 8 purposes, including understanding student thinking and learning to use the LSC-designated instructional materials.

Table 16
Predicted Probabilities, by Whether the Session
Included Problem Solving Activities

	Low	Medium	High
Deepening Teacher Content Knowledge			
Problem Solving Activities ~	0.04	0.30	0.66
No Problem Solving Activities	0.06	0.36	0.58
Creating a Vision of Effective Instruction			
Problem Solving Activities*	0.04	0.26	0.71
No Problem Solving Activities	0.06	0.35	0.59
Learning to Use Instructional Materials			
Problem Solving Activities**	0.05	0.34	0.61
No Problem Solving Activities	0.08	0.42	0.49
Building Professional Networks			
Problem Solving Activities*	0.03	0.24	0.73
No Problem Solving Activities	0.05	0.36	0.59
Learning Pedagogical Strategies			
Problem Solving Activities*	0.04	0.28	0.68
No Problem Solving Activities	0.06	0.36	0.58
Understanding Student Thinking			
Problem Solving Activities**	0.04	0.24	0.72
No Problem Solving Activities	0.07	0.35	0.58

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

Model Four: Approaches Utilized in the Professional Development Session

The final set of models examined the relationship between observers' ratings of the quality of the professional development sessions and the type of approach used in the professional development session. As was the case in the previous models, session factors such as the number of providers and participants were included as control variables in this set of models. It

is important to note that the item asking observers to categorize the primary professional development approach taken in the session was not added to the observation protocol until 1999. Thus, the sample for Model Four is limited to the 1,684 observations with complete data submitted between 1999 and 2003.

The variables included at the session level were:

- Number of professional development providers;
- Number of participants;
- Use of LSC-designated instructional materials; and
- Whether the session was part of a workshop/institute/course seminar (as opposed to study groups/“kit clubs”/discussion groups/school-based meetings/coaching/mentoring).

At the project-level, the following control variables were included:

- Subject/grade-range targeted by the LSC; and
- Number of teachers targeted by the LSC.

For each outcome variable, the following model was run:

$$\begin{aligned} \eta_{Lij} = & B_{0j} \\ & + B_{1j} * (\text{Use of LSC-designated instructional materials}) \\ & + B_{2j} * (\text{Approach: Workshop/institute/course seminar}) \\ & + B_{3j} * (\text{Number of providers: One}) \\ & + B_{4j} * (\text{Number of providers: Two}) \\ & + B_{5j} * (\text{Number of providers: Three}) \\ & + B_{6j} * (\text{Number of participants: 1-10}) \\ & + B_{7j} * (\text{Number of participants: 11-20}) \\ & + B_{8j} * (\text{Number of participants: 21-50}) \end{aligned}$$

$$\begin{aligned} \eta_{Mij} = & B_{0j} \\ & + B_{1j} * (\text{Use of LSC-designated instructional materials}) \\ & + B_{2j} * (\text{Approach: Workshop/institute/course seminar}) \\ & + B_{3j} * (\text{Number of providers: One}) \\ & + B_{4j} * (\text{Number of providers: Two}) \\ & + B_{5j} * (\text{Number of providers: Three}) \\ & + B_{6j} * (\text{Number of participants: 1-10}) \\ & + B_{7j} * (\text{Number of participants: 11-20}) \\ & + B_{8j} * (\text{Number of participants: 21-50}) \\ & + d(2) \end{aligned}$$

$$B_{0j} = G_{00} + G_{01} * (\text{K-8 Mathematics}) + G_{02} * (\text{6-12 Mathematics}) + G_{03} * (\text{6-12 Science}) + G_{04} * (\text{Project Size}) + U_{0j}$$

$$B_{1j} = G_{10}$$

$$B_{2j} = G_{20}$$

$$B_{3j} = G_{30}$$

$$B_{4j} = G_{40}$$

$$B_{5j} = G_{50}$$

$$B_{6j} = G_{60}$$

$$B_{7j} = G_{70}$$

$$B_{8j} = G_{80}$$

Descriptive statistics for the variables used in Model Four, by professional development purpose, are provided in Appendix D.

The number of sessions, regression coefficients, and standard errors for each purpose's model are shown in Table 17. As was the case in the full set of observed lessons, the most common purposes in the 1999–2003 subset of observed sessions were preparing teachers to use the LSC-designated instructional materials and deepening teachers' mathematics/science content knowledge. Professional development sessions targeting leadership strategies and building professional networks were observed least frequently.

Table 17
Regression Coefficients and Standard Errors for Model Four (Approaches),
by Professional Development Purpose

	Creating a Vision of Effective Instruction	Deepening Teacher Content Knowledge	Understanding Student Thinking	Learning Pedagogical Strategies	Learning to Use Instructional Materials	Promoting Reflective Practice	Building Professional Networks	Strategies in Leadership Roles
<i>Number of Sessions</i>	475	704	525	541	740	319	211	214
<i>Intercept</i>	-3.02*** (0.22)	-3.01*** (0.20)	-3.09*** (0.22)	-2.96*** (0.21)	-2.71*** (0.19)	-3.35*** (0.30)	-3.12*** (0.35)	-3.25*** (0.35)
<i>Threshold</i>	2.34*** (0.19)	2.45*** (0.16)	2.40*** (0.19)	2.35*** (0.17)	2.45*** (0.14)	2.58*** (0.26)	2.55*** (0.30)	2.49*** (0.29)
Session Characteristics								
<i>Number of professional development providers (4 or more omitted)</i>								
One	0.77* (0.34)	0.31 (0.31)	0.63~ (0.35)	0.93** (0.35)	0.15 (0.33)	0.31 (0.42)	-0.54 (0.49)	0.03 (0.48)
Two	0.65~ (0.34)	0.13 (0.30)	0.84* (0.34)	1.16** (0.35)	0.07 (0.32)	0.34 (0.43)	0.18 (0.50)	-0.15 (0.47)
Three	0.04 (0.40)	-0.01 (0.34)	0.27 (0.42)	0.89* (0.42)	-0.10 (0.36)	0.46 (0.50)	-0.19 (0.58)	-1.24* (0.54)
<i>Number of participants (51 or more omitted)</i>								
1-10	-0.66 (0.48)	-0.35 (0.49)	-0.09 (0.46)	-0.99* (0.46)	0.29 (0.50)	0.09 (0.62)	1.20 (0.74)	1.63* (0.67)
11-20	-1.12* (0.44)	-0.40 (0.46)	-0.50 (0.44)	-0.99* (0.42)	0.21 (0.48)	-0.13 (0.58)	0.42 (0.66)	0.45 (0.62)
21-50	-0.76~ (0.43)	-0.40 (0.45)	-0.25 (0.43)	-1.01* (0.43)	0.01 (0.49)	0.16 (0.54)	0.35 (0.64)	0.66 (0.56)
<i>Use of LSC-designated instructional materials (No omitted)</i>								
Yes	-0.14 (0.21)	-0.47** (0.18)	-0.11 (0.20)	-0.12 (0.20)	-0.60** (0.18)	0.10 (0.27)	0.07 (0.34)	-0.01 (0.37)
<i>Major professional development approaches:</i>								
Workshops	-0.85* (0.39)	0.39 (0.37)	-0.09 (0.34)	-0.08 (0.35)	0.26 (0.30)	-0.33 (0.37)	0.25 (0.51)	1.23* (0.61)
Project Characteristics								
<i>Project Subject/ Grade Range (K-8 Science omitted)</i>								
K-8 Mathematics	0.25 (0.39)	-0.28 (0.33)	-0.28 (0.35)	0.02 (0.36)	-0.01 (0.37)	-0.07 (0.44)	0.08 (0.62)	0.23 (0.54)
6-12 Mathematics	0.86~ (0.51)	0.12 (0.42)	0.46 (0.47)	0.64 (0.49)	0.29 (0.47)	0.63 (0.65)	-0.47 (0.81)	-0.53 (0.86)
6-12 Science	1.99** (0.62)	0.08 (0.58)	1.02~ (0.60)	1.06~ (0.64)	0.51 (0.64)	1.74* (0.72)	0.88 (0.85)	1.18 (1.10)
<i>Number of Teachers Targeted by the LSC</i>								
+1 standard deviations	0.05* (0.02)	0.01 (0.02)	0.03 (0.02)	0.05** (0.02)	0.02 (0.02)	0.06* (0.03)	0.05~ (0.03)	0.07* (0.03)

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

The probabilities of a session receiving a low, medium, or high rating, by whether it was part of a workshop, as opposed to a study group or coaching/mentoring, are shown in Table 18. Sessions focused on creating a vision of effective instruction have a 0.68 probability of receiving a high rating when part of a workshop compared to a probability of 0.47 when not part of a workshop. In contrast, sessions focused on providing teacher leaders with strategies for their leadership roles were more likely to receive high ratings when conducted in a non-workshop setting.

Table 18
Predicted Probabilities,
by Whether the Session Was Part of a Workshop

	Low	Medium	High
Creating a Vision of Effective Instruction			
Workshop*	0.04	0.28	0.68
Not a Workshop	0.10	0.43	0.47
Strategies in Leadership Roles			
Workshop*	0.04	0.32	0.64
Not a Workshop	0.01	0.13	0.86

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

Conclusions

Across the results of these analyses, there are five key findings. First, session quality ratings are likely to improve as projects mature, perhaps due to increased preparation and experience of the professional development providers. Second, engaging participants in problem-solving/investigations appears to be an effective approach for a number of professional development purposes, including creating a vision of effective instruction, learning to use instructional materials, building professional networks, learning classroom management/pedagogical strategies, and understanding student thinking. A general principle that may underlie these findings is that active learning opportunities and teacher-to-teacher interactions are attributes of high quality professional development. These attributes seem more likely to characterize sessions that engage teachers in problem-solving/investigations.

Third, utilizing the LSC-designated instructional materials appears to be an effective strategy for deepening teacher content knowledge and preparing teachers to implement those materials. The use of these materials in professional development is a fairly straightforward way to connect professional development to the work that teachers do in their classrooms, i.e., professional development sessions are more likely to be “practice-based” when the LSC-designated materials are used. Consequently, these sessions may be more engaging and relevant to teachers, and presumably more likely to translate into changes in their instructional practice.

Fourth, the professional development approach (study groups/coaching/mentoring vs. workshops) was a significant predictor of session quality for only 2 of the 8 purposes, creating a vision of effective instruction and providing strategies in leadership roles. For the purpose of creating a vision of effective instruction, workshops tended to be more effective, while for providing strategies for leadership, workshops tended to be less effective.

Finally, the type of professional development provider leading a session tended not to be an important predictor of session quality, with the exception of sessions focused on creating a vision of effective instruction, promoting reflective practice, and understanding student thinking. For these three purposes, sessions tended to be rated more highly when science/mathematics education faculty were among the facilitators.

It is important to note that the overall measures of professional development session quality are based upon evaluator ratings. Even though training was provided, given the large number of observers involved, interrater reliability is always a concern. In addition, the sessions chosen to be observed were intended to be typical of each LSC’s professional development and several of the factors being investigated (e.g., coaching/mentoring) were observed relatively infrequently. Thus, some caution should be exercised in attempting to generalize these results, especially beyond the realm of the LSC.

Appendix A
Descriptive Statistics for Quality of Professional Development as Projects
Mature Model

Table A-1
Quality of Professional Development

	Percent of Sessions
Capsule Rating	
Low/Medium Rating	8
Medium Rating	35
High Rating	57
Project Year	
Baseline	6
Year One	19
Year Two	26
Year Three	23
Year Four	16
Year Five	7
Year Six	2
Number of Professional Development Providers	
One	39
Two	33
Three	14
Four or more	14
Number of Participants	
1–10	23
11–20	35
21–50	34
51 or more	8
Utilized LSC-Designated Instructional Materials	
Yes	50
No	50

† Percents do not sum to 100 as multiple categories could apply to each session.

Appendix B
Descriptive Statistics For Provider Models by Session Purpose

Table B-1
Deepening Teacher Content Knowledge

	Percent of Sessions
Capsule Rating	
Low Rating	7
Medium Rating	31
High Rating	62
Type of Professional Development Provider[†]	
Regular Full-time or Part-time classroom teachers	47
Teachers on special assignment	32
District Mathematics/Science Supervisors and/or Other District Personnel	12
Business Industry Mathematicians/Scientists and/or University Mathematics/Science Faculty	25
University mathematics/science education faculty	21
Other non-district personnel	21
Number of Professional Development Providers	
One	37
Two	34
Three	15
Four or more	14
Number of Participants	
1–10	21
11–20	37
21–50	36
51 or more	6
Utilized LSC-Designated Instructional Materials	
Yes	51
No	49

[†] Percents do not sum to 100 as multiple categories could apply to each session.

Table B-2
Creating a Vision of Effective Instruction

	Percent of Sessions
Capsule Rating	
Low Rating	6
Medium Rating	30
High Rating	64
Type of Professional Development Provider[†]	
Regular Full-time or Part-time classroom teachers	47
Teachers on special assignment	38
District Mathematics/Science Supervisors and/or Other District Personnel	19
University mathematics/science education faculty	18
Business Industry Mathematicians/Scientists and/or University Mathematics/Science Faculty	13
Other non-district personnel	22
Number of Professional Development Providers	
One	34
Two	31
Three	15
Four or more	20
Number of Participants	
1–10	20
11–20	34
21–50	39
51 or more	7
Utilized LSC-Designated Instructional Materials	
Yes	50
No	50

[†] Percents do not sum to 100 as multiple categories could apply to each session.

Table B-3
Learning to Use Instructional Materials

	Percent of Sessions
Capsule Rating	
Low Rating	9
Medium Rating	36
High Rating	55
Type of Professional Development Provider[†]	
Regular Full-time or Part-time classroom teachers	53
Teachers on special assignment	30
District Mathematics/Science Supervisors and/or Other District Personnel	13
University mathematics/science education faculty	15
Business Industry Mathematicians/Scientists and/or University Mathematics/Science Faculty	13
Other non-district personnel	20
Number of Professional Development Providers	
One	43
Two	33
Three	13
Four or more	11
Number of Participants	
1–10	28
11–20	38
21–50	29
51 or more	5
Utilized LSC-Designated Instructional Materials	
Yes	67
No	33

[†] Percents do not sum to 100 as multiple categories could apply to each session.

**Table B-4
Building Professional Networks**

	Percent of Sessions
Capsule Rating	
Low Rating	5
Medium Rating	31
High Rating	64
Type of Professional Development Provider[†]	
Regular Full-time or Part-time classroom teachers	41
Teachers on special assignment	34
District Mathematics/Science Supervisors and/or Other District Personnel	29
University mathematics/science education faculty	16
Business Industry Mathematicians/Scientists and/or University Mathematics/Science Faculty	17
Other non-district personnel	27
Number of Professional Development Providers	
One	33
Two	30
Three	14
Four or more	23
Number of Participants	
1–10	18
11–20	33
21–50	36
51 or more	13
Utilized LSC-Designated Instructional Materials	
Yes	48
No	52

[†] Percents do not sum to 100 as multiple categories could apply to each session.

**Table B-5
Learning Pedagogical Strategies**

	Percent of Sessions
Capsule Rating	
Low Rating	7
Medium Rating	32
High Rating	61
Type of Professional Development Provider[†]	
Regular Full-time or Part-time classroom teachers	52
Teachers on special assignment	33
District Mathematics/Science Supervisors and/or Other District Personnel	18
University mathematics/science education faculty	15
Business Industry Mathematicians/Scientists and/or University Mathematics/Science Faculty	11
Other non-district personnel	23
Number of Professional Development Providers	
One	41
Two	31
Three	11
Four or more	17
Number of Participants	
1–10	23
11–20	36
21–50	33
51 or more	8
Utilized LSC-Designated Instructional Materials	
Yes	55
No	44

[†] Percents do not sum to 100 as multiple categories could apply to each session.

**Table B-6
Promoting Reflective Practice**

	Percent of Sessions
Capsule Rating	
Low Rating	4
Medium Rating	28
High Rating	68
Type of Professional Development Provider[†]	
Regular Full-time or Part-time classroom teachers	43
Teachers on special assignment	41
District Mathematics/Science Supervisors and/or Other District Personnel	22
University mathematics/science education faculty	18
Business Industry Mathematicians/Scientists and/or University Mathematics/Science Faculty	15
Other non-district personnel	18
Number of Professional Development Providers	
One	37
Two	29
Three	13
Four or more	11
Number of Participants	
1–10	24
11–20	29
21–50	38
51 or more	9
Utilized LSC-Designated Instructional Materials	
Yes	50
No	50

[†] Percents do not sum to 100 as multiple categories could apply to each session.

Table B-7
Understanding Student Thinking

	Percent of Sessions
Capsule Rating	
Low Rating	6
Medium Rating	28
High Rating	66
Type of Professional Development Provider[†]	
Regular Full-time or Part-time classroom teachers	44
Teachers on special assignment	38
District Mathematics/Science Supervisors and/or Other District Personnel	18
University mathematics/science education faculty	19
Business Industry Mathematicians/Scientists and/or University Mathematics/Science Faculty	12
Other non-district personnel	21
Number of Professional Development Providers	
One	39
Two	32
Three	13
Four or more	16
Number of Participants	
1–10	23
11–20	33
21–50	35
51 or more	9
Utilized LSC-Designated Instructional Materials	
Yes	55
No	45

[†] Percents do not sum to 100 as multiple categories could apply to each session.

**Table B-8
Strategies in Leadership Roles**

	Percent of Sessions
Capsule Rating	
Low Rating	6
Medium Rating	30
High Rating	64
Type of Professional Development Provider[†]	
Regular Full-time or Part-time classroom teachers	27
Teachers on special assignment	34
District Mathematics/Science Supervisors and/or Other District Personnel	35
University mathematics/science education faculty	28
Business Industry Mathematicians/Scientists and/or University Mathematics/Science Faculty	15
Other non-district personnel	34
Number of Professional Development Providers	
One	27
Two	27
Three	18
Four or more	28
Number of Participants	
1–10	17
11–20	33
21–50	34
51 or more	16
Utilized LSC-Designated Instructional Materials	
Yes	35
No	65

[†] Percents do not sum to 100 as multiple categories could apply to each session.

Appendix C
Descriptive Statistics for Activities Models by Session Purpose

Table C-1
Deepening Teacher Content Knowledge

	Percent of Sessions
Capsule Rating	
Low/Medium Rating	6
Medium Rating	32
High Rating	62
Professional Development Activity[†]	
Engaged in discussions/seminars/reporting out	77
Engaged in problem solving/investigation focusing on disciplinary content, pedagogy and/or reform issues	80
Listened to a formal presentation	36
Number of Professional Development Providers	
One	37
Two	34
Three	15
Four or more	14
Number of Participants	
1–10	21
11–20	37
21–50	36
51 or more	6
Utilized LSC-Designated Instructional Materials	
Yes	51
No	49

[†] Percents do not sum to 100 as multiple categories could apply to each session.

Table C-2
Creating a Vision of Effective Instruction

	Percent of Sessions
Capsule Rating	
Low Rating	7
Medium Rating	30
High Rating	63
Professional Development Activity[†]	
Engaged in discussions/seminars/reporting out	85
Engaged in problem solving/investigation focusing on disciplinary content, pedagogy and/or reform issues	70
Listened to a formal presentation	40
Number of Professional Development Providers	
One	34
Two	31
Three	15
Four or more	20
Number of Participants	
1–10	20
11–20	34
21–50	39
51 or more	7
Utilized LSC-Designated Instructional Materials	
Yes	50
No	50

[†] Percents do not sum to 100 as multiple categories could apply to each session.

Table C-3
Learning to Use Instructional Materials

	Percent of Sessions
Capsule Rating	
Low Rating	9
Medium Rating	37
High Rating	55
Professional Development Activity[†]	
Engaged in discussions/seminars/reporting out	79
Engaged in problem solving/investigation focusing on disciplinary content, pedagogy and/or reform issues	68
Listened to a formal presentation	37
Number of Professional Development Providers	
One	43
Two	33
Three	13
Four or more	11
Number of Participants	
1–10	28
11–20	38
21–50	29
51 or more	5
Utilized LSC-Designated Instructional Materials	
Yes	67
No	33

[†] Percents do not sum to 100 as multiple categories could apply to each session.

**Table C-4
Building Professional Networks**

	Percent of Sessions
Capsule Rating	
Low Rating	7
Medium Rating	32
High Rating	62
Professional Development Activity[†]	
Engaged in discussions/seminars/reporting out	89
Engaged in problem solving/investigation focusing on disciplinary content, pedagogy and/or reform issues	56
Listened to a formal presentation	48
Number of Professional Development Providers	
One	33
Two	30
Three	14
Four or more	23
Number of Participants	
1–10	18
11–20	33
21–50	36
51 or more	13
Utilized LSC-Designated Instructional Materials	
Yes	48
No	52

[†] Percents do not sum to 100 as multiple categories could apply to each session.

**Table C-5
Learning Pedagogical Strategies**

	Percent of Sessions
Capsule Rating	
Low Rating	7
Medium Rating	31
High Rating	62
Professional Development Activity[†]	
Engaged in discussions/seminars/reporting out	84
Engaged in problem solving/investigation focusing on disciplinary content, pedagogy and/or reform issues	68
Listened to a formal presentation	39
Number of Professional Development Providers	
One	41
Two	31
Three	11
Four or more	17
Number of Participants	
1–10	23
11–20	36
21–50	33
51 or more	8
Utilized LSC-Designated Instructional Materials	
Yes	55
No	45

[†] Percents do not sum to 100 as multiple categories could apply to each session.

Table C-6
Promoting Reflective Practice

	Percent of Sessions
Capsule Rating	
Low Rating	5
Medium Rating	30
High Rating	65
Professional Development Activity[†]	
Engaged in discussions/seminars/reporting out	91
Engaged in problem solving/investigation focusing on disciplinary content, pedagogy and/or reform issues	65
Listened to a formal presentation	39
Number of Professional Development Providers	
One	37
Two	30
Three	13
Four or more	20
Number of Participants	
1–10	24
11–20	29
21–50	38
51 or more	9
Utilized LSC-Designated Instructional Materials	
Yes	50
No	50

[†] Percents do not sum to 100 as multiple categories could apply to each session.

Table C-7
Understanding Student Thinking

	Percent of Sessions
Capsule Rating	
Low Rating	6
Medium Rating	31
High Rating	63
Professional Development Activity[†]	
Engaged in discussions/seminars/reporting out	84
Engaged in problem solving/investigation focusing on disciplinary content, pedagogy and/or reform issues	73
Listened to a formal presentation	39
Number of Professional Development Providers	
One	39
Two	32
Three	13
Four or more	16
Number of Participants	
1–10	23
11–20	33
21–50	35
51 or more	9
Utilized LSC-Designated Instructional Materials	
Yes	55
No	45

[†] Percents do not sum to 100 as multiple categories could apply to each session.

**Table C-8
Strategies in Leadership Roles**

	Percent of Sessions
Capsule Rating	
Low Rating	7
Medium Rating	30
High Rating	63
Professional Development Activity[†]	
Engaged in discussions/seminars/reporting out	88
Engaged in problem solving/investigation focusing on disciplinary content, pedagogy and/or reform issues	40
Listened to a formal presentation	46
Number of Professional Development Providers	
One	27
Two	27
Three	18
Four or more	28
Number of Participants	
1–10	17
11–20	33
21–50	34
51 or more	16
Utilized LSC-Designated Instructional Materials	
Yes	35
No	65

[†] Percents do not sum to 100 as multiple categories could apply to each session.

Appendix D
Descriptive Statistics for Approaches Models by Session Purpose

Table D-1
Deepening Teacher Content Knowledge

	Percent of Sessions
Capsule Rating	
Low/Medium Rating	7
Medium Rating	31
High Rating	62
Professional Development Approach	
Workshop/institute/course seminar	94
Study groups/*kit clubs/discussion groups/school-based meetings/ coaching/mentoring	6
Number of Professional Development Providers	
One	38
Two	34
Three	15
Four or more	15
Number of Participants	
1–10	22
11–20	39
21–50	35
51 or more	4
Utilized LSC-Designated Instructional Materials	
Yes	50
No	50

Table D-2
Creating a Vision of Effective Instruction

	Percent of Sessions
Capsule Rating	
Low Rating	6
Medium Rating	30
High Rating	64
Professional Development Approach	
Workshop/institute/course seminar	92
Study groups/*kit clubs/discussion groups/school-based meetings/coaching/mentoring	8
Number of Professional Development Providers	
One	35
Two	31
Three	15
Four or more	19
Number of Participants	
1–10	20
11–20	35
21–50	38
51 or more	7
Utilized LSC-Designated Instructional Materials	
Yes	50
No	50

Table D-3
Learning to Use Instructional Materials

	Percent of Sessions
Capsule Rating	
Low Rating	9
Medium Rating	36
High Rating	55
Professional Development Approach	
Workshop/institute/course seminar	90
Study groups/kit clubs/discussion groups/school-based meetings/coaching/mentoring	10
Number of Professional Development Providers	
One	43
Two	34
Three	12
Four or more	11
Number of Participants	
1–10	28
11–20	39
21–50	28
51 or more	5
Utilized LSC-Designated Instructional Materials	
Yes	67
No	33

Table D-4
Building Professional Networks

	Percent of Sessions
Capsule Rating	
Low Rating	5
Medium Rating	31
High Rating	64
Professional Development Approach	
Workshop/institute/course seminar	83
Study groups/kit clubs/discussion groups/school-based meetings/coaching/mentoring	17
Number of Professional Development Providers	
One	36
Two	27
Three	14
Four or more	23
Number of Participants	
1–10	21
11–20	33
21–50	35
51 or more	11
Utilized LSC-Designated Instructional Materials	
Yes	49
No	51

**Table D-5
Learning Pedagogical Strategies**

	Percent of Sessions
Capsule Rating	
Low Rating	7
Medium Rating	32
High Rating	61
Professional Development Approach	
Workshop/institute/course seminar	89
Study groups/kit clubs/discussion groups/school-based meetings/coaching/mentoring	11
Number of Professional Development Providers	
One	42
Two	31
Three	11
Four or more	16
Number of Participants	
1–10	23
11–20	38
21–50	32
51 or more	7
Utilized LSC-Designated Instructional Materials	
Yes	55
No	45

**Table D-6
Promoting Reflective Practice**

	Percent of Sessions
Capsule Rating	
Low Rating	4
Medium Rating	28
High Rating	68
Professional Development Approach	
Workshop/institute/course seminar	82
Study groups/kit clubs/discussion groups/school-based meetings/coaching/mentoring	18
Number of Professional Development Providers	
One	39
Two	29
Three	13
Four or more	19
Number of Participants	
1–10	27
11–20	27
21–50	37
51 or more	9
Utilized LSC-Designated Instructional Materials	
Yes	51
No	49

Table D-7
Understanding Student Thinking

	Percent of Sessions
Capsule Rating	
Low Rating	6
Medium Rating	28
High Rating	66
Professional Development Approach	
Workshop/institute/course seminar	89
Study groups/'kit clubs/discussion groups/school-based meetings/coaching/mentoring	11
Number of Professional Development Providers	
One	41
Two	33
Three	12
Four or more	14
Number of Participants	
1–10	24
11–20	35
21–50	34
51 or more	7
Utilized LSC-Designated Instructional Materials	
Yes	55
No	45

Table D-8
Strategies in Leadership Roles

	Percent of Sessions
Capsule Rating	
Low Rating	6
Medium Rating	30
High Rating	64
Professional Development Approach	
Workshop/institute/course seminar	85
Study groups/'kit clubs/discussion groups/school-based meetings/coaching/mentoring	15
Number of Professional Development Providers	
One	27
Two	24
Three	21
Four or more	28
Number of Participants	
1–10	20
11–20	30
21–50	36
51 or more	14
Utilized LSC-Designated Instructional Materials	
Yes	36
No	64