II. Quality of LSC Professional Development

A. Introduction

NSF expects each LSC project to prepare teachers to implement high-quality instructional materials in their classrooms. However, while all of the projects include this goal, they vary considerably in the designs they are using to address it. To some extent, the variations in design are attributable to differences in target populations: one would expect a different approach to professional development for a group of elementary teachers with serious deficiencies in their science/mathematics content background compared to a group of secondary mathematics teachers whose priority needs are in pedagogical areas.

Variations in design may also be due to differences in the kinds of resources that can be brought to bear upon professional development in a particular case. For example, a district that has an ongoing relationship with a nearby science museum or university may deepen that relationship as part of the LSC, while a coalition of small rural districts dispersed over a large geographic area may be more likely to incorporate distance learning into their LSC programs. Finally, the background and experience of key project staff will influence the professional development design, particularly if they seek to replicate components that they have used successfully elsewhere.

The simplest LSC designs are ones in which all teachers have essentially the same professional development experiences. A typical sequence might be to have teachers spend a few days learning the content and pedagogy of one or two units in the summer, and then use those units in the classroom the next year. In most cases, the project would convene periodic meetings during the school year so teachers would be able to share information and get advice from experienced users. The cycle would start again with additional units the next summer.

More complex LSC designs aim to meet the varied needs of their teachers by offering a variety of professional development opportunities. For example, one evaluator described the professional development opportunities in a secondary mathematics project as follows:

> *Each type of professional development activity has a unique characteristic and is designed to meet the diverse needs of the various teachers participating in this LSC. While some activities bring together teachers and administrators from the four participating school districts and other members of the local education community (introductory and advanced summer institutes, follow-up days, mini-series), other activities are building specific, or district specific, and involve teams of teachers with a common interest in a specific issue or the implementation/design of a curricular unit.*

Another evaluator noted that an elementary science project was designing, piloting, and refining a wide range of professional development offerings:

These workshops are developmentally sequenced so that the program begins by helping teachers implement innovative curriculum. For second year teachers, there are opportunities to learn more content, as well as to refine the teaching of these units and to become more generally skilled at inquiry-based instruction. Finally, for the most skilled and experienced teachers, there are opportunities to learn leadership skills, to probe issues of assessment, to learn how to facilitate inquiry learning, and to understand underlying content in much greater depth.

Whether simple or complex in design, each LSC project is attempting to achieve the same overarching goal—improved mathematics/science instruction. In order to do so, the LSC theory of action argues, a project must:

- Have well-prepared professional development providers with in-depth content understanding, and expertise in K–12 mathematics/science education;
- Be able to establish a supportive environment and collegial culture that facilitates teacher learning;
- Provide experiences that deepen teachers' knowledge of the mathematics/science content included in the curriculum and the pedagogy involved in teaching it;
- Provide opportunities for teachers to explore and become conversant with the exemplary instructional materials they will use in their classrooms; and
- Provide support for teachers in both content and pedagogy as they implement these materials.

It is important to note that while teachers in the LSC projects participate in many more hours of professional development than do their typical colleagues in other districts, projects are, nevertheless, finding it quite a challenge to equip teachers with all of the knowledge and skills they need for effective implementation of the designated instructional materials. Trade-offs abound: the more effort spent in preparing teams of teacher leaders to do a good job in working with other teachers, the fewer resources left for providing professional development to "regular" teachers. The more time devoted to having teachers work through the student activities, the less time available to focus on deepening teacher content knowledge beyond what students are expected to know. The more professional development in the summer, the less time available for teacher support during the academic year. The challenge for each LSC project, then, is to design and implement a plan that balances attention to all of the necessary components to optimize teacher learning and create a supportive context for them to use what they have learned to improve mathematics/science learning for their students.

In the following sections, data from professional development observations, teacher questionnaires, and teacher interviews, as well as project evaluation reports, are used to describe the overall quality of LSC projects in a number of key areas.

B. Quality of LSC Professional Development Sessions

For the core evaluation, project evaluators were asked to observe 5–8 professional development activities in each project. Evaluators and PIs were to decide jointly which activities would be observed, selecting sessions to represent the diversity of the project's professional development offerings and to reflect the extensiveness and importance of the various kinds of activities. A total of 402 professional development sessions were observed, an average of approximately seven per project. This section of the report presents a summary of data collected from observations of individual sessions across all LSC projects; it includes descriptive information about the observed sessions and evaluators' assessments of their quality.

Description of LSC Professional Development Sessions

Evaluators documented a number of descriptive features of each professional development session, providing information about targeted participants, presenters/ facilitators, purposes and content focus, and the major types of activities that characterized the sessions.

Participants

The typical professional development session observed for the LSC core evaluation had between 21 and 50 participants; only 2 percent of the sessions had more than 100 participants. Some sessions exclusively targeted teacher leaders (15 percent); most sessions targeted regular teachers (70 percent); and some sessions targeted both lead and regular teachers (12 percent). A total of 7 percent of the sessions included principals or other administrators.

Presenters/Facilitators

As noted earlier, LSC professional development involves presenters/facilitators from a variety of settings. District personnel served in this capacity in 74 percent of the observed sessions, while only 33 percent of the sessions included university faculty as presenters or facilitators. (See Figure 5.) Across all of the observed sessions, two-thirds of the presenters/facilitators were female and one-third, male. As can be seen in Figure 6, 88 percent of the presenters/facilitators were white, and 12 percent members of other race/ethnic groups.

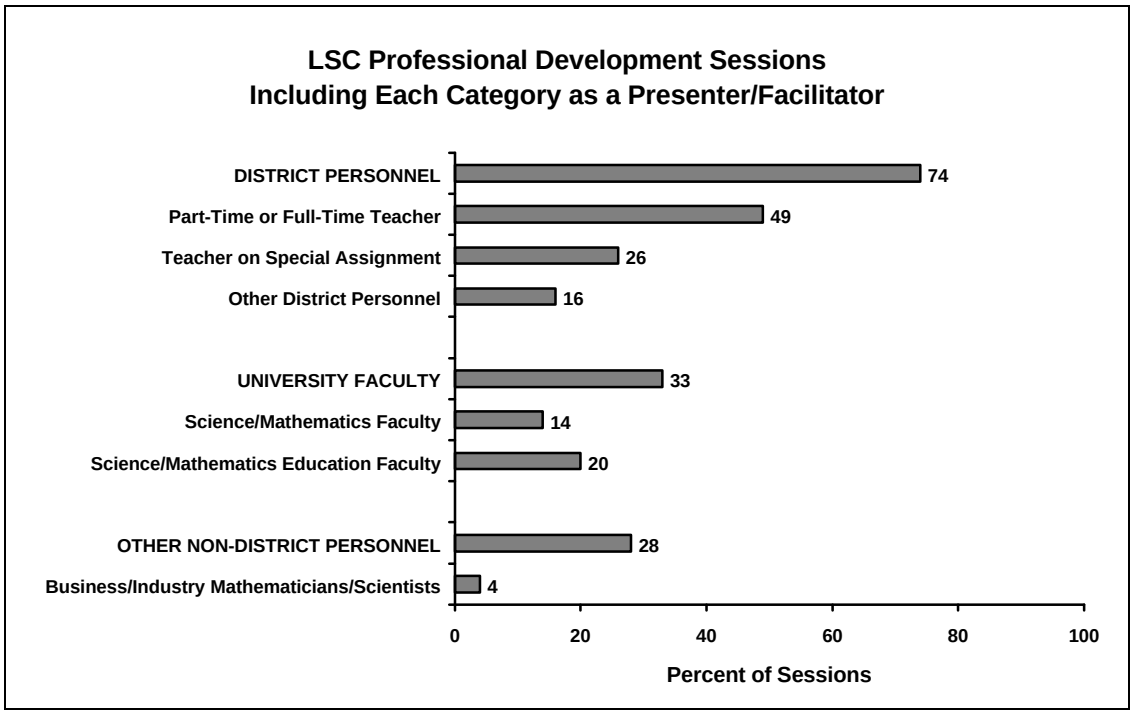


Figure 5

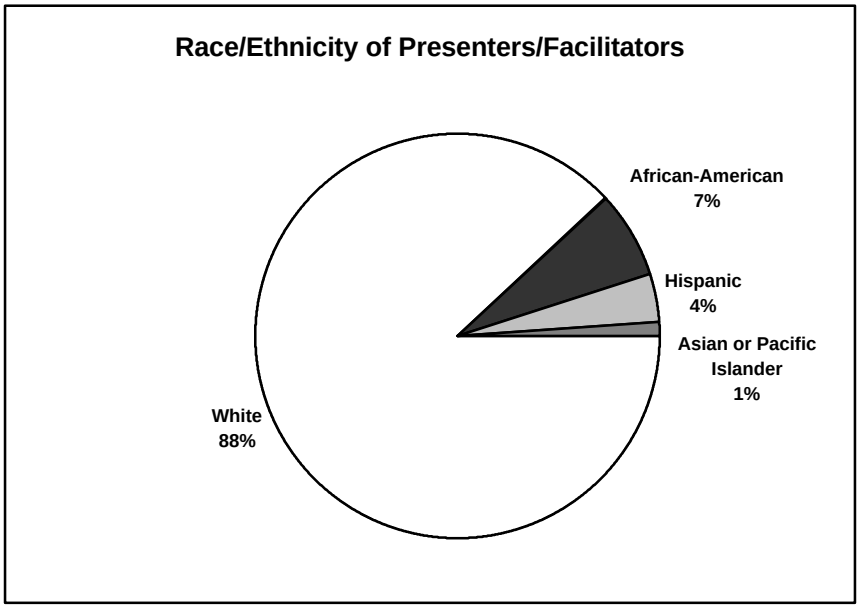


Figure 6

Purposes of the Professional Development Sessions

Evaluators were asked to indicate the major intended purposes of each observed session based on information provided by the session facilitators. The results were nearly identical to those reported in the previous year. As can be seen in Table 2, the most frequently cited purposes were working on classroom pedagogy issues (69 percent), including learning about specific instructional materials; and enhancing teachers' understanding of mathematics/science concepts (41 percent). Overall, fewer than 10 percent of the observed professional development sessions focused on student assessment, equity issues, or developing the capacity of participants to use technology.

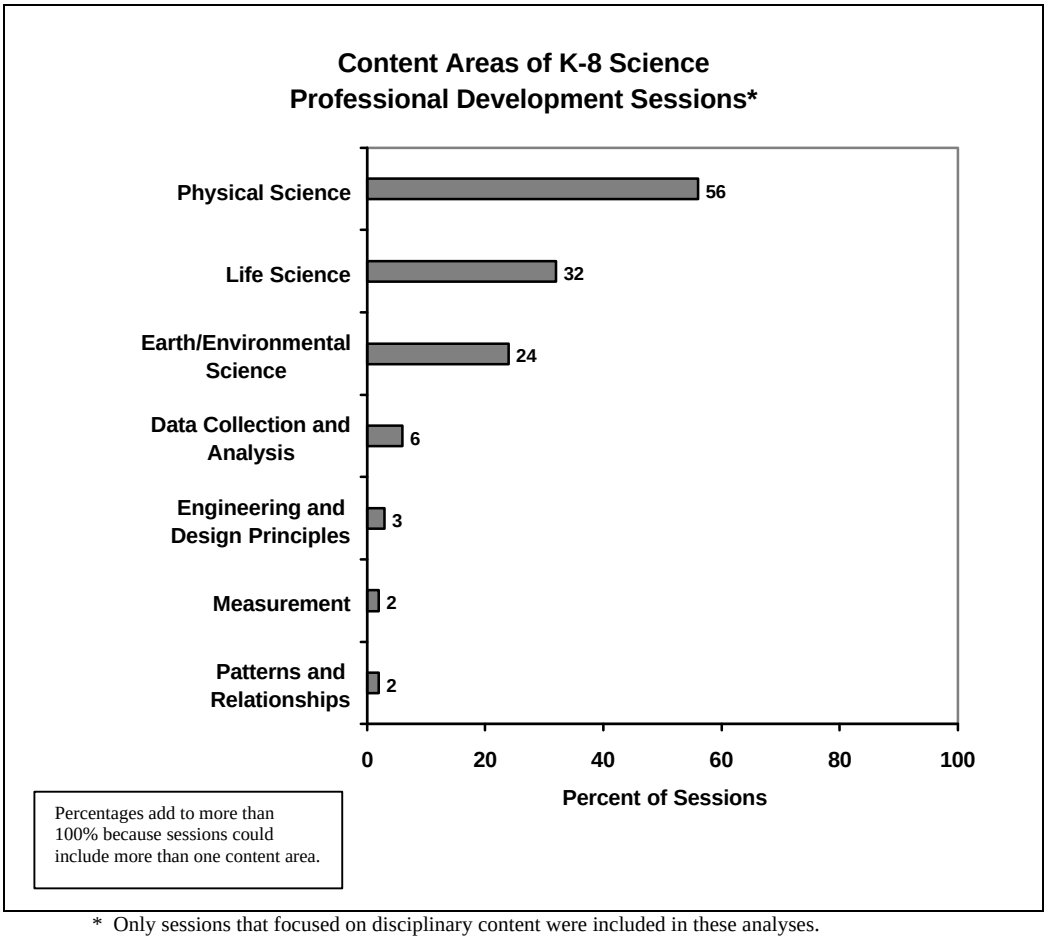
Table 2
Major Intended Purposes of LSC Professional Development Sessions

	Percent of Sessions			
	All Sessions	**K–8 Science**	**K–8 Mathematics**	**6–12 Mathematics**
Working on classroom pedagogy issues*	**69**	**70**	**71**	**65**
Learning about specific instructional materials	43	44	40	44
Learning pedagogical/classroom management strategies	31	33	31	30
Creating a vision of learning through investigation	35	36	39	27
Designing/scoring student assessments	8	8	4	9
Considering issues of access, equity, and diversity	6	6	5	9
Increasing teacher mathematics/science content knowledge	**41**	**38**	**45**	**47**
Promoting reflective practice	**23**	**30**	**19**	**10**
Building professional networks among educators	**18**	**21**	**11**	**17**
Orientation to the project	**14**	**11**	**12**	**17**
Developing capacity of participants to use technology	**2**	**2**	**3**	**4**

* Percents add to more than total for category because sessions could include more than one purpose.

Content Focus of Professional Development Sessions

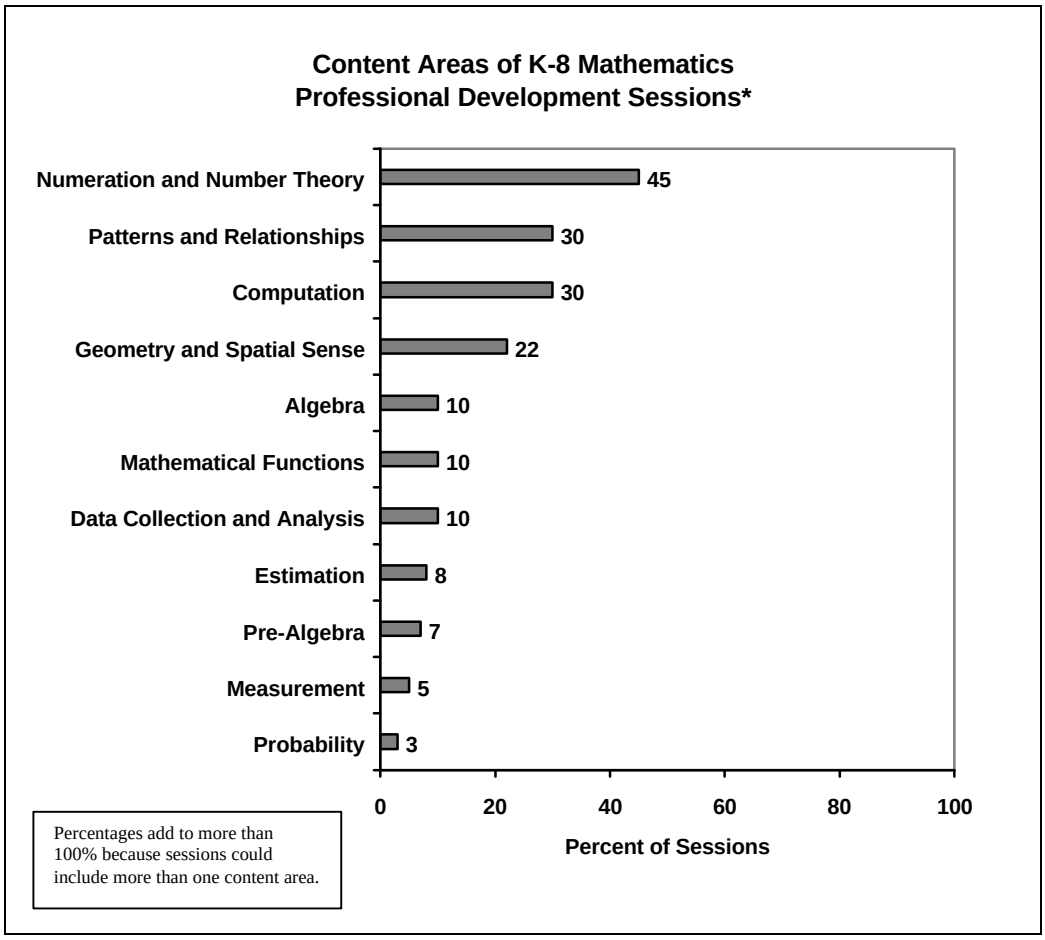
When sessions focused on one or more disciplinary content areas, evaluators were asked to categorize that content. In K–8 science projects, evaluators reported that more than half of the sessions that had a disciplinary content focus dealt with physical science concepts (56 percent), about a third with life science content (32 percent), and about a fourth with concepts from the earth and environmental sciences (23 percent). (See Figure 7.) Only 3 percent of the observed K–8 sessions focused on engineering concepts, and none emphasized the history of science.



* Only sessions that focused on disciplinary content were included in these analyses.

Figure 7

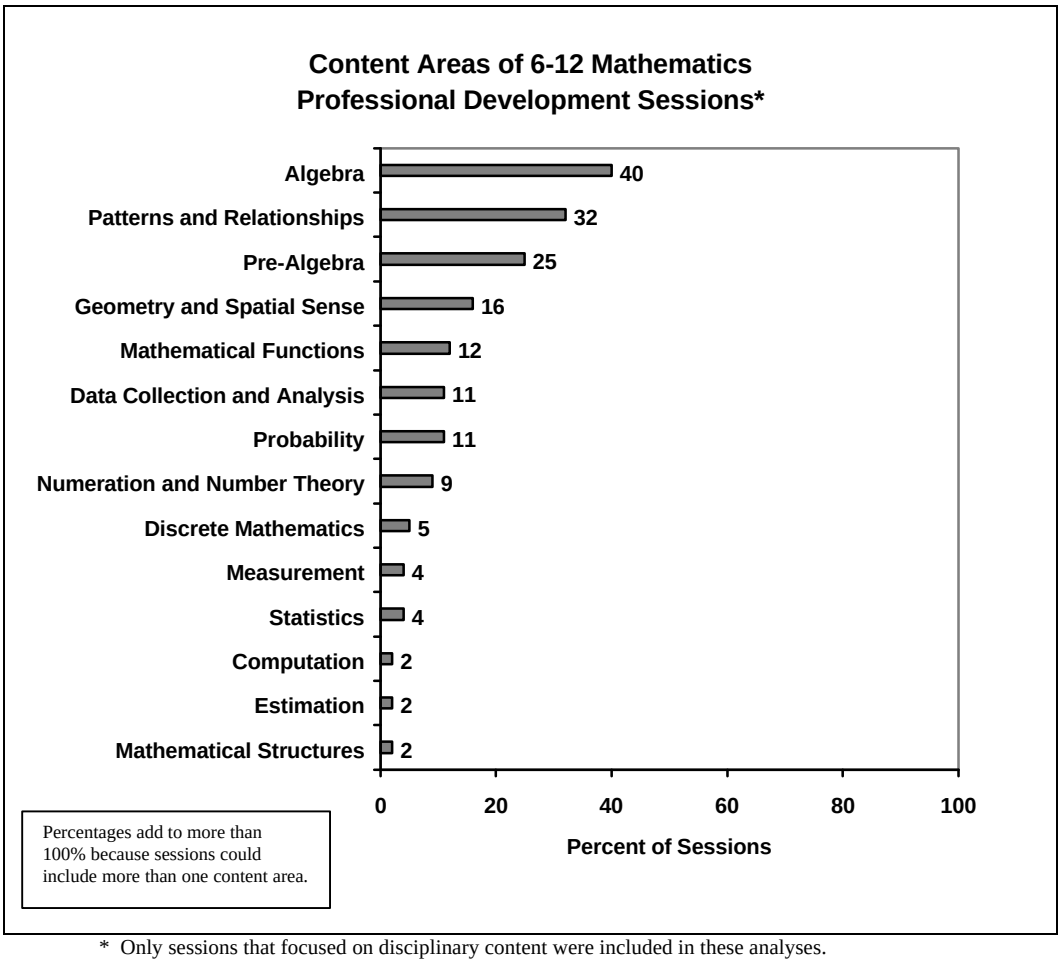
In projects targeting K–8 mathematics, the most heavily emphasized topics were numeration and number theory (45 percent of the sessions that dealt with disciplinary content), patterns and relationships (30 percent), computation (30 percent), and geometry and spatial sense (22 percent). Algebra, mathematical functions, and data collection and analysis were each the focus of 10 percent of K–8 mathematics content-focused sessions. (See Figure 8.)



* Only sessions that focused on disciplinary content were included in these analyses.

Figure 8

As can be seen in Figure 9, algebra was the most commonly emphasized content area in sessions for 6–12 mathematics teachers, with 40 percent of the sessions that dealt with disciplinary content focusing on algebra. Nearly a third of content sessions focused on patterns and relationships, and about a fourth on "pre-algebra." A number of other areas—geometry and spatial sense, mathematical functions, data collection and analysis, probability, and numeration and number theory were each the focus in 9 to 16 percent of the 6–12 mathematics content sessions. Sessions on discrete mathematics, measurement, statistics, computation, estimation, and mathematical structures were less frequent.



* Only sessions that focused on disciplinary content were included in these analyses.

Figure 9

Session Activities

The typical professional development session observed as part of the LSC core evaluation included several different instructional strategies. As can be seen in Table 3, most sessions included discussions or seminars (84 percent), nearly two-thirds of the sessions engaged participants in problem-solving or investigation, and nearly one-half included formal presentations, usually by project staff as opposed to participants. Fewer of the observed sessions involved participants in reading (11 percent) or writing (5 percent) about disciplinary content, pedagogy or reform issues.

Table 3
Major Activities of LSC Professional Development Sessions

	Percent of Sessions			
	All Sessions	**K–8 Science**	**K–8 Mathematics**	**6–12 Mathematics**
Engaged in discussions/seminars	**84**	**84**	**87**	**83**
Whole group led by facilitator	66	64	73	65
Whole group led by participants	12	11	15	14
Small groups/pairs	58	59	55	53
Engaged in problem-solving/investigation	**62**	**57**	**71**	**66**
Listened to a formal presentation	**45**	**49**	**37**	**35**
By presenter/facilitator	45	49	37	34
By participants	4	5	0	3
Read about disciplinary content, pedagogy, or reform issues	**11**	**11**	**13**	**8**
Wrote about disciplinary content, pedagogy, or reform issues	**5**	**8**	**4**	**0**

Observer Ratings of Session Components

In order to assess the quality of professional development sessions, evaluators were asked to rate a number of components for each session they observed, including:

- The design of the session;
- The implementation of the professional development activities;
- The quality of the disciplinary, pedagogical, and/or leadership content; and
- The culture of the session.

For each component area, observers first rated a series of individual indicators of best practice in professional development and/or standards-based mathematics/science instruction. These indicators were rated on a scale ranging from 1, "not at all" to 5, "to a great extent" to document the extent to which that feature characterized the observed professional development session.

Considering those "on-ramp" indicators, observers then assessed the overall quality of each component area. The lowest rating for component areas (Level l) indicated that the session was not at all reflective of best practice. The highest rating (Level 5) indicated that the particular component of the session was extremely reflective of best practices for standards-based mathematics and science education.[4] Evaluators' ratings of the component areas are presented in the following sections.

[4] Copies of the Professional Development Observation Protocol may be found on the LSC Documents Page of the HRI web site: http://www.horizon-research.com/LSC.

Design of Professional Development Sessions

As noted above, observers assessed the design of professional development sessions by rating a series of individual indicators based on current understandings of best practice. Several of these indicators received high ratings (4 or 5 on a five-point scale) in many of the observed sessions. Those indicators that were most often highly rated included:

- The extent to which the session design reflected careful planning and organization (77 percent);
- How well the session design encouraged a collaborative approach to learning (74 percent); and
- the extent to which the session incorporated tasks and interactions consistent with a spirit of investigation (73 percent).

Somewhat fewer sessions were rated highly on:

- The extent to which participants were given an opportunity to share experiences and insights (59 percent);
- Providing adequate time and structure for reflection (55 percent); and
- Providing adequate time and structure for wrap-up/closure (53 percent).

Observers found that the designs of most of the professional development sessions were quite reflective of best practice. As indicated in Figure 10, 68 percent of the professional development sessions received overall design ratings of 4 or 5.

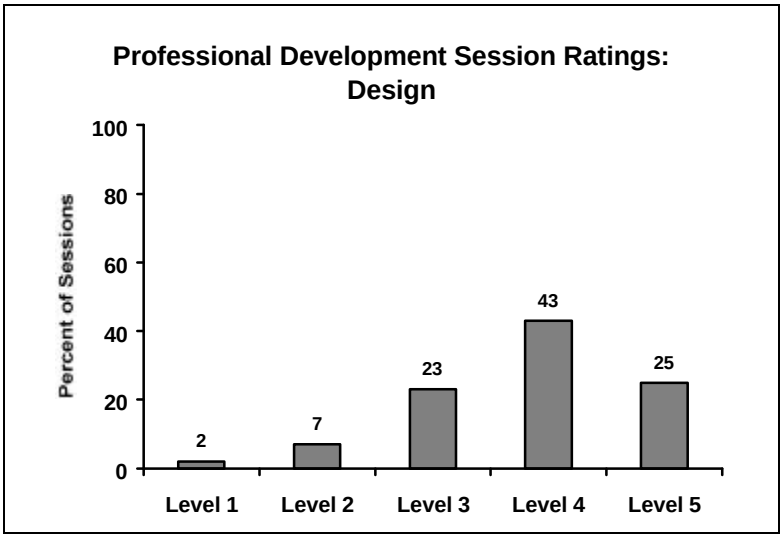


Figure 10

Implementation of Professional Development Sessions
Observers also assessed the quality of implementation of professional development sessions. Indicators most frequently rated 4 and 5 were:

- Whether the facilitator's background and expertise enhanced the quality of the session (80 percent); and

- The extent to which the session incorporated instructional strategies appropriate for its purposes and the needs of adult learners (70 percent).

Fewer LSC professional development sessions were rated highly on other indicators, including:

- How well the session modeled questioning strategies that are likely to enhance the development of conceptual understanding (52 percent); and

- How well the session modeled effective assessment strategies (46 percent).

As indicated in Figure 11, 63 percent of the sessions received overall ratings of 4 or 5 on the quality of implementation.

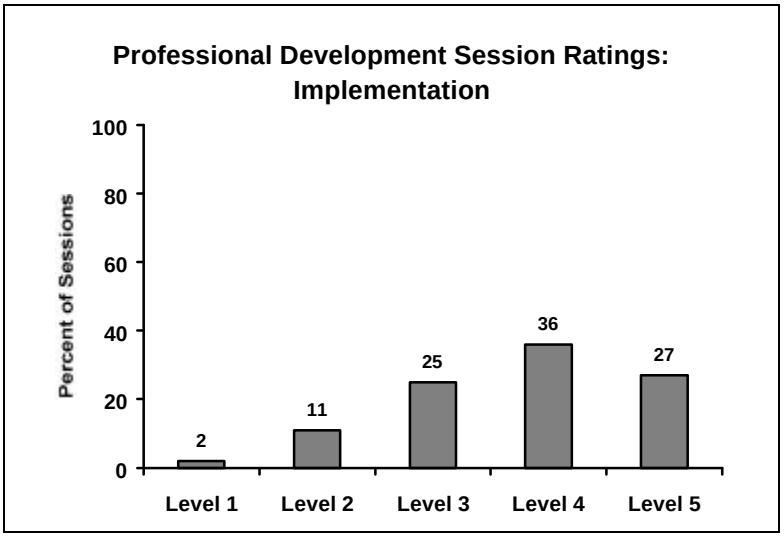


Figure 11

Professional Development Culture

The literature on effective staff development emphasizes the importance of establishing a professional development culture where teachers can explore content and pedagogy in a collegial, risk-free environment. As can be seen in Figure 12, 71 percent of the sessions received synthesis ratings of 4 or 5 in this area. Indicators that were most likely to receive high ratings included:

- Whether active participation of all was encouraged and valued (83 percent); and
- The extent to which there was a climate of respect for participants' experiences, ideas, and contributions (83 percent).

Somewhat fewer sessions were highly rated on:

- The extent to which participants were encouraged to generate ideas, questions, conjectures, and propositions (68 percent); and
- The extent to which investigation and risk-taking were valued (67 percent).

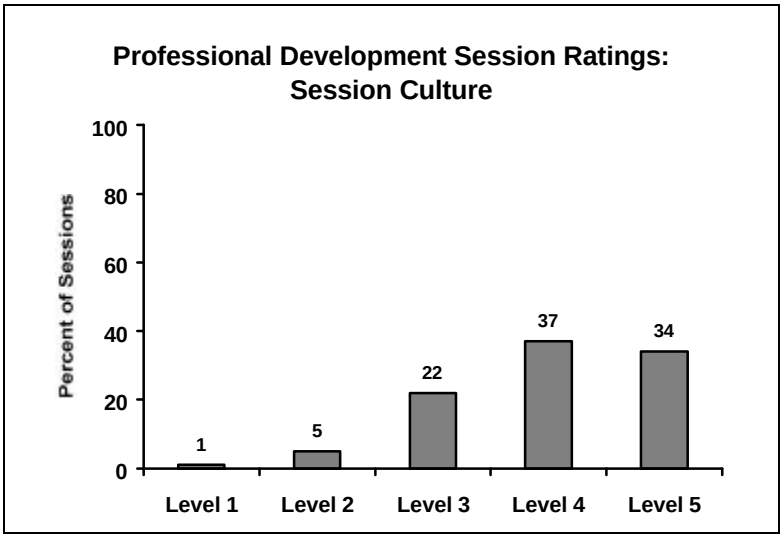


Figure 12

Disciplinary and Pedagogical Content

Evaluators were asked to rate either the quality of the disciplinary content of the observed session, its pedagogical content, or both, depending on the focus of the session. Disciplinary content was rated in 203 of the 402 sessions, with approximately two-thirds of these sessions receiving overall ratings of 4 or 5 in this area. (See Figure 13.) Disciplinary content sessions were most likely to receive high ratings for:

- The extent to which the facilitators displayed an understanding of mathematics/science content (82 percent);
- The appropriateness of the disciplinary content for the purposes of the session and the background of the participants (76 percent); and
- The soundness and appropriateness of mathematics/science content (74 percent).

Fewer sessions received high ratings on:

- The extent to which appropriate connections were made to other areas of mathematics/science, to other disciplines and/or to real-world contexts (55 percent); and
- Whether the degree of closure of conceptual understanding was appropriate for the purposes of the session (52 percent).

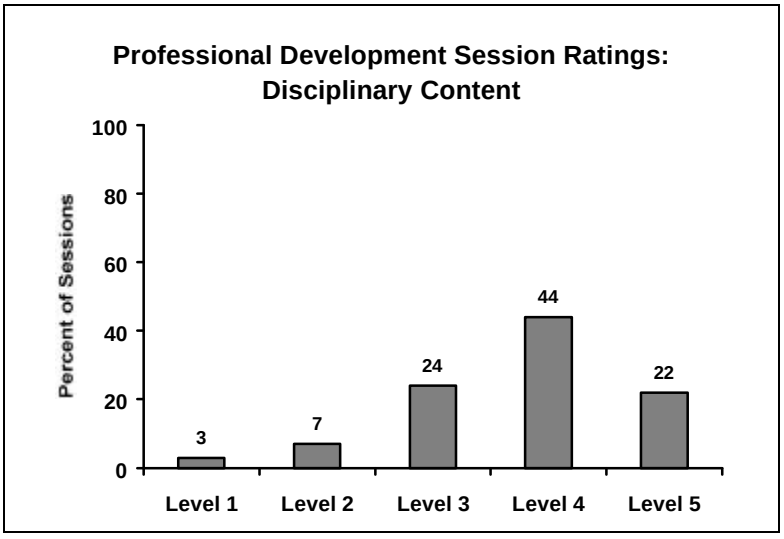


Figure 13

Observers rated 295 of the 402 observed professional development sessions on the quality of their pedagogical content. As can be seen in Figure 14, 67 percent of professional development sessions received ratings of 4 or 5 for overall pedagogical content.

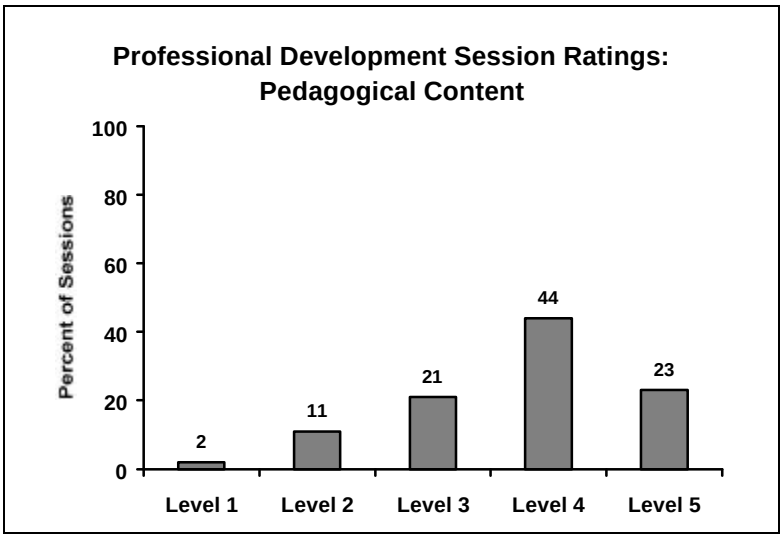


Figure 14

Within the area of pedagogical content, sessions were rated most highly for the extent to which the facilitators displayed an understanding of pedagogical concepts (75 percent received high ratings) and the depth and breadth of attention to instructional materials intended for classroom use (74 percent). In contrast, only 51 percent of the sessions were rated highly for their handling of closure/resolution of understanding of pedagogical concepts.

Overall Assessment of Observed Professional Development Sessions

Observers were asked to consider all information available to them—their own ratings of session components, related interviews, and their knowledge of the project's professional development program—as they assessed the overall quality of each observed session. Observers first considered the likely impact of the session on participants' capacity for exemplary mathematics/science instruction, or the likely impact on leadership capacity when leadership development was a focus of the session instruction. They then assigned "capsule ratings" to characterize the overall quality of the professional development session. Ratings on a five-point scale ranged from "ineffective professional development" (Level 1) to "exemplary professional development" (Level 5).

Sessions' Impact on Participants' Capacity for Exemplary Mathematics/Science Instruction

Observers rated the likely impact of each session on teachers' capacity for exemplary mathematics/science instruction. According to these observers, LSC professional development sessions were most likely to have a positive effect on participants' ability to: (1) implement exemplary classroom instructional materials (77 percent); (2) identify and understand important ideas of mathematics/science (70 percent); and (3) plan and implement high-quality classroom

instruction (70 percent). Fewer sessions were judged likely to have a positive effect on participants' understanding of how students learn (53 percent).

Capsule Ratings of Observed Professional Development Sessions

As would be expected given the high ratings assigned by evaluators for the various components, overall ratings for individual professional development sessions were quite favorable. Only 3 percent of observed LSC sessions were rated as ineffective professional development (Level 1), and 8 percent were rated at Level 2, having quite limited likelihood of helping participants implement exemplary mathematics/science instruction or be leaders in reform. Overall, 59 percent of the observed professional development sessions received ratings of 4 or 5, indicating that those sessions were skillfully facilitated, engaging participants in purposeful work that would likely lead to enhanced capacity to implement exemplary instruction.[5] (See Figure 15.)

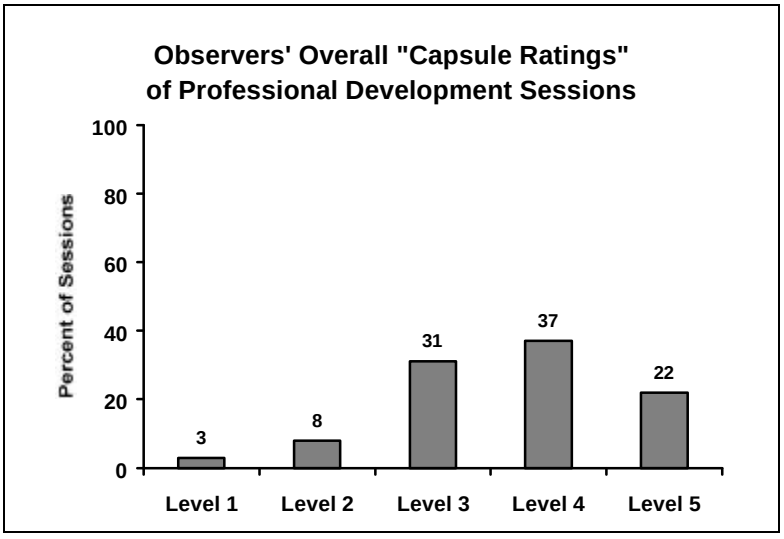


Figure 15

Comparison of Highly Effective and Less Effective Professional Development Sessions

To help identify the features that seem most critical in determining the quality of professional development sessions, HRI compared the most highly rated professional development sessions to those with lower ratings. In each of the component areas—the design of the session, its implementation, the disciplinary and pedagogical content, and the culture of the session—there were specific indicators that distinguished sessions judged to be highly effective from those that were considered less effective.

Table 4 shows the indicators with the largest differences between highly effective (capsule ratings 4 and 5) and less effective (capsule ratings 1–3) professional development sessions. For example, while 71 percent of mathematics and science professional development sessions included in their design, strategies that were appropriate for the purposes of the session, this

[5] It is interesting to note that the percentage of observed sessions receiving high ratings decreased from Year Three (71 percent). This decrease is likely in response to discussions at lead evaluator meetings focused specifically on more stringent criteria for these ratings.

feature characterized 94 percent of the sessions judged to be highly effective, but only 39 percent of the less effective sessions. Similarly, about half of the observed professional development sessions were judged effective in their resolution of disciplinary content understanding; however, this feature was highly rated in 80 percent of the effective sessions, as compared to only 13 percent of the less effective sessions.

Other indicators showed smaller differences when comparing highly effective sessions to those rated less effective. These were typically areas of relative strength for the sessions with low capsule ratings. For example, 60 percent or more of the professional development sessions that were rated ineffective overall, nevertheless, received high ratings for facilitators' understanding of disciplinary content, having a climate of respect for participants, and valuing active participation of all. The differences in percentages of highly effective and less effective sessions receiving high ratings on those indicators were in the 33–38 percent range, compared to the 54–70 percent range for the indicators in Table 4.

Table 4
Indicators that Distinguished Between Highly Effective and Less Effective Professional Development Sessions

	Percent of Sessions with High Ratings			
	All Sessions	Highly Effective	Less Effective	Difference
Design				
Strategies appropriate for purposes of session	71	94	39	55
Adequate time and structure provided for participants' sharing	59	81	27	54
Adequate time and structure provided for wrap-up	53	78	18	60
Implementation				
Effectively incorporated appropriate instructional strategies	70	97	31	66
Facilitators' management style enhanced session	68	94	31	63
Appropriate pace	64	89	29	60
Effectively modeled questioning strategies that are likely to enhance the development of conceptual understanding	52	77	18	59
Disciplinary Content				
Appropriate degree of closure	52	80	13	67
Pedagogical Content				
Explicit attention to classroom strategies	68	94	29	65
Participants were intellectually engaged with important ideas relevant to classroom practice	63	88	25	63
Appropriate depth and breadth of attention to student thinking/learning	60	85	22	63
Appropriate degree of closure	51	79	9	70
Professional Development Culture				
Interactions reflected collaborative working relationships between facilitators and participants	72	95	40	55
Investigation and risk-taking were valued	67	89	34	55
Participants were encouraged to generate ideas, questions, conjectures and propositions	68	90	36	54

C. Professional Development Providers

Based on data from both teachers and project evaluators, the overall quality of professional development providers in the LSC is quite high. Evaluators praised the competence, experience, enthusiasm, and commitment of many of those who provided professional development. In interviews, a number of teachers identified similar qualities of professional development providers—e.g., their enthusiasm, expertise, and organization—as the most valuable part of the LSC project. One teacher noted, for example, "The most helpful aspect was probably the trainers. They were very friendly and made it non-threatening. They were convinced this was the way to teach and spread it to us." Many teachers were also appreciative of the way in which they were treated as professionals throughout the LSC professional development.

In describing effective professional development providers, participants and observers highlighted the importance of the following qualities:

- Experienced in providing professional development;
- Sensitive and responsive to the needs, interests, and concerns of participants;
- Knowledgeable and experienced in using LSC instructional materials;
- In-depth knowledge of content; and
- Ability to model and discuss sound pedagogical strategies.

Projects made use of a number of different types of professional development providers, including district central office staff, teacher leaders, scientists and mathematicians, and authors/ publishers of the designated instructional materials. While specific roles of professional development providers varied extensively among the LSC projects, responsibilities generally included: planning and facilitating professional development sessions; providing expertise (e.g., in content, instructional materials, classroom implementation); and serving as spokespersons for the project.

Preparation of Professional Development Providers

While discussion of capacity-building efforts directed toward project staff or other professional development providers was limited, information provided by evaluators indicates that project staff tended to use national conferences, professional development institutes, and each other as resources for professional development. This description is typical of how project staff themselves engaged in ongoing professional development:

> *The three [project staff]…have spent the last five years deeply engaged with K–12 science professional development and with the implementation of the K–5 FOSS curricular materials…. In interviews, they described developing their own professional knowledge through active networking at the state and national levels through organizations such as the National Science Teachers Association, the National Science Education Leadership Association, and the Center for Urban Science Education Reform. They have collaborated with the National Institute for Science Education in an effort to better understand the issues involved in designing a professional development program for science education teachers. They have also developed practical professional expertise through their ongoing*

support of classroom teachers, in the context of both FOSS curricular materials implementation and numerous enrichment projects, especially in partnership with scientists from [the local university].

One evaluator commented on the importance of preparing scientists who work with the program:

The project's efforts to prepare scientists for offering professional development support has been mixed. When scientists were just asked to provide "expertise" without much preparation, the results were disappointing. However, the obvious skills and knowledge of those scientists who attended the [special training program] and then helped facilitate the [designated] teacher modules is impressive. [The co-director of the project] is to be commended for her efforts to support scientists' understanding of the project's goals and to spend considerable time debriefing with them about their efforts to facilitate project sessions so as to improve their methods.

Another evaluator who described extensive professional development provided by project staff to scientists and engineers who work with the project, noted that the focus of this professional development was on pedagogy, science education standards, involving them in the professional development sessions attended by teachers, and providing experience in working with teachers and students in classrooms.

Preparation of Teacher Leaders

Much of the professional development in LSC projects is provided by teacher leaders. Teacher leaders plan and implement professional development for the targeted teachers—sometimes in a district- or project-wide setting, sometimes at individual schools. In addition to workshops, school-based activities include one-on-one coaching, study groups to support teachers in the implementation of instructional materials, and planning school-wide activities such as Family Mathematics/ Science Nights. Teacher leaders have become part of the formal organizational structure in some districts, through membership on school or district leadership teams.

Projects vary in their approaches to preparing teacher leaders for their roles in the LSC. Key variables involved in the preparation of teacher leaders include the focus of the leadership training; the structure and strategies for enhancing leadership capacity; the extensiveness of professional development; the level of support provided to teacher leaders as they assume their responsibilities; and mechanisms for quality control.

Focus of Teacher Leader Preparation

While individual projects differed in the specific focus taken for leadership development, generally the areas targeted for professional development for teacher leaders were:

- Becoming familiar with LSC instructional materials and the content and pedagogy underlying those materials;

- Developing the skills and knowledge needed for working effectively with other teachers as professional development facilitators, coaches, or support persons; and

- Developing the skills and knowledge required to be an effective change agent for reform in schools or districts.

One project's focus on content knowledge, pedagogical knowledge, and instructional materials is described in this excerpt from an evaluator's report:

> *On the first day of the Institute all participants gathered for a day of working with consultants. The math teacher leaders attended sessions on the nature of mathematical discourse and classroom climate, and the science teacher leaders engaged in discussions about the use of science notebooks and making science the core discipline in one's classroom. Both groups enhanced skills they could use in their classrooms, but also could share with colleagues.*
>
> *Over the next two weeks, grade-level groups met 3–4 times. Teams methodically examined a unit, reacquainting themselves with its broad conceptual underpinnings as well as its individual lessons. Grounded in the materials, they then proceeded to "script" a curriculum for teacher leaders to follow when leading a session. Importantly, all designed workshops followed the same format and were advised by a [district-level teacher leader] and/or consultant.*

Another evaluator described a project's goals for the leadership/facilitation component of teacher leader development as follows:

> *Whole group sessions focused on leadership roles in mathematics reform and developing interpersonal skills. Smaller group sessions on practicing interpersonal skills ran concurrent with sessions on the Third International Mathematics and Science Study (TIMSS). All of these activities were designed to support these five goals that participants: (1) deepen their understanding of themselves as leaders and change agents in the educational system; (2) develop knowledge of powerful strategies for promoting interpersonal communication, managing mindsets, and articulating a reform vision; (3) learn skills for more effective networking, negotiating, and enlisting others in a reform vision; (4) practice leadership strategies and skills and plan for application within a classroom, school, district, or project; and (5) make (or strengthen) a commitment to a particular [district] project that contributes to a reform vision.*

A project's attention toward preparing teacher leaders as change agents in their district is described in this excerpt:

> *The leadership strand is focused on providing key leaders with the necessary knowledge and skills to become change agents for science education reform in the district. The strand includes all 94 principals, 28 assistant principals, eight collaborative teachers, twenty action research teachers, and 94 school-based site facilitators….This cadre will participate in numerous leadership activities throughout the 1998–99 school year that will engage leaders in investigating the*

change process, exploring the nature of systemic reform, and reviewing connections between [the district's] science program and state and national standards.

In addition to general areas of leadership development, evaluators described a focus on specific strategies such as addressing equity, peer coaching, and effective questioning, as illustrated in this evaluator's description of a professional development session for teacher leaders:

At this meeting, facilitators initiated a discussion with the liaison teachers about the kinds of questions that would model and promote effective discourse, questions that would elicit teachers' thinking about the impact of the lesson on students' thinking and understanding of mathematics as well as how well the curriculum supported the teachers' classroom practice. Facilitators distributed a list of sample questions to use. "Were there any surprises? What evidence did you have of students' understanding of mathematics? What would you do differently next time?"

Finally, some projects focused on enhancing teacher leaders' own classroom instruction which, as one K–8 science project evaluator noted, could be considered an important part of leadership development in and of itself:

In all of our studies we have found that teacher leadership comes from and contributes back to good classroom practice. Facilitators will need to continue to develop their capacity to model the teaching style they are trying to elicit from the teacher-participants. It will be important to find a way to have [district teacher leaders] continue to evolve their own practice. Similarly, it is a good reason for [district teacher leaders] to team up with lead teachers who are highly skilled and practiced in teaching specific kits.

Structure and Strategies for Professional Development of Teacher Leaders

Much of evaluators' discussion of leadership development involved a description of the strategies used to develop the capacity of teacher leaders. Among the LSC projects a variety of strategies were mentioned, most notably:

- Leadership institutes;
- Mentoring and apprenticeship activities between project staff and teacher leaders—in particular, in planning and implementing workshops;
- Use of national programs and conferences;
- Consultants (including professional development provided by publishers of instructional materials); and
- Visits to other reform sites.

There was considerable variation in how LSC projects chose to provide professional development to teacher leaders. In some cases, teacher leaders participated in professional development sessions that are similar to the sessions they will conduct with targeted teachers.

> *First, [teacher leaders] are presented with the lessons, much as they will be asked to present them to teachers. These lessons are very clearly thought out, and described in detail in a set of "Instructor Lesson Plans." …[Teacher leaders] then have time to try the lesson out in their own classrooms and come back and discuss it. This means that the [teacher leaders] must themselves modify the lesson to their own particular grade level, thus providing insight into what teachers will have to do to make the lessons appropriate for their own classrooms. The next session allows time for [teacher leaders] to plan in groups of two or three for when they will present the lesson themselves to their Cohort groups. The [project] staff is always there to offer support, and the Principal Investigator [a mathematician] attends many of these sessions, adding depth to presentations on mathematical concepts.*

Another common approach was to schedule activities throughout the summer and academic year focusing on particular aspects of professional development for teacher leaders. In some cases, a small group of full-time district-level teacher leaders participated in professional development to enhance their own leadership skills, then provided professional development to school-based teacher leaders.

> *The lead teachers [have] received over 430 hours of professional development since July 1995. When the LSC project began, science content and pedagogical knowledge of these teachers varied considerably. Through intensive summer training in content and pedagogy, school year workshops, facilitation of small group activities during summer institutes, and work with colleagues in their home schools, these teachers have been prepared to serve as science resource teachers for the district and their own schools.*

In other cases, leadership development was integrated into a menu approach to professional development. These projects offered sessions specifically designed for teacher leaders as well as sessions open to all targeted teachers with embedded leadership strands.

> *During the 1997–98 year [the project] offered a diverse "menu" of professional development offerings, tailored to the meet the different needs of the growing range of program participants. The project categorized its offerings into four domains, with sessions focused on: the student; the disciplines; standards-based materials implementation; and effective instruction. In addition, site-based sessions and leadership development sessions were offered to both teachers and administrators.…Select project offerings have a leadership strand embedded in them, and the staff alerts potential teacher leaders to those sessions.*

Quality of Leadership Development Sessions

As noted earlier, many LSC projects incorporate the use of teacher leaders in their professional development strategies. When evaluators observed professional development sessions that focused on the preparation of teacher leaders they were asked to rate a number of key indicators in the area of leadership content. As can be seen in Figure 16, 68 percent of the sessions focusing on leadership content received a high synthesis rating (4 or 5) in this area. Leadership sessions were most likely to receive high ratings for:

- The extent to which facilitators demonstrated an understanding of leadership concepts (85 percent);
- How well principles of effective staff development were presented/explored (80 percent); and
- The extent to which participants were intellectually engaged with important leadership content (80 percent).

Sessions focusing on leadership concepts were less likely to receive high ratings for:

- Opportunities to consider applications to their leadership roles (58 percent); and
- Quality of information on how to be a reform advocate at the school/district level (50 percent).

When asked about the likely impact of the sessions on participants' leadership capacity, evaluators were most likely to cite professional networking among teacher leaders; leaders' knowledge and understanding of effective classroom practice; and leaders' ability to convey to others a vision of effective mathematics/science classrooms, with roughly 85 percent of sessions deemed to have had a positive impact in these areas. In contrast, only about 60 percent of leadership sessions were judged likely to have a positive effect on teacher leaders' understanding of adult learners, or their awareness of areas where teachers have difficulty.

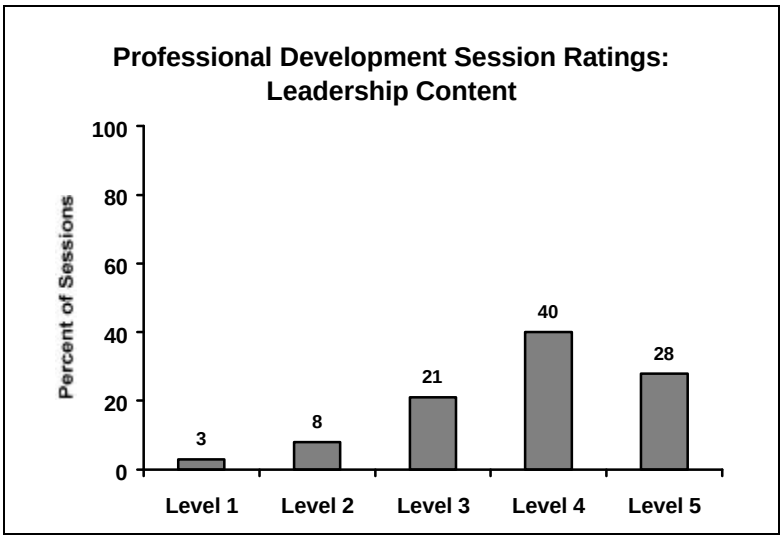


Figure 16

Extensiveness of Professional Development for Teacher Leaders

The timing of professional development for leadership enhancement differed among the LSC projects. Some projects had extensive professional development to prepare leaders prior to their working with targeted teachers; others provided only a minimal amount of professional development to the teacher leaders prior to their taking on leadership responsibilities. In interviews, a number of teacher leaders noted a need for more in-depth preparation, especially in disciplinary content. Said one:

> *I don't feel "worthy" of the Lead Teacher label yet. I want to be more comfortable with a lot of the concepts.*

Projects also varied in the extent to which they provided ongoing professional development experiences for teacher leaders as they took on leadership roles. Some teacher leaders appeared to quickly begin designing and implementing professional development sessions with minimal one-on-one guidance or assistance from project staff. In other projects, staff members worked very closely with teacher leaders throughout the design and implementation process, as described by one evaluator:

> *Project staff have drawn on the expertise of professional staff trainers in [the district's] School Improvement Training Unit to plan and implement the lead teacher training-of-trainers professional development. [District] staff worked closely with project staff to plan and facilitate the [summer] workshop, and are continuing to work with them during this project year to provide follow-up training.*

Quality Control Mechanisms

A number of evaluators specifically identified the quality of professional development training provided for teacher leaders as a strength of the project. A few evaluators elaborated on mechanisms used by projects to assure the quality of professional development that is provided

by teacher leaders to other teachers in the district. Their comments indicate a close link between providing support and assuring high-quality sessions. Strategies that projects used to assure quality included the following:

- Establishing close working relationships between project staff and teacher leaders in the design and implementation of professional development sessions;
- Establishing a team of facilitators with different types of expertise, or pairing experienced and inexperienced facilitators;
- Scripting the professional development sessions to assure consistency among multiple teacher leader facilitators or to guide the selection of appropriate units/activities; and
- Observations and debriefing with project staff to assess quality and provide feedback on professional development sessions.

These same mechanisms tended to be ones that evaluators recommended to projects for improving teacher leader preparedness when the quality of professional development sessions was inadequate or uneven.

Advantages of Using Teacher Leaders

Teacher leaders bring a great deal of credibility to the professional development setting. In interviews, a number of teachers praised teacher leaders for their practical advice in using the instructional materials. When asked about the "most helpful" aspects of the LSC, teachers frequently mentioned getting assistance from teachers who had already used the instructional materials in their classrooms. The following comments were typical:

> *[What I liked best was] the opportunity to do hands-on with other teachers and with the help provided by the facilitators who used it with their students.*
>
> * * *
>
> *They [the trainers] know what works in the classroom. They are actual teachers and they have not been out of the classroom for very long.*

Challenges Involved in the Development of Teacher Leaders

Preparation of teacher leaders plays a critical role in accomplishing project goals—both the immediate goals for professional development of teachers targeted by the LSC project and long term goals for sustained reform. It is clearly a major endeavor to adequately prepare teacher leaders for their roles; the breadth and depth of knowledge and skills required for effective leadership is extensive.

Those evaluators who discussed issues concerning teacher leaders, raised concerns about the quality of the teacher leaders' preparation, and noted the need for additional capacity-building efforts. When evaluators described specific components that needed additional attention, their recommendations covered the scope of the many areas that leadership content could potentially

focus upon: knowledge of mathematics/science content and pedagogy; familiarity (and experience) with the instructional materials that would be used in the schools; presentation, facilitation, and group management skills; clarification of leadership roles and expectations; and feedback to teacher leaders both on their own classroom teaching and on the activities they facilitate.

Many of the evaluators noted a need for continued support to teacher leaders as they engage in the work of the project—both for continued leadership enhancement and for assurance of quality in the professional development the leaders provide to other teachers. A number of evaluators suggested that project staff or experienced, district-level teacher leaders work more closely to supervise and serve as mentors to those teacher leaders who were less far along in developing their leadership skills.

In some cases, evaluators indicated that projects were not devoting sufficient attention to leadership development, and simply needed to put more effort into that component of the program. For example, one evaluator noted that the plan for leadership development was not clear; another observed that there just were not enough teacher leaders available to do the work of the project. In fact, several evaluators commented on the need for increased numbers of teacher leaders or the need to shift greater responsibility from project staff or full-time, district-wide teacher leaders to the more numerous school-based teacher leaders.

A number of evaluators noted that projects themselves were recognizing a need to focus more attention on the development of teacher leaders. Most often it was the need for skilled and knowledgeable teacher leaders to help meet the extensive professional development goals of the project that prompted the increased attention to leadership development. Projects also acknowledged the importance of building the capacity within the district to sustain the work of the project after LSC funding ends.

One evaluator noted that changes in the district context had created a need for the project to garner greater commitment and support via the involvement of teacher leaders. The following excerpt describes how a secondary mathematics project modified its original plan for leadership to focus more on the development of teacher leaders:

> *At the beginning of the project, the PIs saw themselves as not only having primary responsibility for running the project and the workshops, they have also stated that they saw themselves as having a central role in maintaining the project activities at the conclusion of the LSC. Even though they had a few experienced teachers interested in participating as workshop leaders, they did not see the development of a structure for developing teacher leaders as essential….By the fall of 1997, the importance of providing a structure to support these teachers (as well as new ones prepared to join the group) in their development into teacher leaders was taking on increasing importance. There were a variety of reasons for this change. First, was the lack of central administrative support, implying that the viability of the project would depend heavily on the commitment of participating principals and teachers. Second was the recognition that the amount of work required to run the LSC project effectively required additional*

staff capable of taking an active role in planning and running project activities. Finally, their own growing knowledge of teacher development made them more aware that an ongoing structure for developing teacher leaders was necessary to maintain stability and credibility over the long run, especially after the project was completed.

A couple of key challenges emerged as evaluators addressed the quality of leadership development. Both are reflective of the tension projects face as they attempt to balance multiple needs and demands. One challenge raised by evaluators was finding the appropriate balance of attention to developing leadership skills of teacher leaders and improving teacher leaders' own classroom instruction. On the one hand, it is clear that teacher leaders must be comfortable and experienced with the type of instruction that they are advocating. At the very least, this implies familiarity with the instructional materials and sufficient content and pedagogical knowledge to effectively instruct others in their use. In some projects, the leaders themselves need more experience and guidance in the reform-oriented classroom practices—particularly in inquiry-based instruction. At the same time, however, teacher leaders must keep in mind that their own classroom instruction is not the sole, or even primary, focus of their work.

Another pervasive challenge faced by all projects is the mandate to scale up their efforts to serve all of the teachers that they promised to reach with LSC funds. In most projects, meeting this goal requires large numbers of teacher leaders to help deliver professional development and support targeted teachers as they implement new instructional materials in their classes. At the same time, projects must assure that the professional development and support provided by those teacher leaders is consistently high-quality. One evaluator addressed this issue in some detail:

As noted earlier, there is a tension between the need for new teacher leaders to lead workshops, and the need for consistently high-quality sessions. The project leadership has struggled with how to negotiate the process of scaling up. The need for more teacher leaders is evident, as is the need to train them. The [full-time, district-level teacher leaders] have taken to this work. Instead of running introductory materials workshops this year, the [full-time, district-level teacher leaders] became "clinical supervisors" to [part-time] teacher leaders as they facilitated sessions. [Part-time] teacher leaders were often inexperienced, and in some cases hadn't taught the kit themselves or lacked the content knowledge to facilitate a strong session. The [district-level teacher leaders], in their effort to build the capacity of the [part-time] teacher leaders, often did not actively assist during the session, but worked with the leaders prior to and following the workshop. We understand the value of this kind of experiential learning and applaud the Project's effort to develop its leadership pool. However, this year, the net result was that we saw mixed quality or even lowering of quality as the number of workshops expanded. The Leadership Institute was a direct attempt to remedy the less accomplished [part-time] teacher leaders, so the quality of introductory workshops should increase in 1998–99.

Other challenges projects have faced as they have attempted to both develop teacher leaders and scale up are:

- Levels of commitment—e.g., insufficient numbers of teachers willing to make the commitment to leadership roles to begin with and attrition among those who have become experienced leaders;

- Inaccessibility of teachers for leadership training due to scarcity of substitute teachers available to cover classes or district policies that prohibit frequent leaves from classroom responsibilities; and

- Too few project staff available to provide the support and supervision needed to assure continued development of teacher leaders and high-quality professional development.

Evaluator Ratings of Preparedness of Professional Development Providers
Based on the results of their observations, as well as feedback from participating teachers, evaluators rated the overall quality of the LSC in preparing project staff to carry out their roles in providing professional development to targeted teachers. Overall, 71 percent of LSC projects received high ratings (4 or 5 on a five-point scale ranging from 1 "poor" to 5 "excellent"). (See Figure 17.)

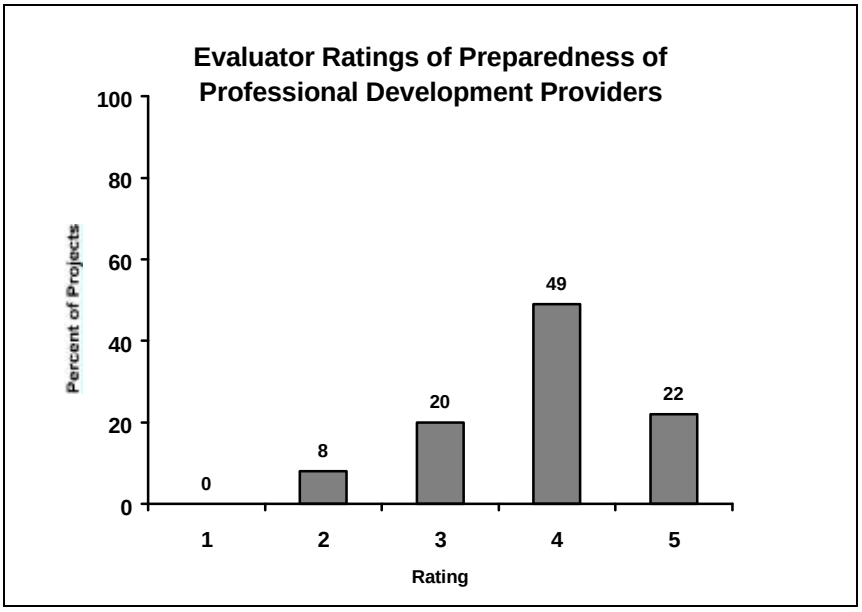


Figure 17

D. Establishing a Professional Development Culture Conducive to Teacher Learning

One of the key enablers of a high-quality professional development program is the establishment of a culture conducive to collaboration and learning. LSC projects use different approaches to establish the kind of collegial environment where teachers feel supported, free to take risks and to ask for help as they grapple with understanding new instructional strategies and content. Evaluators described how professional development providers encouraged teachers to share their experiences while participating in session activities. Such sharing was often linked to opportunities for teachers to network within and across grade levels and districts.

The support that teachers felt from professional development providers and fellow participants affected their comfort level as they considered new content and instructional strategies. As one teacher of a K–8 mathematics project said:

> *During the whole program, I was able to feel comfortable while I was receiving all the feedback from the [project] staff, colleagues, and others…I believe the major reason for this has to do with the way the program was designed. I was able to accept new ideas, advice on changes on my teaching without feeling offended.*

Furthermore, by modeling how to interact in a professional learning community, session facilitators served as examples for teachers to engage their students in similar ways. A teacher of a K–8 science project remarked about the professional development provider, "She made us feel that we are physicists….Being able to revisit content in this new light helped to refresh my memory and made clearer for me the great value of using inquiry-centered methods."

Opportunities for Reflection

Evaluators reported that providing time for teachers to reflect on their learning experiences was a key feature of a high-quality professional development session, allowing teachers to process new content and pedagogy, and to make connections to classroom implementation. The following excerpt describes how one elementary science project scheduled time for reflection throughout the series of professional development sessions:

> *The [project] professional development practice/reflection model was designed to provide opportunities for teachers to enhance their classroom practice by sharing their experiences with colleagues. Professional development workshops offered for teachers new to the [project] were scheduled at three-week intervals so that teachers could explore a series of Learning Experiences from the module at one workshop, go back to the classroom to teach the lessons, then come back to the next professional development workshop to process their experiences with their colleagues, and learn a new series of Learning Experiences. This model gave teachers the opportunity to explore what worked, what did not work effectively, and in what areas they needed more knowledge and preparation.*

Sharing Experiences with Other Teachers

Evaluators noted that when teachers had opportunities to share and reflect together, it led to the cooperative building of knowledge. Interestingly, there appeared to be a reciprocity between gaining new knowledge and fostering collegiality in the professional development culture, as this evaluator of a K–12 mathematics project noted:

> *Opportunities for teachers to collaborate with one another were useful not only because it helped deepen their knowledge of effective pedagogy through active participation, but also because it helped make them feel more connected as a part of a professional learning community. Such a bond helped teachers themselves in their viewing of the profession, and also made them better teachers, because they were not operating in a vacuum.*

Similarly, an evaluator noted that "Teachers found that sharing the process of deepening content and pedagogical knowledge with peers (was) instrumental in creating a collegial atmosphere."

Teachers clearly valued the opportunities the LSC professional development provided for them to share experiences with other teachers; in fact, collaborating with other teachers was the most frequently cited "helpful" aspect of the LSC. Said one teacher:

> *Having the opportunity to be around other teachers with the same ideas and sharing the influences of this program on other teachers and on myself, being able to discuss ways that you can make [science teaching] more process-oriented and use a more discovery-based learning style, was really useful. Anytime you have teachers together, we're sharing ideas, people are connecting, giving [each other] positive feedback for that style of teaching; you get an opportunity to share your own experience with [the kit]…how useful it's been and how much the kids are excited by it. Other teachers always have great ideas that you can then use.*

Teachers appreciated the opportunity to work with other teachers at their grade level, especially if they rarely did so outside the LSC. They also found it helpful to interact with teachers in other grades so they could see where the students had been and where they were going.

> *I was real happy with the workshops because not only did you get to explore and work though the materials, but more importantly for me was being able to exchange ideas and talk with other teachers about the same thing we were all teaching. This was really important for me because I am the only 7th grade teacher in my school. From the workshops, I was able to get ideas, see shortcuts, and to talk about what works. I really learned a lot and appreciated the time I got to talk to other 7th grade teachers.*

* * *

> *I liked the fact that in the seminars we were grouped with high school and middle school teachers so we could see where the students were going to go in mathematics after they left elementary school.*

When asked about additional help they needed in order to implement the kind of instruction envisioned by the LSC, a number of teachers cited additional opportunities for networking with other teachers, both within the project and more widely.

> *[I would like] more time during the school year to get together with other teachers. More release time to visit other teachers and have other teachers visit us.*

* * *

> *I would like to network with others around the state and country. We don't go outside our own borders. I would like to see broader sharing and working together.*

Challenges Inherent in Building a Culture of Trust

Depending on participants' prior experience in professional development, it may take some time for a culture of trust to evolve during the course of a professional development program. In some cases, the fact that the LSC professional development is mandated struck some teachers as counterproductive.

> *I like the support, mostly the support is fine. [It's great to have] the opportunity for professional development, hands-on classes, etc. But I think they need to offer it, not cram it down our throats…make it available but not require it.*

The process of creating a professional learning community based on trust sometimes required considerable adjustment among participants. One evaluator described how working in small groups over an extended period was an uncommon experience for most of the teachers and that the LSC was, in some cases, the first time they had engaged with colleagues in discussing professional issues. Getting past "turfism" and natural competitiveness can be challenging, not only in the school setting but in a new professional development setting as well.

Some projects found that simply allowing teachers to voice their concerns helped the project professional development move forward.

> *The trainers gave us time at the meetings to vent and share concerns we had about the kits. This strategy removed our initial frustration and allowed us to collaborate.*

Sometimes disparities between teachers' expectations for professional development and the design of a particular LSC created tensions. For example, orienting a session toward enhancing teacher knowledge and skills was problematic when the participants had expected that the workshop would provide activities they could take back and use with their students. Said one evaluator of an elementary science project:

> *Some teachers are so accustomed to the type of one-shot staff development experience that centers on "make and take" activities that they are not prepared*

to be treated as adult learners, to expand their own thinking, to take risks toward changing their practice, or to read background research articles provided. The [professional development providers] are aware of the effects of years of conditioning that superficial staff development has had on teachers, and for the most part, are prepared to counteract those tendencies. When a teacher asks for printed copies of a segment of a professional development session so he can use it the next week with his students, for instance, [session facilitators] diplomatically explain (as they make handouts available) that the experience isn't necessarily intended to be replicated with children, but for teachers as adult learners.

Another evaluator pointed out that while most project teachers had an understanding of teaching the targeted subject via the inquiry approach, they had not yet come to think of their own professional development as an inquiry about teaching. She stressed the need for LSC professional development to focus on this view, and ventured that this approach to professional development may be ultimately what sustains teachers' interest in how their students learn.

Finally, there were the challenges associated with trying to balance the pressures of mandated state curricula and assessment requirements with fostering a learning community. As one evaluator put it,

[The state] mandates a course of study in science and places enormous pressures on districts, schools, teachers to comply with its guidelines and to accept its testing practices without opportunity for dialogue about their impacts. This state driven, "top-down" approach (which fails to value districts, "schools," and teachers' feedback) makes the project's job of creating a "professional learning community" more difficult.

Evaluator Ratings of Professional Development Culture

Using all of the information available to them, including teacher comments and their own observations, evaluators rated the overall success of each project in creating a climate conducive to teacher learning. Overall, 70 percent of projects received ratings of 4 or 5 in this area. (See Figure 18.)

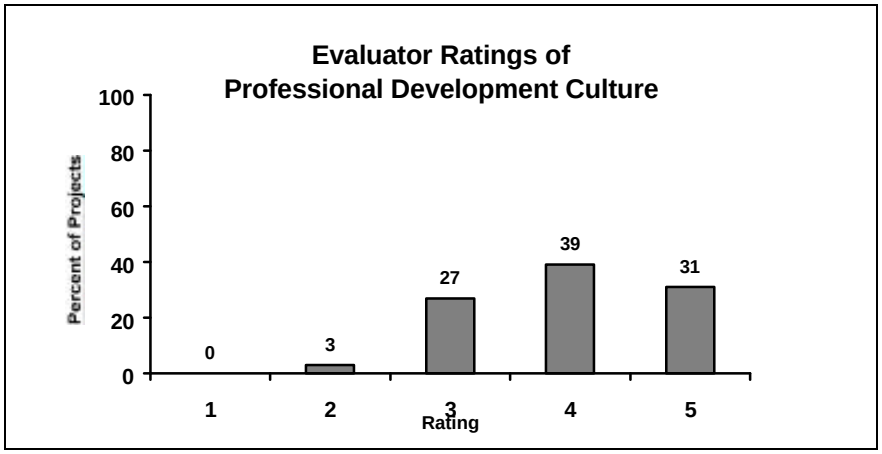


Figure 18

E. Deepening Teacher Mathematics and Science Content Knowledge

LSC projects vary both in the extent of emphasis on deepening teacher content knowledge and how they go about it. This section describes how the LSC projects have approached the need to deepen teacher knowledge of mathematics and science.

Increased Focus on Teacher Content Knowledge

Based on evaluator reports, there has been a trend toward increased emphasis on mathematics/ science content. The increased attention to content-based professional development has sometimes come about because of teachers' expressed needs. On other occasions, once they began professional development, project staff recognized that gaps in teacher content knowledge were more extensive than they had realized initially. Finally, NSF's focus on teacher content knowledge at the PI meetings appears to have reinforced the importance of addressing teacher content needs in an in-depth, coherent fashion.

While every LSC project faces difficult decisions about how best to distribute the 100/130 hours of professional development, evaluators of K–8 science projects were particularly likely to note that there wasn't enough time available to address teacher content needs. The following comments are typical.

> *The teachers are provided with the essential content for each kit. However, two days does not allow for enough time to give thorough, in-depth treatment of the science content, especially, since the college training of elementary teachers in the state does not require a very extensive science core.*

* * *

> *Providers of content background for kits agree that they can only "scratch the surface" of a particular subject in the time that is available for kit-specific training.*

Some projects schedule equal amounts of time for each module/kit/unit in the student instructional materials. Other projects have tried to prioritize teacher content needs and focus on areas that are likely to be least familiar to teachers. For example, one evaluator noted that the project had a major focus on content background and that physical science was the area chosen for intensive study "because it is the one with which most K–6 teachers are least familiar" An evaluator of a K–8 mathematics project indicated that a statistics workshop was provided to introduce teachers to content in the area of data "quite a bit of which was new for most teachers." Similarly, an evaluator of a secondary mathematics project noted that "the sessions focus on content that is new to participants (e.g., discrete mathematics, probability, and statistics)."

The diversity of content needs among teachers has created a challenge for many projects. For example, the evaluator of a secondary mathematics project indicated a need for facilitators to pay more attention to the different learning needs of individual mathematics teachers, noting that "when the pace [of the professional development sessions] is at the level necessary to cover the

curriculum in the time allowed, teachers who need to strengthen their background the most often gain the least."

In response to the diversity of content needs in their targeted teacher population, a number of projects have developed a range of professional development activities and encouraged teachers to select from a menu of those activities that address their priority needs. In that way, teachers who need to concentrate on the "basics" underlying particular units can do so, while those ready to go deeper can access more advanced content-based courses. Explained the evaluator of an elementary mathematics project:

> *Two of the Year One days, facilitated by mathematics experts, focus specifically on content and many of the second year offerings also center on increasing content knowledge, with the added benefit that teachers can choose a particular area of interest or need. Third-year schools delved into MathLand, collecting samples of student work across content strands, with much time devoted to discovering and identifying the underlying mathematics in a student activity.*

Some projects went further and first asked teachers to "specify exactly what content they wished to learn" and then designed the workshops to meet their expressed needs, as in this K–8 science project:

> *Teachers submitted the general topics they wished to study when they enrolled. During the workshop, facilitators read the participant journals at the end of each session and worked each evening to find the materials needed the following day.*

Involving Content Experts

The LSC projects have developed a myriad of ways to involve content experts in providing professional development to participating teachers. Scientists and mathematicians serve as PIs or co-PIs; they often help plan and implement content-based professional development activities and serve as resources in sessions focusing on instructional materials implementation. In many cases, scientists and mathematicians team up with teacher leaders in providing professional development both during workshops in the summer and in sessions held throughout the academic year.

A number of evaluators reported that teachers were quite appreciative of the efforts of the scientists and mathematicians. For example, the evaluator of a K–8 science project reported:

> *The disciplinary content sessions not only provide science training for teachers but also enable them to make personal connections to the scientists leading the activities. Teachers have responded in an overwhelmingly positive way to the opportunities to learn from professional scientists. They feel that the instruction provided by the scientists allowed them the experience of going "back to school." As one teacher said in reference to her scientist-instructor: "The scientist made our session last summer. We learned so much in just a couple of days. I mean it was kind of overwhelming at first, but mostly it was exciting, kind of like being back in college or something." Another teacher spoke zealously of the unique*

experience of working directly with a research scientist: "You just feel like a special person when you're with a scientist. I don't know maybe because they're closed off from schools and societies so much because they're busy studying and doing their research, they're kind of like an unknown, like a god or something. And having them there with us was just magical and beautiful."

In contrast, a few evaluators described less successful uses of scientists and mathematicians. For example, the evaluator of a K–8 science project noted that:

The workshop design was not a good match for the participants. Some of the scientists were not effective "content specialist" partners for the teacher/participants. Too often, they took over the investigation or offered "mini-lectures" to explain the lesson rather than [helping teachers] to conduct the investigation. The jig-saw design assumed teachers had more content knowledge than this group appeared to have. It did not provide adequate time or opportunity for teachers to deepen their knowledge of the science content in the module and, without that understanding, the analytical process appeared to be largely unsuccessful.

Finally, some projects have worked with nearby colleges and universities to offer courses that go beyond the professional development provided as part of the LSC, in order to meet their teachers' content needs. In one project, the local university "offered three sections of science content classes exclusively to (LSC project) teachers. Another project included in its overall professional development plan "university course offerings designed to provide an economical means for interested teachers to increase content knowledge and meet [state] teaching credential requirements." And another evaluator reported that the project's partnership with two universities has led to a formal master's program in each institution with a mathematics emphasis designed for elementary teachers, and noted that nearly every school in the district has at least one teacher enrolled in one of these programs.

Using Student Instructional Materials as a Vehicle to Enhance Teacher Content Knowledge

Evaluators report that most projects work on deepening teacher content knowledge in the context of the designated instructional materials. For example,

With the exception of some of the leadership sessions, all workshops are centered on the use of the IMP curricular materials. The PIs are committed to the idea that it is through using these materials that teachers learn the curriculum, experience new approaches to teaching, and develop deeper understandings of the mathematical ideas underlying standards-based curriculum.

* * *

The project's directors learned early on that the new curricular materials (Everyday Mathematics and Connected Mathematics), themselves made the best basis for initial professional development. As demanding as these curricula are,

they forced learning of mathematics on cadres of teachers not broadly versed in the subject matter.

Similarly, evaluators indicated that "through the use of exemplary materials as students, the participants quickly identify questions they have about science content"; "opportunities were provided for the teachers to deepen their understanding of mathematics as they investigated the curriculum materials"; and "in actually doing activities and problems from the Core-Plus texts, teachers are exposed to the basic mathematics content of the program."

One evaluator noted that the materials themselves enhance teachers' content knowledge.

The LSC-designated curricula are well constructed and the units' lessons unfold to tell a conceptual "story," so teachers with little or no content knowledge are exposed to some content simply by working through the lessons in the introductory unit training. Specific conceptual issues arise as teachers examine and engage in the lessons they are expected to teach. For example, in the FOSS "Balance and Motion" kit progressive lessons establish a relationship between an object's balancing point and the distribution of its weight, a concept that some teachers grapple with for the first time during their introductory kit training.

However, while working on content in the context of the student materials can both deepen teacher content knowledge and help teachers see connections to the classroom, there is a risk that teachers will focus so much on pedagogy that the content may not get sufficient emphasis. The following excerpt from a K–8 mathematics evaluation report is a typical example of where the content got lost in the process.

At one professional development session held for teachers in February, two lead teachers facilitated a cooperative [learning] activity. The activity involved spatial awareness and at the same time modeled group participation strategies. The session involved building a three-dimensional object by considering four to six different viewpoints. Each member of the group was given a unique viewpoint of the structure and, in concert with other group members, the task was to build a final structure of wooden cubes that matched each viewpoint. A lead teacher asked the participants, "What mathematics is involved in this activity?" and teachers listed spatial relations, geometry, and directionality. The lead teacher then asked, "What are the implications of this for the classroom teachers?" and the discussion moved to essential classroom elements that promote learning. The discussion centered on group participation. The teachers focused on structuring cooperative group interactions and used the activity to demonstrate the value of collaboration. The discussion on content was minimized. We use this example to show how readily a discussion question on mathematical content can become simply a listing of topics without making further connections or a drawing out of participants' knowledge on any one of the topics listed.

This problem appears to be most pervasive in elementary science projects. For example, an evaluator reported that the teachers "did not appear fully engaged as learners with new science

content related to the curricular materials. Most of the discussion centered on where to purchase insects and what time of year was best to teach about silkworms and obtain the mulberry leaves."

When teachers expressed concerns about how the project dealt with teacher content knowledge, they were most likely to note that the content presented was not appropriate for the grade levels they taught, that they were already familiar with the content presented, or that the depth of treatment was inadequate to further their understanding.

> *Almost everything was at too high level-I had to come up with ideas on my own of how to modify the lessons for my kids to use.*
>
> * * *
>
> *I didn't really learn anything; I knew most of the stuff that was covered in the workshops.*
>
> * * *
>
> *Some things went too in depth over tedious things. Did not need to spend so much time on simple ideas.*

A few evaluators were extremely critical of the quality of the project's treatment of mathematics/science content. For example, the evaluator of one elementary science project noted that the module-specific sessions had very little focus on science content, and that the observed sessions that did focus on science content were not well designed. The conclusion: the project professional development sessions "have thus far contributed little to increase participants' knowledge of science content."

While most evaluators were more positive about the projects' approaches to deepening teacher content knowledge, evaluators frequently noted the need to be "more deliberate about the disciplinary content being taught" and the importance of balancing the learning of the "mechanics of the kits" with helping teachers understand the underlying conceptual framework. Said one evaluator of a K– 8 science project:

> *The primary focus of the structured-use workshops is in helping participants learn the "nuts and bolts" of the kits so that they can implement them (as designed) in their own classrooms. Nevertheless, it is important that these 15-hour workshops include the learning and understanding of key content ideas.*

Several evaluators suggested "going deeper" to give teachers a more comprehensive perspective, even if it meant sacrificing breadth in content coverage. For example:

> *Rather than surveying many mathematical content areas during content-related in-services, a more in-depth exploration of one big idea at each grade level (e.g., Kindergarten: Sorting and Classifying, First Grade: Patterns, Second Grade: Number Sense, third Grade: Area and Perimeter, Fourth Grade: Fractions, etc.)*

may be more effective. This practice might increase content area knowledge and build the capacity to facilitate conceptual understanding among students.

* * *

Teacher content knowledge remains an issue for the project. The teachers need enough knowledge to teach the content of the kit, but there is a developing awareness among the project staff of the need to have a deeper conceptual understanding. [The project needs to focus on] knowledge that allows connections to be made both to real-life situations and to the big themes that are inherent to science understanding in terms of scientific literacy.

Content Beyond the Student Materials

Some projects include more advanced content in order to deepen teacher understanding of the content addressed in the student materials. One project, for example, has teachers take a content-based mathematics course, in addition to workshops on student instructional materials.

Integrated Mathematics I is a 30-hour, credit-bearing course designed to build the mathematics content knowledge of teachers in such specific areas of mathematics as probability and statistics, number theory, and plane and transformational geometry. Unit-specific workshops are designed to build knowledge of curriculum, pedagogy, and assessment through a focus on specific units of study.

Another project involves teachers in learning science content through research using the Internet.

The facilitators possessed the subject knowledge and could have lectured the content information. However, the sessions were structured so that the participants learned through investigation and researched the content in reference books and on the Internet. Some teachers remarked to the observer that they didn't know that they could do research. They felt that they weren't scientists and thought that they required someone, perhaps a high school science teacher with a science degree, to tell them what to teach. They had come to the summer workshops expecting kit training or a lecture approach with some hands-on activity. At first, they were upset because the presenters weren't "giving" content. By the end of the week, teachers saw that they could learn science content on their own, without an expert to tell them what to teach. They also noticed that they understood the concepts when they researched, collaborated, and were given some structure for organizing their research and investigation.

An approach evaluators found particularly effective was to start with a focus on the "big picture," showing how key mathematics and science concepts were developed over time across modules/kits/units, followed by grade level explorations that continued the theme by looking at the development of concepts across activities within a unit.

Another approach deemed promising was to first provide an orientation to student materials, then have the teachers try them out in the classroom, and then focus professional development on the content issues that teachers encountered in the process. However, in some cases, the "follow-up" sessions were voluntary, which raised the question of whether all teachers are engaging with the content to a sufficient extent.

> *Content Modules in Electricity, Animals, Forces, and Motion, and Sinking and Floating were offered as advanced options. These workshops attract teachers who have used kits in their classrooms and who desire deeper understanding of the underlying science content.*

Several projects worked on deepening teacher content understanding in total or near total isolation from student instructional materials, either because the participating teachers were using a very wide variety of reform-oriented materials, or because the districts/schools/teachers had not yet decided which materials they will be using. In those cases, the evaluators tended to note that the content taught to teachers was "aligned with" or "linked to" national, state, and/or district standards, rather than saying they were tied to designated instructional materials. For example, one project that serves teachers in multiple districts offered fairly generic content-based professional development:

> *As many as 218 teachers signed up for the content class most appropriate to the grade level they teach: Chemistry and Matter for Upper Grades; Matter for Primary Grades; Sound; Electricity and Magnetism; Force and Motion for Upper Grades; or Balance, Force, and Motion for Primary Grades….Each class took field trips to see physical science in action. For example, the Sound class went to the [city] symphony, a music studio, and audiology and ultrasound labs. The Force and Motion class explored the mechanical advantage of simple machines on an historic ship docked [nearby].*

Evaluators in projects that did not use student instructional materials as the basis of professional development sometimes talked about the link by noting that the activities used to teach content to teachers could be used in K–12 classrooms, as well. The following example, from a project focused on grades 6–12 mathematics, was typical of projects where some or all of the districts/schools had not yet adopted reform instructional materials.

> *The mathematics is relevant to the middle school curriculum and it is presented in a way that portrays mathematics as inquiry. Most of the activities the teachers have worked on are appropriate for their participants' classroom situations, embody significant mathematics, and have been very engaging to the participants.*

At the same time, an evaluator of another secondary mathematics project pointed out that basing professional development on activities not tied to a particular set of materials was confusing to the teachers.

> *Unfortunately, some teachers were still not able to utilize these lessons and activities to their fullest and, in many cases, were not able to distinguish between*

the lessons developed to improve their mathematics backgrounds and those that they could take to their classrooms.

In a few instances, the activities used to develop teacher content knowledge were not at all related to the content of the designated instructional materials. Here the issue was not that teachers might be confused about whether to use the activities with their classes, but whether the activities were helpful to the teachers. In one elementary mathematics project, for example, the evaluator reported concern about "the activities not appropriately coinciding with subject matter by grade level." In another case, the evaluator of an elementary science project reported that the lecture series included in the summer activity was unrelated to the district curriculum, and as such, a luxury that a project with so many unprepared teachers cannot afford.

The lectures, even though most are engaging and provide worthwhile content, are disconnected from the district's curriculum. I do not believe that these particular lectures contribute much useful content knowledge for the teachers to use with the district curriculum.

Finally, in some projects the fact that the various districts are using different curricula has led to an almost total lack of emphasis on disciplinary content, as in these K–8 science projects:

Since there is no one curriculum, they have taken a general approach to have teachers become familiar with strategies and knowledge aligned with best practice. To this extent, most of the professional development is designed to help teachers reflect on instructional practices and curricular goals.

* * *

Most of the science knowledge provided by the project is in science process and inquiry with the hope that the teacher inquiry will support science content development.

Evaluator Ratings of the Quality of Treatment of Disciplinary Content

When they prepared their annual reports, evaluators considered the data they had from observations, interviews, and questionnaires and came up with an overall rating of the quality of the project's treatment of disciplinary content. As can be seen in Figure 19, only 56 percent of projects received high ratings in this area (4 or 5 on a five-point scale). There were large differences by subject and grade range, with 87 percent of 6–12 mathematics projects compared to only 39 percent of K–8 science projects receiving high ratings for disciplinary content.

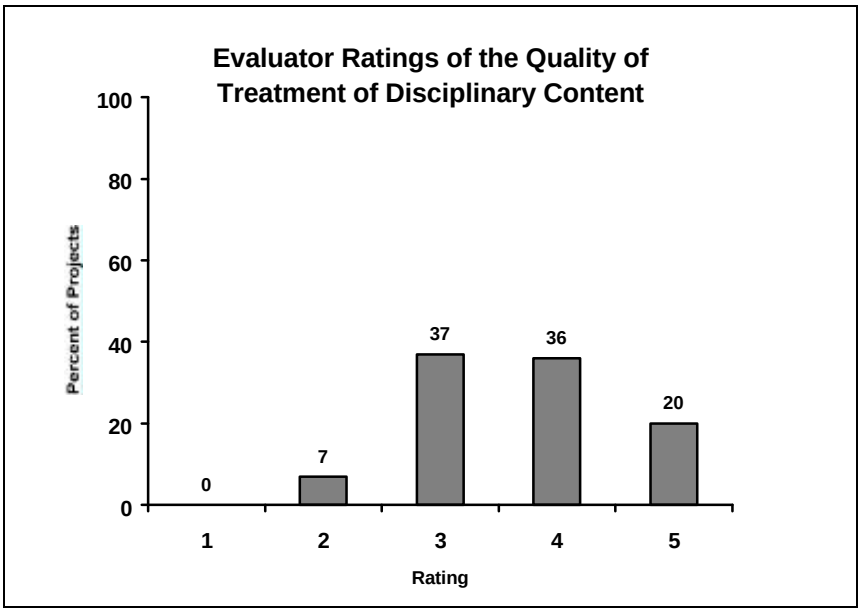


Figure 19

F. Preparing Teachers to Implement Exemplary Instructional Materials

The overriding goal of the LSC initiative is to improve the teaching of mathematics/science through the use of exemplary instructional materials in classrooms. All other project activities are intended to support that goal, whether they are aimed specifically at deepening teacher content knowledge, providing a mechanism for materials distribution and management, and/or ensuring that school and district policies and practices are aligned with the LSC vision of effective mathematics and science education. As noted earlier, with a few exceptions, the instructional materials intended for classroom use are the centerpiece of LSC projects' efforts. This section describes how the LSC projects are going about preparing teachers to implement these instructional materials in their classrooms.

In some projects, the initial proposal did not specify which instructional materials teachers would use, but rather listed several materials that individual districts, schools, or teachers might choose. This approach was sometimes chosen out of necessity. For example, when there were multiple districts involved, project staff might not have the authority to designate a particular set of materials across the entire project. In other cases, this approach was chosen as a matter of strategy in order to increase ownership in the materials that were eventually selected, as in this K–8 mathematics project:

> *One of the strengths of the project is that the elementary teachers are empowered to make the decision of what materials to adopt in this coming year. To that end, they have had some exposure to each of the three curricula the project is recommending.*

* * *

> *Program staff selected, designed, and implemented professional development activities for the [project] seminars to prepare and process the trial lessons from each of three reform curricula. Teachers had the opportunity to learn the lesson, teach it, reflect on it, share experiences and get feedback from colleagues teaching the same grade or teaching at another level, as well as from program staff who were knowledgeable about the curriculum materials, mathematics content, and pedagogy.…Teachers commented on the effectiveness of an adoption process that involved teachers in making the decision, and gave them the opportunity to try out a variety of curricula before making the final decision.*

Some projects involved teacher leaders in working with groups of teachers to identify the instructional materials to be used. The evaluator of a K–12 mathematics project explained the role that the "liaison teachers" played in the selection process as follows:

> *They gathered and analyzed curriculum preference data from teachers in their schools and facilitated a discussion of the data with teachers to come up with the school's first and second choice. The liaison teachers came together at the summer institute and selected the district's K–12 mathematics curricula (Trailblazers, MathScape, UCSMP).*

In some cases, evaluators expressed concern, or reported concerns of others, over the length of time the selection process was taking. While flexibility and responsiveness to teacher input were valued, the down side was that the process consumed time and resources that could otherwise be targeted toward increasing teacher knowledge and skills.

Working Through the Instructional Materials

Almost all of the LSC projects devote a considerable amount of professional development time to providing teachers with opportunities to explore the instructional materials they are expected to use in their classes. Typically, the teachers work on the student activities, discussing pedagogical as well as content issues, with facilitation by teacher leaders who have already used the materials in their classes, as described by the evaluator of this elementary science project:

> *In general, the module training workshops have usually provided participants opportunities to do some or all of the following: become familiar with the teachers' guide and the sequence of lessons; examine the materials; try out some of the activities; hear from workshop facilitators about their own classroom experiences with the module and/or see some of their students' work; consider instructional approaches—such as questioning skills and use of the four-stage learning cycle; examine assessments developed for the kit by the publishers; share ideas for extending activities and/or integrating them with other subject areas, most especially math and language arts; and make charts and other materials to prepare for classroom use.*

Similarly, the evaluator of a secondary mathematics project noted:

> *Since teachers themselves work with the IMP curriculum materials in the professional development sessions, they have the opportunity not only to become familiar with the materials but also to do so in the company of other mathematics teachers. They are able to note where the group encounters difficulty and can be prepared for similar situations in their own classes. In addition, facilitators alert teachers to pitfalls they have encountered in their own teaching. Thus, teachers have both their own experiences and those of the facilitator-teachers who have taught the curriculum previously to draw from when they prepare their own classes.*

In the typical pattern, teachers explored the materials during a summer workshop, tried them out in the classroom, and met periodically throughout the academic year to talk about implementation issues. Several projects tried to jumpstart the process by assigning teachers the task of teaching some of the learning experiences to their peers, a practice teachers found to be extremely valuable.

Projects have struggled mightily with time constraints; there simply is not enough time for all teachers to have in-depth experience with every activity in the instructional materials. Many projects addressed this issue by having some sessions to give participants an overview of the entire program and other grade-level sessions "specifically targeted at engaging participants with the kit they will use," a strategy that both facilitators and participants found effective.

A few projects took the approach of having teachers look through all of the materials, try out some activities, and ask questions of the professional development providers on hand. Evaluators at these sites, and sometimes the teachers themselves, suggested a need for more structure. For example, an evaluator of a secondary mathematics project reported:

> *In response to "How can we make this workshop more effective?" on the workshop evaluation, one participant wrote: "Actually have someone...teach the group through the lessons. It is very tedious to constantly motivate myself to continue through the material. We will go faster and learn more if someone leads us through the lessons as if we were the students!"*

Some teachers saw the workshops as an opportunity to prepare materials for their lessons, and were disappointed if they did not have time to do so.

> *I wanted to have time in the workshops to make the things we needed for the lessons we were going to teach so that they were ready to use the next day in the classroom.*

* * *

> *I think cluster area trainings where teachers make and take ideas, posters, etc would be good.*

In contrast, evaluators argued that projects need to "delve more deeply" into key issues related to implementation of the student materials.

> *Now that most of the introductory workshops and sessions that provide an overview of the project have been conducted for educators in the district, it is important for the [project] staff to design future workshops that encourage teachers to think more deeply about issues. This does not necessarily mean simply adding time into the agenda for reflection and small group discussion. [Project] staff need to narrow their focus and clearly identify the most pertinent goals for each session, designing workshops that incorporate opportunities for teachers to think about and discuss how the curricular materials can help them meet their science education goals for students—and not just how to manage the materials in their classrooms.*

Modeling Effective Pedagogy

One of the key strengths of many of the LSC projects, evaluators report, is the fact that they routinely model effective pedagogical practices. The following comments were typical:

> *Modeling of effective teaching was a strong component of all five professional development observations. Participants were not lectured regarding how to assess. Instead, they were actively engaged in hands-on activities centered around key issues of student assessment. After experiencing the hands-on activities, participants were given opportunities to discuss and reflect.*
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> * * *
>
> *As they did last year, [project] staff perceptively chose the right moment and precise forms of questions to ask (and/or in providing additional information) to help advance a participant's inquiry. The level of dialogue was exemplary, and provided a model for teachers to use in their own classrooms.*

Sometimes teachers were aware of the fact that the professional development was modeling effective practice, and were able to reflect independently on the implications for their teaching For example, an evaluator of a secondary mathematics project described how effective implementation of a particular workshop helped teachers increase their understanding of quality mathematics instruction.

> *As the participants worked in groups and shared their thoughts with the total group, the facilitator asked open-ended questions, probed for explanations and elaboration, and made sure everyone was participating in the discussion. It was a very good example of effective instruction that allowed the participants to cover a substantial amount of curriculum material, to observe exemplary questioning behaviors, and to get specific suggestions from the facilitator based on his experience with the curriculum. The participants recognized the quality of*

instruction that was being provided and openly commented about the techniques that the facilitator used.

An evaluator of a K–8 science project reported that even though a particular institute's primary focus was content, "teachers derived as much pedagogical enlightenment as science content knowledge" from the modeling of effective pedagogy, citing the following teacher's comments, among others:

> *I now know what key concepts are, and have some good ideas about how to make them comprehensible—first to me, and then to my students. Each time I hear the concepts I understand them a little better. Watching the teaching styles of our instructors was invaluable—their questioning of the learners showed me how to question my students.*

On occasion, LSC professional development providers did not model the strategies they were advocating teachers use. Said one teacher in response to a question about what was least helpful about the LSC: "Presenters who are supposed to be providing new/innovative techniques and they lecture us. They tell us how bad it is to lecture, then they lecture." Similarly, evaluators reported:

> *During this session, the facilitators did much of the talking, walking participants through lessons in the guidebook. Occasionally, participants were asked to try a particular lesson, but the specific content objectives were never mentioned, nor were teachers' understanding of the "science" in the investigation discussed. Rather, the focus of the workshop appeared to be on managing the materials and "getting through" the lessons.*
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> * * *
>
> *While [the speaker's] talk was an interesting comparison of standards and recent curriculum emphases, when combined with the 1½ days of county-sponsored speakers, participants were noticeably restive and resentful about being lectured to by "talking heads."*
>
> * * *
>
> *In the context of the teacher FOSS workshop, teacher-participants were not engaged in activities as learners for more than ten minutes, and were not asked to follow the hands-on experience with a discussion of the data and the building of ideas. The presenter said several times during the 2½-hour session that "there just isn't enough time" to give a good introduction to the ideas.*

The Need for Explicit Discussion of Pedagogy

In some cases, evaluators reported that simply modeling effective pedagogy was not sufficient to enable teachers to apply what they had learned. For example, an evaluator of a K–8 science

project reported that, despite the modeling in the professional development sessions, participants may not have deepened their pedagogical knowledge as much as the project expected.

> *While participants felt that they had a better handle on the needed strategies, not many were able to articulate what those strategies are beyond general descriptions—giving more hands-on time, doing before reading, letting students explore, etc. With the focus on doing the kit activities and discussing their procedural aspects, the specific strategies being modeled were seldom observed being discussed explicitly in the sessions.*

The optimal strategy, a number of evaluators suggested, was to model effective instructional strategies in professional development, and then to engage teachers in reflecting on these strategies and their classroom application.

> *After participants have experienced a unit as a learner, the project staff guides participants to reflect on the pedagogy that the staff modeled for them. These discussions are often very animated and the participants, upon reflection, seem to raise many issues that will be very relevant to their teaching of the unit in the future.*

When teachers expressed concerns about how the project dealt with pedagogical issues, they were most likely to talk about the fact that they had "heard it all before," and in some cases were already using the strategies, or that the project spent too much time covering the same territory over and over again.

> *[The least helpful aspect of the LSC was the] repetition. Our district has provided some of this and the teachers have had it before.*

* * *

> *It is sometimes boring to me. I've been teaching "this way" for years, so a lot of this is old hat to me.*

* * *

> *There were one or two in-services where I felt that the presenters belabored the point. I understood what they wanted to get across within the first hour or, at most, within a half day and I did not need to go over it again and again.*

At the same time, a number of teachers, especially secondary mathematics teachers, indicated a need for a greater focus on pedagogy.

> *Personally it did not give me what I needed to know. What I needed was help on doing portfolios, paper management, cooperative groups and help on the implementation rather than the math.*

* * *

In addition to becoming familiar with the curriculum, more time should have been spent on methods for teaching it.

Achieving Balance between Content and Pedagogy

Some projects have separate sessions for content, pedagogy, and exploration of instructional materials, but create opportunities for forging linkages among them. For example, the evaluator of an elementary science project reported that:

References to kits and other curriculum materials are often woven into professional development sessions that focus on content or pedagogy.

Other projects attempt to integrate the study of content and pedagogy within the context of the designated instructional materials.

Each of the sessions [was] carefully designed and presented to give the teachers both an introduction to the science kits and the underlying scientific principles contained in each. The purpose of teaming the lead teacher trainers with science subject matter experts was so that questions relating to both the pedagogy and content of the kits could be addressed. There were both large group and individual discussions between participating teachers and the subject matter experts when such content questions were posed.

* * *

The professional development culture emphasizes an integration of pedagogy and disciplinary content. Based on the experience they had in the previous year, the project made a commitment to do more to help teachers with both pedagogy and content – and to integrate those two strands as much as possible. This year's summer institute offered sessions facilitated by both science resource teachers and scientists, combining pedagogy, kits and content. This is an improvement over last year's schedule which had science resource teachers facilitating pedagogy and kits sessions in the morning and scientists teaching separate content courses in the afternoon. It is to the project's credit that they are ambitious enough to try and combine the learning of kits, a general pedagogical framework (the learning cycle), and science content all into a single fabric.

* * *

A third point is the integration of issues of pedagogy, content and assessment using the IMP curriculum as the site for explorations in these areas. Maintaining close ties to the curriculum helps keep the investigation of these issues close to actual implementation in the classroom.

As noted earlier, projects that "fell off the balance beam" typically did so by overemphasizing the "nuts and bolts" of implementing the kits. On occasion, however, evaluators reported that "working through the kits was overshadowed by focusing on content."

> *We are certainly sympathetic to the ambitious goal of empowering teachers to teach science well, beyond the dependence on a particular kit. And while we understand the danger of facilitators simply leading teacher participants step-by-step through the kits, our sense is that the kits could still play a more decisive and concrete role in the professional development training of teachers at the early stages of the reform process. Teachers need to know the kits well and to see successful modeling of their use in the classroom. Otherwise, there is a danger of teachers not even teaching the kits, either because of a lack of concrete knowledge about the materials or a lack of confidence in them.*

One evaluator summed up her recommendations for "module training" sessions by noting that the design needs to incorporate a number of key components:

1. *Clearly identify the objectives for the module: What big ideas, what scientific processes are central for students to explore and understand? What do participating teachers currently know about these concepts/processes? What is important for them to find out? How can the training sessions/project follow-up, provide support?*
2. *Select module investigations that teachers can plan, set up, carry out, and discuss as "adult" learners.*
3. *Model teaching behaviors classroom teachers are expected to incorporate and have participants reflect on their experiences, both as learners during the sessions and as teachers of young children.*
4. *Set aside sufficient time for teachers to discuss how they can assess students' learning; provide one or more assessment tools for classroom use; examine, score, and discuss student work on such assessments and/or assessments of teachers' own work during the training.*

Increased Focus on Assessing Student Understanding

Evaluators report that projects have increased their focus on understanding student thinking and assessing student learning, and are using student work as the basis of professional development more often than in the past. A number of evaluators in both mathematics and science projects reported that the projects "put more emphasis on assessment this past year" or even that "the major theme of training for the year was student assessment."

Evaluators of mathematics projects were most likely to talk about this area as helping teachers "get inside students' heads" and understand how students think about key concepts, while evaluators of science projects were more likely to talk about professional development on the uses of "performance-based" or "authentic" assessment. In some cases, assessment was considered in the context of student learning of specific content, with teachers involved in examining student work, developing assessment criteria, and creating rubrics for grading. As described by the evaluator of a project that addresses both science and mathematics:

The Science Embedded Assessment System (SEAS) and the school-wide mathematics portfolios developed at Year Three mathematics schools provide a means for professional development to impact student assessment. Both practices focused on the baseline curriculum (FOSS/MathLand) and provided ample opportunities for teachers to examine student work and develop rubrics.

Similarly, an evaluator of an elementary science initiative reported that project staff focused on assessment during the year, working with teachers to review and score students' work on performance-based assessments that were designed to accompany their modules.

Attending to assessment helped teachers gain an understanding of the goals of the instructional materials, as the following teacher in an elementary science project explained:

Only now that we're on assessment has it become clear what the objectives are.

Other projects addressed assessment more broadly. For example, teachers in one K–8 science project explored the use of performance tasks, discussed each of them, and related them to a more general discussion of assessment.

Participants built a rocket out of a film canister, water, Alka-Seltzer, construction paper, and tape. They then graphed the results of launching the rocket several times. Facilitators distributed two versions of the experiment to participants without their awareness: one version contained minimal information in the prompts (e.g., Was your prediction correct?), the other version requested more detailed information (e.g., Explain why, using evidence from your investigation). Participants were given time to use the [project's] scoring rubrics to assess their own products.…There was also some discussion of how teachers would score the activities for their own classroom use, and a comparison of the teachers' criteria with the scoring system used for [state assessment].

The evaluator of another elementary science project described how the project phased in consideration of student assessment in the overall professional development sequence, and included an example of how exploration of a specific assessment task led to a broader discussion of assessment issues:

The first and second years of training focused on the kits themselves and on the content and pedagogical issues surrounding their use. Assessment questions were left to be addressed during the training offered in the 1997–1998 school year. As the 1997–1998 in-service days approached, there is little doubt that some teachers expected to be handed "tests" for each kit which they could use without much thought on their part. The LSC staff wisely avoided this simplistic approach. Instead, they provided teachers hands-on experiences in assessment. They involved teachers in the discussion and application of these experiences to classroom practice in order to develop a broad base of understanding of the complex issues underlying student assessment.

Even though the evaluation reports provided evidence of an increased focus on student assessment in a number of projects, more professional development related to assessment was one of the most frequently cited areas when teachers were asked about additional help needed. The following comments were typical:

> *Assessment is always the last thing talked about and they ran out of time [at the summer institute]. I would like a hands-on assessment for each kit.*
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> * * *
>
> *Evaluation--ways to evaluate the children, not just at the end of the unit, but step by step.*
>
> * * *
>
> *Ways to grade…how much to let the grade be truly from the individual and how much from the cooperative effort.*

The Role of Inquiry in Science Learning

Scientific inquiry is central to the National Science Education Standards, but there is not yet agreement on the defining characteristics of such inquiry. Evaluation reports provided evidence of this lack of consensus about the meaning of inquiry—among teachers, among project staff, and among project evaluators. Said one evaluator:

> *This project, like many others, has more work to do in helping teachers understand, envision, and teach "inquiry-based science." At times, the term "inquiry" is used in a haphazard way—largely equating it to the notion of "hands-on" instruction.*

One evaluator seemed to define inquiry as "allowing students to design and carry out their own investigations," expressing concern that "teachers are implementing the FOSS units in a fairly lock-step fashion," and suggesting that the project develop "an inquiry strand for teachers that want to go beyond implementing the FOSS units."

Some projects have worked diligently to foster a shared understanding of inquiry-based learning among project staff, including sending teacher leaders to the Exploratorium's Inquiry Institute. The evaluator of one such project shared an excerpt from a teacher leader's description of inquiry learning to a group of teachers in a professional development session as evidence of this deepened understanding.

> *Well, all of you probably know what inquiry is, but now the question is, how do we do this in a classroom?…Doing hands-on does not guarantee inquiry; inquiry means planning, review, analyze, interpret, and communication of results. This [inquiry model] addresses children who learn in all different aspects and modalities—new knowledge that stimulates new questions.*

In some cases, however, even when there is agreement in principle on what constitutes good inquiry, the lack of appropriate modeling in the professional development may have interfered with teachers' understanding of inquiry-based instruction. For example:

> *The teachers seem to understand that the expectations of the project are to introduce science curriculum materials through an inquiry approach in the classroom....but there may be issues interpreting what an inquiry approach looks like in the classroom. The professional development activities observed, on occasion, directed teachers through the activities. An inquiry approach was not always actively modeled.*
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> * * *
>
> *What the sessions lacked, however, was a consistent thread of what a good inquiry-based classroom would look like. Some facilitators were adept in modeling good inquiry. Other facilitators crammed a lot of information into rather short time spans, and tried to cover everything. As a result, participants in these sessions did not get the opportunity to reflect, discuss, question, or see first hand how to apply more effective pedagogy in their own classrooms.*

Moreover, even when the professional development provided a good model of learning through inquiry, teachers need to have images of what this process looks like in actual classrooms. For example, an evaluator of a K–8 science project reported:

> *During our visits to this summer's workshops, we repeatedly heard questions like: "How would we do this if we are teaching for understanding?"…At present, there is a lot of discussion, but teachers do not have access to visual examples of good teaching.*

As one evaluator suggested:

> *It might be useful for the project to identify good models of effective "inquiry-based" instruction to share with teachers. From emerging lead teachers to national consultants, we would recommend looking inside and outside the district for real classroom examples that illustrate the district's vision for high-quality science teaching. Such examples can be found in videos, or in the classrooms of local lead teachers.…We would encourage the project to continue to find and use real classrooms as a focus of at least some of the professional development work that is done.*

Adding to, Revising, or Not Using "Designated" Materials

The intent of the LSC program is that teachers will use the designated materials as the basis of their instruction. Individual teachers may structure or pace a lesson somewhat differently, based both on their teaching styles and the needs of their particular students, but the expectation is that they will use the instructional materials as designed.

While the vast majority of LSC projects, in fact, focus on implementing existing, exemplary materials, in several projects teachers are expected to develop their own instructional materials. For example, one elementary science project has involved teachers in developing lessons "requiring multiple modes of instruction to address the learning styles of all students in their classes." The evaluator in this project reported teachers' comments about "the time it was taking them to develop a unit on one topic" and "concerns about being able to take the time to do the same thing for their other units." In an elementary mathematics project, the district has decided to delay purchasing instructional materials for a year. The evaluator reports that "therefore, teachers trying to change their teaching are spending an inordinate amount of time devising lessons." Similarly, a teacher in another elementary mathematics project lamented that she has not "had time to develop any [units] of [my] own."

However, even if time were available, quality would be a concern since many teachers do not have the in-depth content knowledge necessary to develop high-quality materials. The evaluator of an elementary science project expressed concern about the varied quality of the teacher-developed materials. "The flaw here is that teachers wrote the materials versus adopting professionally developed units." Similarly, the evaluator of a secondary mathematics project reported that "the quality of the inquiry units developed by the teachers needs attention."

> *There does not seem to be a mechanism built into the project, that allows school facilitators to constructively critique and provide feedback to teachers as they implement units they have constructed themselves. The difference in quality, in both the mathematics content and pedagogy, of teacher made units is apparent upon classroom visitation. While it is commendable that teachers feel motivated to design their own units and implement those units, somehow the community of teachers needs to take the next step and work together to critique and revise the units.*

In a few cases, project evaluators described circumstances that they considered appropriate, but nevertheless seemed inconsistent with the underlying tenets of the LSC program. For example, the evaluator of a K–8 science project described "an innovative revision to the curriculum [that] was put in place at the request of, and in collaboration with, the teachers involved in the LSC project."

> *A new series of units called "Discovering Patterns in Science" has been developed. These units provide ways for teachers to engage students in finding and understanding patterns in science that are revealed by studying a particular topic throughout the school year. For each grade, "Patterns" activities have been devised that relate to the core curriculum units for that grade. For example, in fourth grade, pattern activities include: (1) collecting weather data to forecast the weather and (2) ecology-related studies about food chains and food webs, energy movement in the system, and plant life cycles.*

Similarly, the evaluator of a K–8 mathematics project explained:

> *[The project] does not necessarily use curriculum materials teachers are expected to use in their classrooms. Indeed, one of the main premises of [the project] is that it is* not *a training vehicle for the newly adopted curriculum series, nor a set of make-and-take activities. Rather, it sees itself as a two year overall professional development program which raises both the mathematical competencies of teachers and their pedagogical skills. The materials used in the sessions are vehicles for teaching content and pedagogy. However, teachers can use the [project] lessons and materials if they happen to fit in with what they are currently teaching, and the topics roughly follow the sequence of the adopted textbook series.*

Finally, one evaluator, apparently unaware of NSF's purposes for the LSC initiative, declared emphatically that the project "is not a curriculum-based project and ensuring that teachers implement curriculum is not its responsibility."

Evaluator Ratings

In addition to describing the quality of the project's treatment of pedagogical content, the lead evaluator was asked to provide an overall rating in this area. As can be seen in Figure 20, 70 percent of projects received ratings of 4 or 5 in this area.

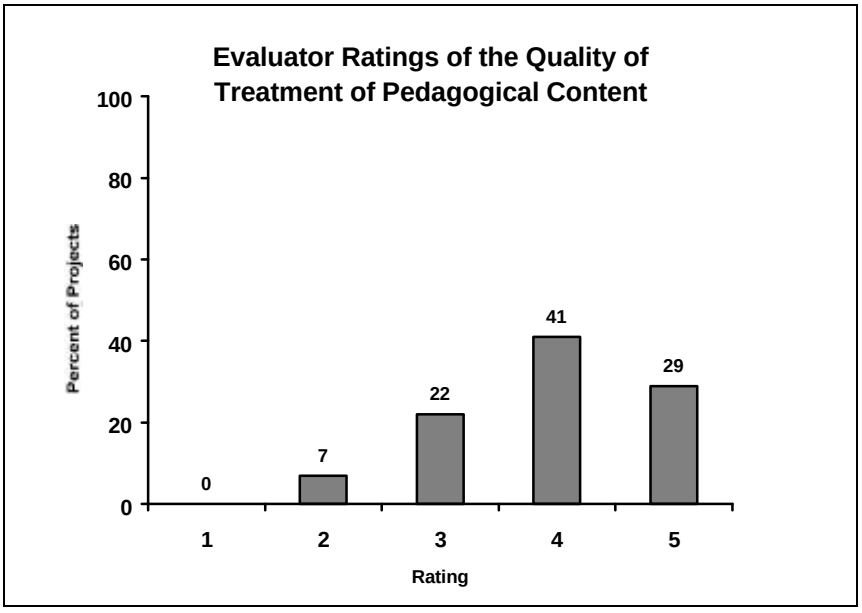

Figure 20

G. Support for Teachers as They Implement the Instructional Materials

One of the characteristics that distinguishes LSC programs from traditional professional development offerings is their year-round structure. In addition to providing intensive professional development in the summer when teachers can devote full time to these activities for one or more weeks, LSC projects typically provide professional development activities during the academic year. Across the projects, these activities include project-wide workshops; school-based workshops and study groups; demonstration lessons; and mentoring/peer coaching. A typical project incorporates several of these approaches, providing ongoing support for teachers as they implement the instructional materials in their classrooms.

Combination of Project-Wide and School-Based Activities

Many LSC projects interweave project-wide professional development workshops with activities that occur at the individual school sites. One evaluator described the multiple strategies a K–8 science project had devised to support teachers as follows:

> *First there is the summer academy, that groups teachers into lower and upper grades. Teachers have commented on how this structure allows them to make connections with teachers in other grades and from other schools that they can ask for support during the year. Second, there is a "mini-institute" during the year for teachers at each grade-level to come together with a scientist and discuss the content in specific kits and further build teacher networks. The LSC and district also support teacher networking by restructuring the school days to allow teachers to meet in the afternoons once a week—once a month these afternoon meetings focus on science. These meetings generally involve those teachers that have been involved in the summer academies and other teachers interested in teaching science more effectively.*

The evaluator of a secondary mathematics project noted the advantages of providing ongoing professional development:

> *The project's design for professional development which includes professional development days scattered throughout the year as well as during the summer is a strength. Teachers report that the opportunity to network and talk with each other during the year at the professional development sessions is very helpful.*

Similarly, the evaluator of a newly-initiated mathematics project noted that the project will incorporate a number of mechanisms for providing support for teachers throughout the implementation process, including project-wide academic-year meetings, and activities at individual schools.

> *The project design includes four follow-up meetings during the academic year where project directors and experienced [project] teachers can respond to problems in a whole group setting. The participants will also be able to share ideas and implementation stories with their peers. The project directors have also encouraged teachers to use mentoring, peer observations, and networking as*

support mechanisms to help them with implementation issues that arise more frequently during the year.

Several projects are using school-level achievement data as a vehicle for conversations about improving instruction. For example, one evaluator reported that an elementary mathematics project gave participating teachers an "articulation assignment" to ensure that they would "discuss what they are doing with other teachers at their school, thus encouraging more of a mathematics professional climate for the school." The assignment was to analyze the school's Stanford 9 test score data by grade level and write an action plan on how the grade level will address raising test scores.

Other projects have supplemented their workshops by creating opportunities for teachers to visit other classrooms in the participating districts "to develop deeper understanding of constructivist approaches and effective teaching strategies," or have arranged for teachers to observe the implementation of exemplary materials in classrooms in other districts.

Some projects are experimenting with study groups, where small groups of teachers meet on a regular basis. In one project, for example, "several schools have grade levels that have made a commitment to teach the same kit at the same time this coming year, so that they can collaborate and share the challenges and successes of using the kit." Another evaluator reports that the project has initiated an action research component to "help teachers to pursue their individual interests," but noted that "participants are still a bit fuzzy about what they are to do" and that the efforts have not yet fulfilled expectations.

In general, both project-wide and school-based activities during the academic year seem to be important sources of support for teachers, providing opportunities for them to share with one another and learn about effective implementation from more experienced users. Interviews with participating teachers made it clear how much teachers value these interchanges. The following comments were typical of many:

Getting advice from other teachers who have already used the instructional materials is always the most useful part of any training. It is the most practical and it is tailored to what is real in terms of the time, space, and children.

* * *

It was wonderful to find out that you were not the only teacher having a certain dilemma. All of us were experiencing the same problem of how can our students communicate their reflections or findings in science with such poor literacy skills. The suggestions from other people in our group were so valuable.

An evaluator summarized his description of the quality of an LSC project's professional development by noting that:

The combination of workshops with ongoing classroom assistance remains a powerful aspect of the project. The separate workshop offerings that address

science content, inquiry learning, use of the kits, and leadership development provide a comprehensive approach to professional development. The level of onsite technical assistance provided by the science specialists is a rare occurrence in education today that holds great potential for significant improvement in the way teaching and learning are carried out in these districts.

Use of Teacher Leaders for Ongoing Support

LSC projects typically involve one or more kinds of "teacher leaders" in their professional development activities. Variously called lead teachers, mentors, resource teachers, instructional specialists, teachers-in-residence, or teachers on special assignment, they often provide ongoing support to teachers as they implement the instructional materials in their classes.

The summer 1997 workshop participants who were using an NSF curriculum for the first time were assigned a teacher mentor to support them individually during the year; e.g., classroom observations, review of lesson materials, discussions of instructional strategies.

* * *

Each school has a school facilitator who supports participants' implementation of inquiry units, supports study groups preparing to teach new units, debriefs with teachers in the midst of new units, keeps the administration involved in and knowledgeable about project activities, supports the professional development of the lead teachers, participates in school mathematics initiatives and serves as a consultant as needed. These individuals have allowed the LSC to have a continuous and obvious presence in each of the schools.

Evaluators report that many LSC projects are using peer coaching and demonstration teaching approaches, and that these appear to be working quite well. Typically, a teacher leader works with individual teachers who request the assistance. Sometimes the teacher leader teaches part or all of a lesson, "thus providing a real model for the teacher in his/her own classroom." For example, an evaluator described how an elementary science project used teacher leaders to help teachers become comfortable with the instructional materials.

The strengths of the resource teachers included the one-on-one support they could provide, including in some cases actually teaching a lesson that the target teacher could observe or assist with, then teaching alongside them in a team situation until the target teacher felt confident enough about the content and lesson to proceed on his or her own.

At other times, the teacher leader observed a lesson, in some instances capturing it on videotape, and followed up with one-on-one discussion of the lesson. In interviews, teachers often raved about the utility of the coaching sessions. The following comments were typical:

This [peer coaching] was an outstanding component. The conferences and coaching nurtured my teaching ability in all levels, from management to lesson focus.

* * *

[There were] a few times when I would have normally dropped a lesson had someone not been coming into my classroom. For some reason whenever I get peer coached it is not my best lesson. It is something I'd rather not have them see. It's like couldn't they have come in yesterday! But what has been great about that [peer coaching] is that we have had time to brainstorm ideas and I have gone back and tried them. And Wow! Yeah! This is what needs to happen and it has helped bring me along.

In other cases, evaluators cited evidence provided by the teacher leaders themselves about the effectiveness of their coaching, as in the following quote by a teacher leader from a K–8 science project:

As an example, there's a teacher in one of my schools who was convinced she could not use the kits because it meant having her students work in cooperative groups. I offered to model the kit, went into the classroom and got the students divided up and spoke about working together in pairs, started on the activity, and it went very smoothly, and she was surprised. Later in the day the same students were having some problems with some things, she decided to try pairing them up again and they were so involved from working in pairs that the discipline and management problems she was experiencing were kind of disappearing, so I think I've already made an impact.

Examples such as these led various evaluators to conclude that "the in-class professional development has proved to be very effective," "the validity and usefulness of in-class support has proven extremely important," even "essential for the success of the LSC project."

Ongoing Support from Scientists and Mathematicians

Recognizing that content questions would arise during the course of implementation, and that teacher leaders would not always be a sufficient resource in this area, quite a few LSC projects have set up mechanisms for teachers to continue communication with content experts during the academic year. For example, some projects have sessions during the year "for teachers at each grade level to come together with a scientist and discuss the content in specific kits." Other projects have set up listservs, or paired teachers with "e-mail scientists," or established "Ask an Expert" help-desks in an effort to increase the accessibility of content experts. Finally, some projects have arranged for scientists/mathematicians to provide assistance in classrooms, including one elementary science project that has "a unique feature of offering continued support via college student partnerships. The participating colleges provide college students as partners to teachers."

Whether the support was provided by science undergraduates or Ph.D. scientists, as long as it was relevant and accessible, teachers appreciated the help. The following teacher's comment was typical:

> *The scientist in my classroom was very helpful. She not only played the role of information resource person for the teacher, but also took the role of a teacher's aide during the activities and fieldtrips. Further, she brought in extra materials and teaching equipment from [the university] which gave a great impact on my teaching the unit.*

Materials Needed for Instruction

Assembling all of the materials needed for instruction can be quite a challenge to teachers. LSC teachers were delighted when the project made sure that they received all of the materials they needed when they needed them. When asked about the "most helpful" aspects of the LSC, many teachers talked about getting the materials they need for instruction.

> *Science is now fun because I open this plastic box and its all there. I don't have to go shopping over the weekend or dig through my cupboards because it's all complete.*
>
> * * *
>
> *They've really gotten to the heart of the teacher with the kits because everything is there for you. That's one of the things that discourages you from doing the hands-on activities, is that it takes so long to get all that stuff together, and you want to do it, but it's just the idea of time and when you have it right there, you do it because it's all there for you, the lesson plans and supplies and everything are there, so you do it.*
>
> * * *
>
> *We got $10,000 worth of manipulatives; ten tubs of this stuff….[It] was like a God-send. We've got brand new teachers in our school and they get these ten tubs and they go, "What am I going to do with it?" And, I'm going, "You're so lucky! It took me 17 years to collect my own manipulatives. I had to beg, steal, borrow and do workshops to get my own manipulatives and now, you just get it handed to you!"*

Teachers were correspondingly annoyed when projects were not able to keep them well supplied with the necessary materials, frequently citing the logistics involved with materials management as the "least helpful" aspect of the LSC. Problems included missing materials, insufficient materials for the number of students in the class, issues involved in scheduling the kits, and in keeping organisms alive.

> *[The least helpful aspect of the LSC is] the inflexibility of the order and duration of kits in schools. [It's] a problem because of trying to correlate with others on*

grade level and other subjects too. For example, I received the weather kit during the dead of winter, and so being able to go outdoors to do activities was not always feasible.

* * *

When we get the modules, tadpoles are dead. [It would be more effective] to purchase them ourselves or order them ourselves. We have a hard time, snails were rotten due to a snow day. The worst module I've had is the live animals. It's difficult to keep them alive.

Concerns about the Adequacy of Support for Teachers During Implementation

While a number of evaluators described successful support mechanisms, others expressed concerns about the level of support teachers received for classroom implementation of the LSC reforms. In some cases, the concern had to do with poor attendance at follow-up sessions and the likelihood that some of the teachers who needed help the most were not getting it. In other cases, there were concerns about the quality of the school-based professional development activities. For example, after describing how the LSC project "is providing ongoing support in a variety of formal and informal ways," an evaluator noted that the project "needs to focus on making the school-site gatherings more productive." Another evaluator noted that teacher leaders' demonstration lessons were sometimes inappropriate, giving the example of a kindergarten lesson that talked about norms and means. Similarly, several evaluators cautioned that scientists and mathematicians might have difficulty providing content help at an appropriate level for the target audience. For example:

Using the project mentors and content specialists as responders to posted questions will help to make up for their limited availability to be in the school to interact with teachers. However, the project may need to monitor their responses (perhaps editing them at first) to ensure appropriateness of the content level for elementary schools.

More often, the issue was not the quality of the support, but simply the need for more support. In fact, more follow-up support was the most frequent response to a teacher interview question about additional assistance needed. Many teachers asked for opportunities to talk with other teachers, observe other teachers, have another teacher come into their class and provide coaching, or simply to have another adult to help out in the classroom.

More time to meet with other teachers would be nice. I would love to observe other teachers to see how they are meeting student needs and supplementing the core curriculum.

* * *

I need to be able to go to the lead teacher in the school for help and to answer questions.

At the same time, resources are limited, and it is difficult to envision how some of the more intensive support activities can be scaled up to reach all of the targeted teachers, no less sustained after the LSC funding period. In one case, for example, the evaluator reports that the project director "visits each participating teacher to observe and critique a lesson." Evaluators note that "such one-on-one support is very time consuming," and that the PIs "recognize that this level of support cannot continue indefinitely without additional project personnel."

Evaluator Ratings of Support for Teachers During Implementation

Based on interview, observation, and questionnaire data, evaluators provided an overall rating of the quality of the follow-up support provided to teachers as they implemented the instructional materials in their classrooms. As can be seen in Figure 21, overall, 70 percent of projects received high ratings in this area, and none received a rating below 3 on a five-point scale.

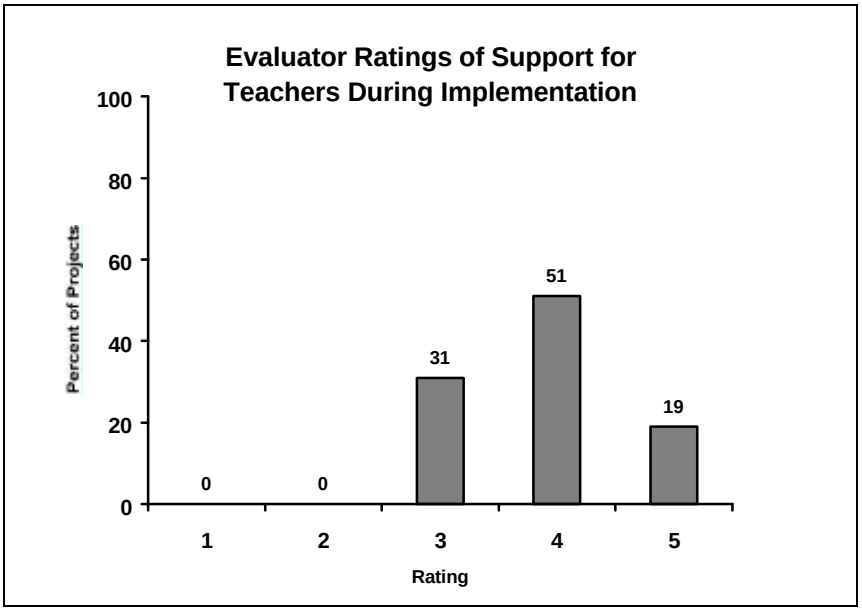

Figure 21

H. Evaluator Ratings of the Quality of LSC Professional Development Programs

At the close of the data collection year, evaluators were asked to use all of the information available to them to place the project on a continuum, from predominance of ineffective professional development, through various stages of improvement, to a system of predominantly well-designed professional development. As can be seen in Table 5, more than half of the LSC professional development programs in each subject were rated at "Level 4: Emerging Infrastructure of Well-Designed Professional Development," with another one-fifth considered to have a predominance of well-designed professional development. Ratings for K–8 science projects were significantly lower than those for either K–8 or 6–12 mathematics projects.

Table 5
Continuum Ratings for Quality of LSC Professional Development

	Percent of Projects*			
	All Projects	**K–8 Science**	**K–8 Mathematics**	**6–12 Mathematics**
Level 1: Predominance of Ineffective Professional Development	0	0	0	0
Level 2: Exploring Quality Professional Development	2	3	0	0
Level 3: Transitioning to Quality Professional Development	19	29	0	0
Level 4: Emerging Infrastructure of Well-Designed Professional Development	59	56	75	53
Level 5: Predominance of Well-Designed Professional Development	22	12	25	47
Mean Continuum Rating Level	4.0	3.8	4.3	4.5

* Projects that address two subject areas are included in each subject, but counted only once in the total of all projects.

I. Teacher Perceptions of the Overall Quality of LSC Professional Development Programs

As part of the core evaluation, each year a sample of teachers is asked about the overall quality of the LSC professional development. In the spring of 1998, 452 teachers who had participated in 20 hours or more of LSC professional development were interviewed by project evaluators. In addition, 7,091 teachers who had participated in LSC professional development answered questions about the quality of those experiences.

Teachers who indicated they had participated in LSC professional development were asked to respond to a series of statements about those experiences. Overall, nearly a third indicated that they are given considerable time to work with other teachers (4 or 5 on a five-point scale ranging from 1 "not at all" to 5 "to a great extent"), and that they are given extensive time to reflect on how to apply what they are learning to their classrooms, and nearly half that they receive considerable support for implementation.

It is interesting to note that the LSC has incorporated these features to a greater extent than did previous science and mathematics professional development offerings in these districts. In their baseline year (1996) Cohort 2 participants were asked to describe mathematics/science professional development in their districts, and in 1997 and 1998 they were asked the same questions about LSC professional development. As can be seen in Figure 22, there is a large difference in support for implementation, with more than twice as many teachers reporting that they received considerable support as part of the LSC compared to professional development prior to the LSC.

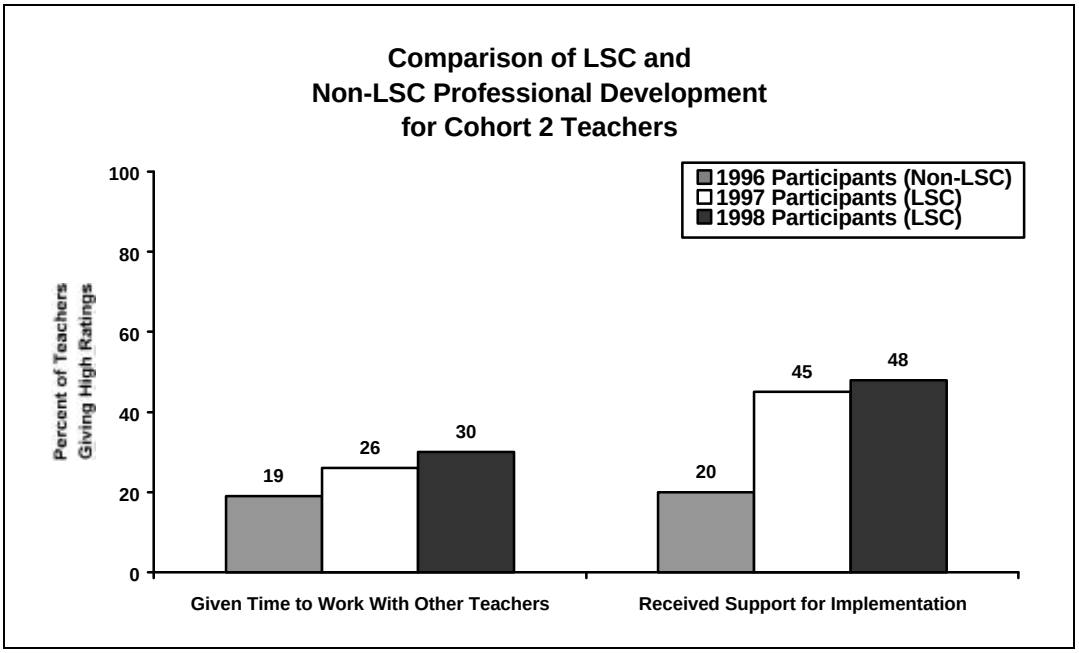

Figure 22

Table 6 shows teacher ratings of LSC professional development programs overall, with 5 percent of teachers rating the professional development "poor" or "very poor," 49 percent "fair" or "good," and 46 percent "very good" or "excellent."

Table 6
Teacher Ratings of LSC Professional Development Programs Overall

	Percent of Teachers					
	Very Poor	**Poor**	**Fair**	**Good**	**Very Good**	**Excellent**
K–8 Science	1	3	16	31	33	16
K–8 Mathematics	2	6	22	32	27	11
6–12 Mathematics	2	5	18	30	32	13
All Teachers	1	4	18	31	31	15

Figure 23 shows the percent of teachers in each subject and grade range who rated LSC professional development "very good" or "excellent," analyzed by level of treatment. Note that the greater the level of participation, the higher the ratings. Similarly, Figure 24 shows the results on a composite variable on quality of the LSC professional development created from teachers' responses to several items on the 1998 questionnaire. Again, the more hours of participation in LSC professional development, the higher the ratings of quality.

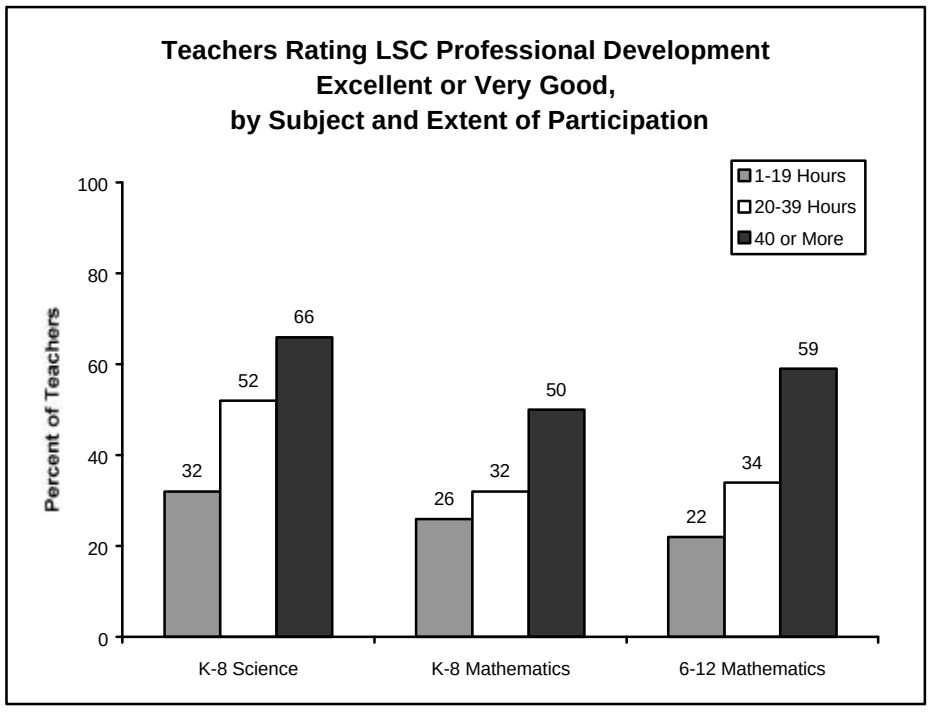

Figure 23

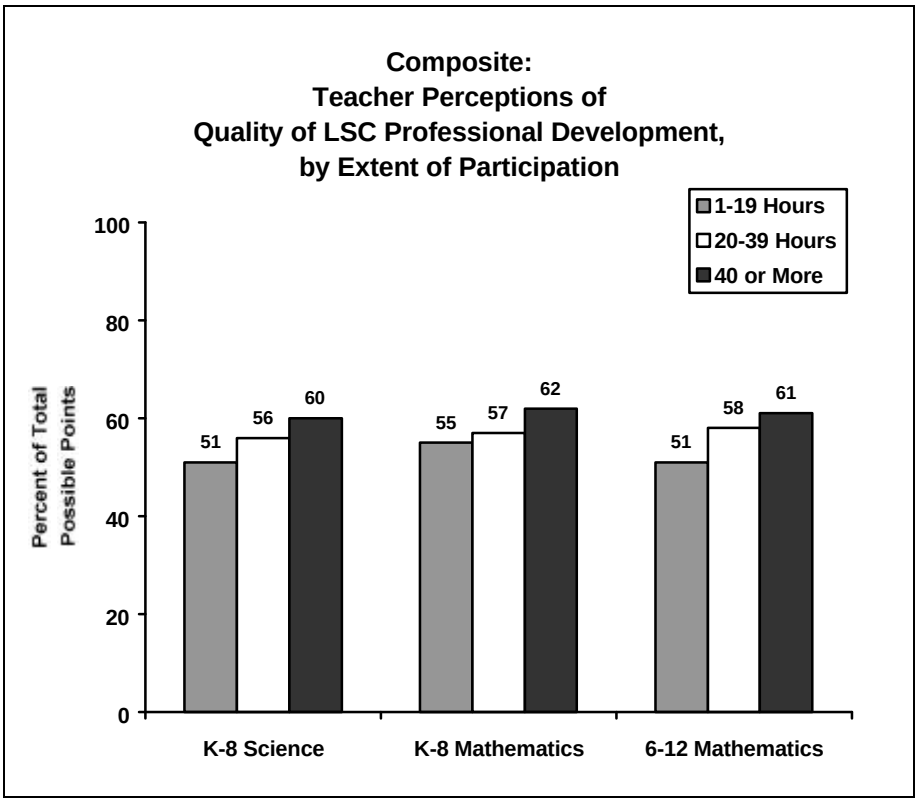

Figure 24

Teacher interviews yielded a similar finding. Evaluators asked a random sample of teachers who had participated in the LSC professional development for at least 20 hours to talk about their experiences in the program and used these responses to characterize each teacher's opinions on a five-point scale from very negative to very positive. Overall, 60 percent of teachers who had participated in 10 or more days of LSC professional development had highly positive opinions of the LSC program, compared to 49 percent of those with lower levels of participation.

Teachers were asked specifically about both the most helpful and least helpful aspects of their LSC program. In the *most helpful* category, teachers were most likely to cite:

1. ***Collaborating with other teachers***, including learning what teachers in other grades and schools are doing in their classrooms, and getting advice from teachers who have already used the instructional materials.

2. ***Learning about the instructional materials*** they will be using in class, especially having direct experience to build familiarity with the materials.

3. ***Getting the hands-on materials needed for instruction.***

4. ***Having the opportunity to deepen their content knowledge***.

In the *least helpful* category, teachers were most likely to cite:

1. ***Inadequacies in how some projects dealt with pedagogy***, including too narrow a scope of strategies presented, too much repetition, and too little focus on assessment.

2. ***The time commitment required to participate*** in professional development, including concerns about the amount of time they needed to be out of the classroom, and the difficulty involved in attending sessions after a full day of teaching.

3. ***Inadequacies in how some projects dealt with mathematics/science disciplinary content*** including cases where the content presented was not appropriate for the grade or subjects they teach; the teachers were already familiar with the content and found the professional development repetitive; or the content was not presented well.

4. ***Inadequacies in support provided*** by some projects during implementation, including problems with materials distribution and resupply, and limited access to teacher leaders.[6]

When asked about the kinds of *additional help* they needed in order to implement what they had learned in their LSC professional development, teachers cited a few key areas:

1. ***More support during implementation,*** including more contact with project staff and teacher leaders, as well as opportunities for demonstration lessons/coaching in their own classrooms.

2. ***Easier access to instructional materials***, including additional sets of materials; more reliable replacement of consumables; and more flexibility in when they received the kits and how long they could keep them.

3. ***More professional development in pedagogy,*** especially in using a variety of assessment approaches.

4. ***More time for planning instruction,*** both individually and with other teachers in their school.

5. ***More opportunities for sharing*** with other teachers in the project.

[6] Even though teacher questionnaire results indicated a greater overall level of support for implementation as part of the LSC than in previous professional development, and evaluators generally gave high marks to the extent of the support in the LSC, teachers in some projects expressed dissatisfaction with the level of support they received.