CHAPTER THREE

Science and Mathematics Professional Development

Overview

Science and mathematics teachers, like all professionals, need opportunities to keep up with advances in their field, including both disciplinary content and how to help their students learn important science/mathematics content. Staying up-to-date is particularly challenging for teachers at the elementary level, as they typically teach multiple subjects. The 2012 National Survey collected data on teachers' participation in in-service education and other professional activities, as well as data on study groups, one-on-one coaching, and other professional growth opportunities provided by schools and districts. These data are discussed in this chapter.

Teacher Professional Development

One important measure of teachers' continuing education is how long it has been since they participated in professional development. As can be seen in Tables 3.1 and 3.2, more than 80 percent of middle and high school science teachers, and mathematics teachers at each grade range, have participated in discipline-focused professional development (i.e., focused on science/mathematics content or the teaching of science/mathematics) within the last three years. Elementary teachers stand out for the relative paucity of professional development in science or science teaching, with only 59 percent having participated in the last three years.

Table 3.1
Science Teachers' Most Recent Participation in Science-Focused† Professional Development, by Grade Range

	Percent of Teachers		
	Elementary	**Middle**	**High**
In the last 3 years	59 (2.0)	82 (2.3)	85 (1.3)
4–6 years ago	16 (1.4)	6 (1.2)	7 (0.7)
7–10 years ago	5 (0.8)	3 (1.0)	2 (0.3)
More than 10 years ago	5 (0.8)	4 (1.3)	1 (0.4)
Never	15 (1.4)	6 (1.4)	5 (1.0)

† Includes professional development focused on science or science teaching.

Table 3.2
Mathematics Teachers' Most Recent Participation in Mathematics-Focused† Professional Development, by Grade Range

	Percent of Teachers		
	Elementary	Middle	High
In the last 3 years	87 (1.3)	89 (1.6)	88 (1.0)
4–6 years ago	7 (0.9)	4 (0.7)	6 (0.6)
7–10 years ago	1 (0.4)	1 (0.5)	2 (0.4)
More than 10 years ago	1 (0.3)	2 (0.6)	1 (0.3)
Never	3 (0.7)	4 (1.0)	4 (0.7)

† Includes professional development focused on mathematics or mathematics teaching.

Although some involvement in professional development may be better than none, a brief exposure of a few hours over several years is not likely to be sufficient to enhance teachers' knowledge and skills in meaningful ways. Accordingly, teachers were asked about the total amount of time they had spent on professional development related to science/mathematics teaching. As can be seen in Table 3.3, roughly 30 percent of middle and high school science and mathematics teachers, and far fewer of their elementary colleagues, participated in more than 35 hours of science/mathematics-focused professional development in the last three years.

Table 3.3
Time Spent on Professional Development in the Last Three Years, by Subject and Grade Range

	Percent of Teachers		
	Elementary	Middle	High
Science			
Less than 6 hours	65 (1.9)	30 (2.6)	23 (1.6)
6–15 hours	22 (1.7)	24 (1.8)	20 (1.1)
16–35 hours	8 (0.9)	20 (2.0)	21 (1.4)
More than 35 hours	4 (0.7)	27 (2.0)	36 (1.1)
Mathematics			
Less than 6 hours	35 (2.1)	22 (2.1)	23 (1.5)
6–15 hours	35 (1.6)	24 (2.1)	24 (1.4)
16–35 hours	20 (1.5)	23 (1.6)	22 (1.1)
More than 35 hours	11 (1.0)	31 (1.9)	32 (1.5)

The data were also analyzed to examine the extent to which science and mathematics classes with different characteristics are taught by teachers who have participated in more than 35 hours of professional development. Interestingly, in science and mathematics, classes at both ends of the spectrum in terms of level of prior achievement are more likely than classes with students of average or mixed prior achievement to be taught by teachers who have had more than 35 hours of professional development in the last three years (see Table 3.4). Note also that mathematics classes with the highest percentage of non-Asian minority students are more likely than those with the lowest percentage to be taught by teachers who have participated in a relatively large amount of professional development in their field in the last three years.

Table 3.4
Classes Taught by Teachers with More than 35 Hours of Professional Development in the Last Three Years, by Subject and Equity Factors

	Percent of Classes	
	Science	Mathematics
Prior Achievement Level of Class		
Mostly High Achievers	33 (2.6)	28 (1.8)
Average/Mixed Achievers	19 (1.0)	20 (1.0)
Mostly Low Achievers	25 (2.8)	30 (2.2)
Percent of Non-Asian Minority Students in Class		
Lowest Quartile	20 (1.9)	19 (1.6)
Second Quartile	19 (1.5)	21 (1.4)
Third Quartile	27 (2.0)	23 (1.7)
Highest Quartile	23 (2.0)	29 (1.9)

Teachers who indicated they had recently participated in professional development were asked about the nature of those activities. Data for science teachers are shown in Table 3.5, and for mathematics teachers in Table 3.6. For each subject/grade-range combination, workshops are the most prevalent activity, with 84–92 percent of teachers who had participated in professional development activities in the last three years indicating they had attended a workshop. Roughly three-fourths of middle and high school mathematics and science teachers, but fewer of their elementary school colleagues, report participating in professional learning communities or other types of teacher study groups. Middle and high school teachers also attend science/mathematics teacher association meetings at a higher rate than do elementary teachers, likely a reflection of the fact that elementary teachers are responsible for teaching, and keeping up with, multiple disciplines. Finally, not only are elementary science teachers less likely to have participated recently in professional development, they are far less likely to have received feedback on their teaching from a mentor/coach than any other group.

Table 3.5
Science Teachers Participating in Various Professional Development Activities in the Last Three Years, by Grade Range

	Percent of Teachers		
	Elementary	Middle	High
Attended a workshop on science or science teaching	84 (1.8)	91 (1.7)	90 (1.2)
Participated in a professional learning community/lesson study/teacher study group focused on science or science teaching	55 (2.4)	75 (2.5)	73 (1.6)
Received feedback about your science teaching from a mentor/coach formally assigned by the school/district/diocese[†]	24 (2.5)	47 (3.5)	54 (2.4)
Attended a national, state, or regional science teacher association meeting	8 (1.2)	35 (2.8)	44 (1.7)

[†] This item was asked of all teachers whether or not they had participated in professional development in the last three years.

Table 3.6
Mathematics Teachers Participating in Various Professional Development Activities in the Last Three Years, by Grade Range

	Percent of Teachers					
	Elementary		Middle		High	
Attended a workshop on mathematics or mathematics teaching	91	(1.0)	92	(1.4)	89	(1.0)
Participated in a professional learning community/lesson study/teacher study group focused on mathematics or mathematics teaching	66	(1.7)	76	(2.2)	73	(2.1)
Received feedback about your mathematics teaching from a mentor/coach formally assigned by the school/district/diocese†	46	(2.2)	57	(3.0)	54	(2.2)
Attended a national, state, or regional mathematics teacher association meeting	10	(1.0)	32	(2.5)	38	(1.5)

† This item was asked of all teachers whether or not they had participated in professional development in the last three years.

The emerging consensus about effective professional development suggests that teachers need opportunities to work with colleagues who face similar challenges, including other teachers from their school and those who have similar teaching assignments. Other recommendations include engaging teachers in investigations, both to learn disciplinary content and to experience inquiry-oriented learning; to examine student work and other classroom artifacts for evidence of what students do and do not understand; and to apply what they have learned in their classrooms and subsequently discuss how it went.[4] Accordingly, teachers who had participated in professional development in the last three years were asked a series of additional questions about the nature of those experiences.

As can be seen in Tables 3.7 and 3.8, many secondary science and mathematics teachers (ranging from 54 to 70 percent) have had substantial opportunity to work closely with other teachers from their school and/or subject in their professional development. These percentages are somewhat lower for elementary teachers, especially for science-focused professional development activities. Similarly, only about a third of elementary science teachers, compared to roughly half of teachers in the other subject/grade categories have had substantial opportunity to try out and then discuss what they have learned in their professional development. Relatively few teachers in any subject/grade-range combination (ranging from 31 to 44 percent) have had substantial opportunity to examine classroom artifacts. Still, teachers who have participated in professional development appear to be pleased with the experiences as very few teachers believe that their recent professional development was a waste of their time.

[4] Elmore, R. F. (2002). *Bridging the gap between standards and achievement: The imperative for professional development in education.* Washington, DC: Albert Shanker Institute.

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., and Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal 38*(4), 915–945.

Table 3.7
Science Teachers Whose Professional Development in the Last Three Years Had Each of a Number of Characteristics to a Substantial Extent,† by Grade Range

	Percent of Teachers					
	Elementary		Middle		High	
Worked closely with other science teachers from your school	34	(3.5)	61	(3.5)	62	(2.6)
Worked closely with other science teachers who taught the same grade and/or subject whether or not they were from your school	37	(3.4)	54	(4.0)	58	(2.6)
Had opportunities to try out what you learned in your classroom and then talk about it as part of the professional development	34	(3.3)	51	(4.5)	47	(2.4)
Had opportunities to engage in science investigations	48	(3.5)	52	(3.0)	45	(2.8)
Had opportunities to examine classroom artifacts (e.g., student work samples)	31	(3.5)	40	(3.4)	33	(2.4)
The professional development was a waste of time	8	(2.0)	5	(1.1)	8	(1.1)

† Includes teachers indicating 4 or 5 on a 5-point scale ranging from 1 "Not at all" to 5 "To a great extent."

Table 3.8
Mathematics Teachers Whose Professional Development in the Last Three Years Had Each of a Number of Characteristics to a Substantial Extent,† by Grade Range

	Percent of Teachers					
	Elementary		Middle		High	
Worked closely with other mathematics teachers from your school	54	(2.3)	70	(3.0)	67	(2.3)
Worked closely with other mathematics teachers who taught the same grade and/or subject whether or not they were from your school	49	(2.3)	57	(3.2)	56	(2.4)
Had opportunities to try out what you learned in your classroom and then talk about it as part of the professional development	46	(2.6)	51	(2.7)	47	(2.4)
Had opportunities to engage in mathematics investigations	46	(2.3)	51	(3.1)	41	(2.0)
Had opportunities to examine classroom artifacts (e.g., student work samples)	43	(2.4)	44	(3.1)	36	(2.4)
The professional development was a waste of time	5	(1.0)	4	(1.1)	7	(0.9)

† Includes teachers indicating 4 or 5 on a 5-point scale ranging from 1 "Not at all" to 5 "To a great extent."

Responses to these six items describing the characteristics of professional development experiences were combined into a single composite variable called "quality of professional development." As can be seen in Table 3.9, the mean scores on this composite are quite similar across subject/grade-range categories except for elementary science where teachers rated the quality of their professional development lower than the other subject/grade-range combinations.

Table 3.9
Teacher Mean Scores for the Quality of Professional Development Composite, by Subject and Grade Range

	Mean Score			
	Science		Mathematics	
Elementary	55	(1.8)	62	(1.0)
Middle	65	(1.5)	66	(1.3)
High	62	(1.2)	63	(1.2)

As can be seen in Table 3.10, for both science and mathematics, classes in the smallest schools are taught by teachers who report lower quality professional development experiences than classes in the largest schools. There are no significant differences by school community type or proportion of students eligible for free/reduced-price lunch.

Table 3.10
Class Mean Scores for the Quality of Professional Development Composite, by Subject and Equity Factors

	Mean Score	
	Science	**Mathematics**
Percent of Students in School Eligible for FRL		
Lowest Quartile	60 (1.6)	65 (1.7)
Second Quartile	61 (1.7)	63 (1.2)
Third Quartile	64 (2.2)	64 (1.2)
Highest Quartile	62 (1.4)	65 (1.4)
School Size		
Smallest Schools	56 (2.1)	61 (1.4)
Second Group	62 (1.6)	63 (1.3)
Third Group	63 (1.3)	64 (0.9)
Largest Schools	63 (1.3)	68 (1.4)
Community Type		
Rural	59 (1.8)	62 (1.0)
Suburban	62 (1.1)	64 (0.9)
Urban	62 (1.7)	66 (1.3)

College courses have the potential to address content in more depth than may be possible in other professional development venues, such as workshops. As another indicator of the extent to which science and mathematics teachers are staying current in their field, the National Survey asked teachers when they had last taken a formal course for college credit in both disciplinary content and how to teach that content. As can be seen in Table 3.11, 53 percent of elementary science teachers, 40 percent at the middle school level, and 32 percent at the high school level have not taken a course for college credit in either science or the teaching of science in the last 10 years, including a handful of teachers who indicated they had never had coursework in these areas. Grade range differences are less pronounced in mathematics, with 46 percent of elementary teachers and 38 percent of middle grades teachers not having taken coursework in mathematics or the teaching of mathematics in the last 10 years (see Table 3.12).

Table 3.11
Science Teachers' Most Recent College Coursework in Field, by Grade Range

	Percent of Teachers					
	Elementary		Middle		High	
Science						
In the last 3 years	8	(0.9)	22	(2.4)	24	(1.2)
4–6 years ago	17	(1.6)	14	(1.4)	19	(1.1)
7–10 years ago	17	(1.4)	19	(2.1)	18	(1.2)
More than 10 years ago	57	(2.0)	44	(2.7)	38	(1.2)
Never	1	(0.3)	1	(0.5)	1	(0.5)
The Teaching of Science						
In the last 3 years	11	(1.1)	21	(2.1)	25	(1.4)
4–6 years ago	15	(1.5)	14	(1.3)	16	(1.1)
7–10 years ago	14	(1.4)	16	(1.8)	14	(1.1)
More than 10 years ago	49	(1.9)	38	(2.6)	29	(1.2)
Never	11	(1.1)	11	(1.7)	16	(1.4)
Science or the Teaching of Science						
In the last 3 years	12	(1.2)	27	(2.6)	33	(1.4)
4–6 years ago	19	(1.5)	16	(1.5)	19	(1.0)
7–10 years ago	16	(1.4)	17	(2.0)	16	(1.1)
More than 10 years ago	52	(2.0)	39	(2.8)	31	(1.2)
Never	1	(0.3)	1	(0.5)	1	(0.5)

Table 3.12
Mathematics Teachers' Most Recent College Coursework in Field, by Grade Range

	Percent of Teachers					
	Elementary		Middle		High	
Mathematics						
In the last 3 years	12	(1.1)	19	(1.4)	18	(1.1)
4–6 years ago	17	(1.4)	20	(1.5)	19	(1.1)
7–10 years ago	20	(1.3)	18	(1.6)	15	(1.0)
More than 10 years ago	50	(1.7)	43	(1.8)	48	(1.8)
Never	1	(0.3)	1	(0.4)	0	(0.1)
The Teaching of Mathematics						
In the last 3 years	14	(1.3)	19	(1.5)	20	(1.1)
4–6 years ago	17	(1.4)	17	(1.4)	15	(1.0)
7–10 years ago	18	(1.2)	16	(1.5)	13	(0.9)
More than 10 years ago	46	(1.7)	35	(2.2)	40	(1.5)
Never	5	(0.7)	13	(1.7)	13	(1.6)
Mathematics or the Teaching of Mathematics						
In the last 3 years	16	(1.4)	23	(1.6)	26	(1.3)
4–6 years ago	19	(1.3)	22	(1.6)	19	(1.1)
7–10 years ago	19	(1.4)	17	(1.6)	14	(1.0)
More than 10 years ago	45	(1.8)	37	(1.9)	41	(1.7)
Never	1	(0.3)	1	(0.4)	0	(0.1)

Another series of items asked about the focus of the opportunities teachers had to learn about content and the teaching of that content in the last three years, whether through professional development or college coursework. In science, teachers report that their recent professional development/coursework heavily emphasized planning instruction to enable students at different levels of achievement to enhance their understanding of the targeted ideas, monitoring student

understanding during instruction, and assessing student understanding at the end of instruction on a topic (see Table 3.13). Professional development for elementary teachers was more likely than that for teachers in the higher grades to emphasize implementing the science instructional materials designated for use in their classroom. Surprisingly, learning opportunities for elementary science teachers were less likely than those for their middle and high school counterparts to emphasize deepening teacher content knowledge and considering difficulties students might have in learning particular ideas.

Table 3.13
Science Teachers Reporting That Their Professional Development/Coursework in the Last Three Years Gave Heavy Emphasis† to Various Areas, by Grade Range

	Percent of Teachers					
	Elementary		Middle		High	
Assessing student understanding at the conclusion of instruction on a topic	47	(3.1)	54	(3.6)	58	(2.1)
Planning instruction so students at different levels of achievement can increase their understanding of the ideas targeted in each activity	47	(3.1)	64	(3.5)	56	(2.1)
Monitoring student understanding during science instruction	45	(3.0)	54	(3.3)	55	(2.2)
Learning about difficulties that students may have with particular science ideas and procedures	30	(2.6)	42	(3.1)	49	(2.5)
Deepening their science content knowledge	37	(2.9)	51	(4.0)	48	(2.1)
Finding out what students think or already know about the key science ideas prior to instruction on those ideas	41	(2.8)	46	(3.8)	44	(2.3)
Providing enrichment experiences for gifted students	32	(2.7)	30	(3.0)	33	(2.2)
Implementing the science textbook/module to be used in their classroom	39	(3.5)	30	(2.9)	29	(1.7)
Providing alternative science learning experiences for students with special needs	22	(2.5)	26	(2.7)	28	(2.1)
Teaching science to English-language learners	21	(2.5)	18	(2.4)	18	(1.8)

† Includes teachers responding 4 or 5 on a 5-point scale ranging from 1 "Not at all" to 5 "To a great extent."

Although hands-on/laboratory activities have traditionally been a hallmark of science instruction, emphasis on the use of manipulatives to help students learn mathematics has been a more recent phenomenon. As can be seen in Table 3.14, a large proportion of mathematics teachers, especially at the elementary level, report that their professional growth opportunities in the last three years heavily emphasized learning how to use hands-on activities/manipulatives for mathematics instruction. Other areas emphasized were planning instruction so students at different levels of achievement can increase their understanding of targeted ideas, learning about difficulties that students may have with particular ideas and procedures, monitoring student understanding during instruction, and assessing student understanding at the end of instruction on a topic. As is the case in science, recent professional development for elementary mathematics teachers was more likely than that for middle and high school mathematics teachers to emphasize implementing particular instructional materials. In contrast to science, where the results are similar across grade ranges, larger proportions of elementary mathematics teachers than high school teachers indicate that their recent professional development/coursework focused heavily on finding out what students think or already know about the targeted ideas prior to instruction, and providing enrichment experiences for gifted students.

Table 3.14
Mathematics Teachers Reporting That Their Professional Development/Coursework in the Last Three Years Gave Heavy Emphasis† to Various Areas, by Grade Range

	Percent of Teachers		
	Elementary	Middle	High
Learning how to use hands-on activities/manipulatives for mathematics instruction	80 (2.3)	67 (3.4)	55 (2.3)
Planning instruction so students at different levels of achievement can increase their understanding of the ideas targeted in each activity	60 (2.8)	64 (3.4)	53 (2.3)
Assessing student understanding at the conclusion of instruction on a topic	58 (2.5)	57 (3.9)	49 (2.3)
Monitoring student understanding during mathematics instruction	56 (2.5)	55 (3.9)	49 (2.1)
Learning about difficulties that students may have with particular mathematical ideas and procedures	49 (2.7)	51 (3.4)	46 (2.3)
Deepening their mathematics content knowledge	43 (2.6)	44 (3.4)	35 (1.9)
Implementing the mathematics textbook/program to be used in their classroom	55 (3.0)	39 (3.5)	32 (1.9)
Finding out what students think or already know about the key mathematical ideas prior to instruction on those ideas	43 (2.4)	37 (3.5)	32 (1.9)
Providing alternative mathematics learning experiences for students with special needs	33 (2.6)	39 (3.4)	30 (1.9)
Providing enrichment experiences for gifted students	37 (3.0)	30 (3.3)	21 (1.9)
Teaching mathematics to English-language learners	21 (2.3)	19 (2.2)	18 (1.6)

† Includes teachers responding 4 or 5 on a 5-point scale ranging from 1 "Not at all" to 5 "To a great extent."

Several items related to a focus on student-centered instruction in recent teacher professional development/coursework were combined into a composite variable. As can be seen in Table 3.15, the mean scores are the same for elementary science and elementary mathematics, with an average of 57 out of a possible 100 points. It is interesting to note that in science, professional development for middle and high school teachers gave more emphasis to student-centered instruction, and professional development for high school mathematics teachers had less focus on student-centered instruction.

Table 3.15
Teacher Mean Score on the Extent to which Professional Development/Coursework Focused on Student-Centered Instruction Composite, by Subject and Grade Range

	Mean Score	
	Science	Mathematics
Elementary	57 (1.6)	57 (1.2)
Middle	64 (1.4)	55 (1.5)
High	62 (1.2)	50 (0.8)

Table 3.16 provides information about the extent to which science and mathematics classes with different demographic characteristics have access to teachers who have had recent opportunities to learn about student-centered instruction. Interestingly, mathematics classes classified as consisting mostly of low achievers tend to be taught by teachers with higher scores on this composite than classes consisting of mostly high achievers. In addition, teachers of science and

mathematics classes with a high proportion of non-Asian minority students report a higher focus on student-centered instruction in their professional development/coursework than teachers of classes with relatively few non-Asian minority students.

Table 3.16
Class Mean Scores on the Extent to Which Professional Development/Coursework Focused on Student-Centered Instruction Composite, by Subject and Equity Factors

	Mean Score	
	Science	**Mathematics**
Prior Achievement Level of Class		
Mostly High Achievers	59 (2.3)	45 (1.9)
Average/Mixed Achievers	48 (1.3)	48 (1.2)
Mostly Low Achievers	51 (3.8)	51 (1.5)
Percent of Non-Asian Minority Students in Class		
Lowest Quartile	45 (2.1)	42 (1.8)
Second Quartile	49 (2.1)	44 (1.7)
Third Quartile	51 (2.8)	50 (1.5)
Highest Quartile	53 (2.6)	55 (1.7)

In addition to asking teachers about their involvement as participants in professional development, the survey asked teachers whether they had served in various leadership roles in the profession in the last three years. As can be seen in Tables 3.17 and 3.18, elementary teachers are far less likely than their secondary counterparts to have led teacher study groups, served as mentors/coaches for other teachers, and taught in-service workshops focused on science/mathematics. In contrast, elementary teachers are more likely than middle and high school science/mathematics teachers to have supervised student teachers in the last three years.

Table 3.17
Science Teachers Serving in Various Leadership Roles in the Last Three Years, by Grade Range

	Percent of Teachers		
	Elementary	**Middle**	**High**
Led a teacher study group focused on science teaching	4 (1.0)	19 (2.5)	26 (2.1)
Served as a formally assigned mentor/coach for science teaching	5 (1.0)	17 (2.2)	24 (2.2)
Supervised a student teacher	38 (2.5)	24 (2.5)	23 (1.7)
Taught in-service workshops on science or science teaching	3 (0.9)	15 (2.1)	17 (1.9)

Table 3.18
Mathematics Teachers Serving in Various Leadership Roles in the Last Three Years, by Grade Range

	Percent of Teachers		
	Elementary	**Middle**	**High**
Led a teacher study group focused on mathematics teaching	8 (1.4)	21 (2.4)	25 (1.9)
Supervised a student teacher	35 (2.3)	24 (2.6)	23 (2.0)
Served as a formally assigned mentor/coach for mathematics teaching	10 (1.5)	22 (2.5)	22 (1.8)
Taught in-service workshops on mathematics or mathematics teaching	6 (1.2)	14 (2.1)	15 (1.4)

Professional Development Offerings at the School Level

The data presented in this chapter thus far are drawn from the teacher questionnaires. The 2012 National Survey of Science and Mathematics Education also included "School Program Questionnaires" for science and mathematics, each completed by a person designated by the school coordinator as knowledgeable about school programs, policies, and practices in the designated subject.

School science and mathematics program representatives were asked whether professional development workshops in the designated discipline were offered by their school and/or district/diocese (if relevant), possibly in conjunction with other school systems, colleges or universities, museums, professional associations, and/or commercial vendors. As can be seen in Table 3.19, locally offered workshops are more prevalent in mathematics than in science, and within each subject, are more prevalent in schools that include elementary grades than those that include grades 9–12.[5]

Table 3.19
Professional Development Workshops Offered Locally in the Last Three Years, by Subject and Grade Range

	Percent of Schools	
	Science	**Mathematics**
Elementary	48 (2.9)	65 (2.8)
Middle	42 (3.6)	60 (3.3)
High	36 (4.0)	51 (4.3)

Respondents who indicated that mathematics/science workshops were offered locally were asked about the extent to which that professional development addressed each of a number of areas. In both science and mathematics, locally offered workshops are more likely to emphasize state standards than any other of the listed areas. Locally offered workshops in science have a greater focus on investigation-oriented teaching strategies than those in mathematics. In contrast, workshops offered at the local level in mathematics are more likely than those in science to emphasize how to monitor student understanding during instruction and how to provide alternative learning experiences for students with special needs (see Table 3.20).

[5] Elementary school is defined as any school containing grade K, 1, 2, 3, 4, and/or 5; middle school is defined as any school containing grade 6, 7, or 8; and high school is defined as any school containing grade 9, 10, 11, or 12.

Table 3.20
Locally Offered Professional Development Workshops in the Last Three Years with a Substantial Focus† in Each of a Number of Areas, by Subject

	Percent of Schools			
	Science		Mathematics	
State science/mathematics standards	64	(2.9)	76	(2.5)
Science/mathematics content	52	(3.2)	60	(3.0)
How to use particular science/mathematics instructional materials	52	(3.1)	55	(3.1)
How to use technology in science/mathematics instruction	41	(2.9)	46	(2.9)
How to monitor student understanding during science/mathematics instruction	33	(2.6)	43	(2.7)
How students think about various science/mathematics ideas	31	(2.4)	39	(2.8)
How to adapt science/mathematics instruction to address student misconceptions	31	(2.7)	38	(2.8)
How to use investigation-oriented science/mathematics teaching strategies	51	(3.2)	36	(2.9)
How to provide alternative science/mathematics learning experiences for students with special needs	11	(1.7)	22	(2.8)
How to teach science/mathematics to students who are English language learners	18	(2.5)	20	(2.3)

† Includes schools where respondent indicated 4 or 5 on a 5-point scale ranging from 1 "Not at all" to 5 "To a great extent."

One concern about professional development workshops is that teachers may not be given adequate assistance in applying what they are learning to their own instruction. Teacher study groups (Professional Learning Communities, lesson study, etc.) have the potential to help teachers focus on instruction. School science and mathematics program representatives were asked whether their school has offered teacher study groups in the last three years where teachers meet on a regular basis to discuss science/mathematics teaching and learning. As can be seen in Table 3.21, in elementary schools, study groups are more likely to have been offered in mathematics than in science.

Table 3.21
Teacher Study Groups Offered at Schools in the Last Three Years, by Subject and Grade Range

	Percent of Schools			
	Science		Mathematics	
Elementary	32	(3.0)	46	(3.0)
Middle	43	(3.7)	51	(3.7)
High	47	(4.4)	48	(4.4)

Tables 3.22–3.26 present additional information provided by school program representatives about school-based teacher study groups focused on science and mathematics. As can be seen in Table 3.22, these study groups are similar in terms of whether teachers have been required to participate, whether the groups have operated on specified schedules, and whether they have had designated leaders. When study groups have had designated leaders, in both science and mathematics, the leaders have been most likely to come from within the school (see Table 3.23).

Table 3.22
Characteristics of Teacher Study Groups, by Subject

	Percent of Schools†	
	Science	Mathematics
Participation is required	79 (2.5)	78 (2.3)
School specifies schedule	62 (2.9)	66 (2.7)
Has designated leaders	56 (3.3)	65 (2.8)

† Includes only those schools that offered teacher study groups in the last three years.

Table 3.23
Origin of Designated Leaders of Teacher Study Groups, by Subject

	Percent of Schools†	
	Science	Mathematics
From within the school	87 (3.0)	87 (3.1)
From another school in district/diocese‡	26 (3.2)	28 (3.3)
From external sources	13 (3.0)	13 (2.8)

† Includes only those schools that offered teacher study groups in the last three years with designated leaders.
‡ Item presented only to public and Catholic schools.

Table 3.24 shows the frequency and duration of school-based study groups that have a specified schedule. Note that although most study groups in both science and mathematics have met for the entire school year, there is considerable variation in the frequency of study group meetings, with roughly a third meeting more than twice a month, but some meeting far less frequently.

Table 3.24
Frequency and Duration of Teacher Study Groups, by Subject

	Percent of Schools†	
	Science	Mathematics
Frequency		
Less than once a month	25 (4.0)	18 (3.0)
Once a month	31 (3.6)	33 (2.4)
Twice a month	12 (1.9)	15 (2.3)
More than twice a month	31 (3.5)	34 (3.1)
Duration		
The entire school year	89 (2.3)	90 (2.1)
One semester	7 (1.9)	4 (1.6)
Less than one semester	4 (1.2)	5 (1.4)

† Includes only those schools that offered teacher study groups in the last three years with specified schedules.

Most schools limit participation in their science/mathematics-focused study groups to teachers from their school, and most include teachers from multiple grade levels (see Table 3.25). Many study groups include school and/or district administrators.

Table 3.25
Composition of Teacher Study Groups, by Subject

	Percent of Schools[†]			
	Science		Mathematics	
Limited to teachers from this school	66	(3.9)	76	(2.8)
Include teachers from other schools in the district/diocese[‡]	35	(3.8)	23	(2.7)
Include teachers from other schools outside of their jurisdiction	7	(3.0)	4	(1.7)
Include teachers from multiple grade levels	65	(3.4)	61	(2.3)
Include school and/or district/diocese administrators	44	(3.7)	50	(2.7)
Include higher education faculty or other "consultants"	10	(2.4)	15	(2.0)
Include parents/guardians or other community members	0	(0.1)	3	(1.0)

[†] Includes only those schools that offered teacher study groups in the last three years.
[‡] Item presented only to public and Catholic schools.

School program representatives were also asked about the activities typically included in teacher study groups focused on science/mathematics teaching and learning. As can be seen in Table 3.26, 73 percent of study groups in science and 83 percent in mathematics have involved teachers in analyzing student assessment results. Roughly two-thirds of study groups in each subject have had teachers analyze student instructional materials and plan lessons together. Considerably fewer study groups have engaged teachers in the analysis of classroom artifacts and conducting science/mathematics investigations.

Table 3.26
Description of Activities in Typical Teacher Study Groups, by Subject

	Percent of Schools[†]			
	Science		Mathematics	
Teachers analyze student science/mathematics assessment results	73	(3.5)	83	(2.4)
Teachers analyze science/mathematics instructional materials	65	(3.3)	65	(2.7)
Teachers plan science/mathematics lessons together	67	(3.0)	62	(3.2)
Teachers analyze classroom artifacts	37	(3.6)	34	(2.7)
Teachers engage in science/mathematics investigations	25	(2.9)	30	(2.3)

[†] Includes only those schools that offered teacher study groups in the last three years.

Although there is general agreement that teachers can benefit from participating in professional development workshops and study groups, it is often difficult to find time for them to do so. In schools that offered in-service workshops and/or teacher study groups within the last three years, school representatives were given a list of ways in which time might be provided for teachers to participate, and asked to indicate which were used in their school. As can be seen in Table 3.27, teacher work days during the school year have been the most likely to be used, including 63 percent of schools for mathematics and 55 percent for science. Somewhat fewer schools have used common planning time, teacher work days outside the regular school year, substitute teachers, and early dismissal or late start for students to provide time for professional development.

Table 3.27
How Schools Provide Time for Science/Mathematics Professional Development[†]

	Percent of Schools			
	Science		Mathematics	
Professional days/teacher work days during the students' school year	55	(2.6)	63	(2.3)
Common planning time for teachers	41	(2.6)	53	(2.3)
Professional days/teacher work days before and/or after the students' school year	38	(2.2)	50	(2.4)
Substitute teachers to cover teachers' classes while they attend professional development	36	(2.8)	43	(2.4)
Early dismissal and/or late start for students	29	(2.1)	37	(2.4)

[†] Includes in-service workshops and teacher study groups.

As noted earlier, professional development workshops and teacher study groups can provide important opportunities for teachers to deepen their content and pedagogical content knowledge, and to develop skill in using that knowledge for key tasks of teaching, such as analyzing student work to determine what a student does and does not understand. When resources allow, going the next step and offering one-on-one coaching to help teachers improve their practice can be a powerful tool. School program representatives were asked whether any teachers in their school had access to one-on-one coaching focused on improving their science/mathematics instruction; these data are shown in Table 3.28. At both the elementary and middle grades levels, schools are significantly more likely to provide coaching in mathematics than in science; there is no significant difference at the high school level.

Table 3.28
Schools Providing One-on-One Science/Mathematics Coaching

	Percent of Schools			
	Science		Mathematics	
Elementary	17	(1.9)	27	(2.3)
Middle	17	(2.1)	26	(2.6)
High	22	(2.0)	26	(2.4)

In schools where science/mathematics teachers have access to one-on-one coaching, program representatives were asked who provides the coaching services. As can be seen in Table 3.29, in both subjects, approximately two-thirds of schools have a combination of teachers/coaches and administrators serve in this capacity.

Table 3.29
Teaching Professionals Providing Science- and Mathematics-Focused One-on-One Coaching

	Percent of Schools[†]			
	Science		Mathematics	
Both teachers/coaches[‡] and administrators	64	(4.0)	68	(3.5)
Teachers/coaches[‡] only	25	(3.5)	21	(2.8)
Administrators only	12	(3.5)	11	(2.4)

[†] Includes only those schools that provide science/mathematics-focused coaching.
[‡] Includes teachers/coaches of all levels of teaching responsibility: full-time, part-time, and not teaching.

Although most schools have both teachers/coaches and administrators provide coaching, it appears that teachers/coaches are responsible for the bulk of it. Table 3.30 shows the percentage of schools that indicated coaching is provided by different professionals to a substantial extent. In science, 34 percent of schools have teachers/coaches with full teaching loads provide one-on-one coaching to a substantial extent; 24 percent use teachers/coaches who do not have classroom teaching responsibilities. Forty percent of schools have one-on-one mathematics coaching provided to a substantial extent by teachers/coaches who do not have classroom teaching responsibilities; 28 percent use teachers/coaches with full class loads to a substantial extent.

Table 3.30
Professionals Providing Science- and Mathematics-Focused One-on-One Coaching to a Substantial Extent[†]

	Percent of Schools[‡]			
	Science		Mathematics	
Teachers/coaches who do not have classroom teaching responsibilities	24	(3.4)	40	(3.7)
Teachers/coaches who have full-time classroom teaching responsibilities	34	(3.8)	28	(3.2)
District/Diocese administrators including mathematics supervisors/coordinators[§]	20	(2.9)	25	(3.2)
The principal of your school	14	(4.1)	16	(3.3)
Teachers/coaches who have part-time classroom teaching responsibilities	17	(3.1)	14	(2.4)
An assistant principal at your school	7	(1.9)	9	(2.0)

[†] Includes schools where respondent indicated 4 or 5 on a 5-point scale ranging from 1 "Not at all" to 5 "To a great extent."
[‡] Includes only those schools that provide science/mathematics-focused coaching.
[§] Presented only to public and Catholic schools.

Finally, school program representatives were asked about the services provided to teachers in need of special assistance; the data for science and mathematics are shown in Tables 3.31 and 3.32, respectively. Note that at least half of the schools at each grade range have mentors or coaches who provide guidance to teachers in particular need of help. Roughly 40 to 50 percent of schools in the various subject/grade-range categories provide seminars, classes, and/or study groups for this purpose. In science, as the grade range of the school increases, schools become increasingly likely to provide a higher level of supervision for these teachers; the apparent differences by school grade range in mathematics are not statistically significant.

Table 3.31
Services Provided to Science Teachers in Need of Special Assistance in Teaching, by Grade Range

	Percent of Schools					
	Elementary		Middle		High	
Guidance from a formally designated mentor or coach	51	(3.4)	50	(3.3)	63	(3.3)
Seminars, classes, and/or study groups	41	(2.5)	52	(3.0)	50	(3.7)
A higher level of supervision than for other teachers	12	(2.1)	21	(2.3)	34	(2.7)

Table 3.32
Services Provided to Mathematics Teachers in Need of Special Assistance in Teaching, by Grade Range

	Percent of Schools		
	Elementary	Middle	High
Guidance from a formally designated mentor or coach	56 (3.5)	59 (3.4)	66 (3.6)
Seminars, classes, and/or study groups	53 (3.2)	49 (3.4)	43 (3.6)
A higher level of supervision than for other teachers	25 (2.5)	30 (2.7)	36 (3.7)

Additional analyses were conducted to see if each of a number of professional development resources is equitably distributed across schools. As can be seen in Table 3.33, schools with different proportions of students eligible for free/reduced-price lunch are about equally likely to provide assistance to science teachers in need. In contrast, the largest schools are significantly more likely than the smallest schools to offer science-focused teacher study groups. The most variation is in the percentage of schools offering one-on-one coaching, which is more likely to be offered in schools in the highest quartile of proportion of students eligible for free/reduced-price lunch than in schools in the lowest quartile. The largest schools are more likely than the smallest to offer coaching, and schools in urban areas are most likely and schools in rural areas least likely to offer one-on-one coaching.

Table 3.33
Schools Providing Various Services to Science Teachers, by Equity Factors

	Percent of Schools		
	Science-Focused Study Groups	One-on-One Science-Focused Coaching	Assistance to Science Teachers in Need[†]
Percent of Students in School Eligible for FRL			
Lowest Quartile	34 (4.7)	16 (3.1)	81 (4.0)
Second Quartile	34 (4.1)	17 (3.9)	78 (3.3)
Third Quartile	49 (4.0)	18 (2.6)	79 (3.6)
Highest Quartile	40 (4.2)	28 (3.8)	86 (3.0)
School Size			
Smallest Schools	35 (4.6)	14 (2.4)	82 (2.8)
Second Group	41 (4.2)	21 (3.0)	80 (3.3)
Third Group	41 (4.1)	24 (3.1)	83 (3.5)
Largest Schools	49 (3.9)	30 (4.1)	81 (3.8)
Community Type			
Rural	42 (4.4)	11 (2.2)	80 (3.1)
Suburban	38 (3.2)	20 (2.1)	83 (2.3)
Urban	38 (4.0)	30 (2.8)	80 (3.7)

[†] Assistance defined as guidance from a formally designated mentor or coach; seminars, classes, and/or study groups; or a higher level of supervision than for other teachers.

Table 3.34 shows analogous data for mathematics. The largest schools are substantially more likely than the smallest schools to offer each of these services, and schools with the largest proportion of students eligible for free/reduced-price lunch are substantially more likely than those in the lowest quartile to offer mathematics-focused study groups and one-on-one coaching.

In addition, urban schools are much more likely than either rural or suburban schools to offer one-on-one coaching in mathematics.

Table 3.34
Schools Providing Various Services to Mathematics Teachers, by Equity Factors

	Percent of Schools					
	Mathematics-Focused Study Groups		One-on-One Mathematics-Focused Coaching		Assistance to Mathematics Teachers in Need†	
Percent of Students in School Eligible for FRL						
Lowest Quartile	39	(4.8)	22	(3.6)	76	(5.5)
Second Quartile	46	(4.9)	26	(4.5)	87	(4.0)
Third Quartile	56	(4.0)	29	(3.8)	90	(3.0)
Highest Quartile	61	(4.4)	41	(3.9)	81	(3.3)
School Size						
Smallest Schools	40	(4.4)	22	(3.0)	78	(4.2)
Second Group	52	(4.5)	30	(3.3)	86	(3.6)
Third Group	55	(3.8)	31	(3.5)	87	(2.8)
Largest Schools	67	(4.1)	43	(4.1)	91	(2.7)
Community Type						
Rural	48	(4.5)	18	(2.8)	84	(3.5)
Suburban	47	(3.4)	25	(2.5)	85	(3.0)
Urban	54	(4.2)	47	(4.0)	80	(3.2)

† Assistance defined as guidance from a formally designated mentor or coach; seminars, classes, and/or study groups; or a higher level of supervision than for other teachers.

Summary

With the exception of elementary science, a large percentage of science and mathematics teachers have participated in science/mathematics-focused professional development in the last three years. However, the extent to which professional development experiences incorporate elements of best practice varies. For example, of the science and mathematics teachers who have participated in professional development, the majority of secondary teachers have had opportunities to work closely with other teachers from their school or who teach the same subject/grade. In contrast, few science and mathematics teachers have had more than 35 hours of professional development in the last three years.

Workshops are the most prevalent form of professional development, and participation in teacher study groups is also quite common. Roughly one-third of secondary science and mathematics teachers have attended a meeting of a national, state, or regional professional association; few elementary teachers have attended such meetings in the last three years. Similar percentages of teachers have taken a formal course for college credit in science/mathematics, or the teaching of science/mathematics, in the last three years.

The emphasis of these professional development opportunities, across the subject and grade-range categories, has largely been on planning instruction to enable students at different levels of achievement to enhance their understanding, monitoring student understanding during instruction, and assessing student understanding at the end of instruction on a topic. Learning

how to use hands-on/manipulatives has also been focused on heavily in mathematics professional development, especially at the elementary level. In science, deepening teacher content knowledge has been less of an emphasis at the elementary level than at the secondary level; in mathematics, grade level differences are less pronounced.

School program representatives were asked about locally offered professional development opportunities. In-service workshops have been the most prevalent form of professional development offered, and have been more common in mathematics than in science. In many schools, these workshops have had a substantial focus on state science/mathematics standards, science/mathematics content, and/or using instructional materials.

Teacher study groups also have been fairly common in both subjects and all grade ranges, with the exception of elementary science. These teacher study groups tend to involve teachers in analyzing student assessment results, analyzing instructional materials, and/or jointly planning lessons. Analyzing classroom artifacts and engaging teachers in science/mathematics investigations are less common. About one-fourth of schools offer one-on-one coaching in mathematics; about one-fifth offer coaching in science. Coaching in science and mathematics is typically provided by both teachers/coaches and administrators; however, teachers/coaches tend to shoulder more of this responsibility. Interestingly, one-on-one coaching is more prevalent in schools that are large, urban, or high-poverty.