Chapter Five

Instructional Objectives and Activities

A. Overview

Most science and mathematics teachers at the secondary level teach multiple classes. To minimize response burden, teachers were asked to provide detailed information about instruction in a particular, randomly selected science or mathematics class. Questions focused on teachers' objectives for instruction, the class activities they use in accomplishing these objectives, and how student performance is assessed. These results are presented in the following sections.

B. Objectives of Science and Mathematics Instruction

The survey provided a list of possible objectives of science and mathematics instruction and asked how much emphasis each would receive in the entire course. Table 5.1 shows the percentage of science classes whose teachers indicated heavy emphasis for each objective.

One instructional objective stands out as key in science classes at all grade levels, with two-thirds or more of grades K–4, 5–8, and 9–12 science classes giving heavy emphasis to learning basic science concepts. Two-thirds of the grade 5–12 teachers also give heavy emphasis to learning science process/inquiry skills, an objective much less likely to be emphasized in grades K–4. Interestingly, despite the reported emphasis on science process and inquiry skills, classes at all levels are much less likely to stress having students learn to explain ideas in science (21–39 percent) or learn to evaluate arguments based on scientific evidence (8–29 percent), two skills integral to scientific inquiry.

Quite a few science classes focus on having students learn important terms and facts of science, ranging from 42 percent in grades K–4 to 52 percent in grades 9–12. About one-fifth of classes at each grade level emphasize preparing students for standardized tests. The objectives least likely to be emphasized heavily in science classes are learning about the history and nature of science and learning about the applications of science in business and industry.

Table 5.1
Science Classes with Heavy Emphasis on Various Instructional Objectives, by Grade Range

	Percent of Classes					
	Grades K–4		Grades 5–8		Grades 9–12	
Learn basic science concepts	66	(2.7)	76	(2.1)	81	(1.3)
Increase students' interest in science	57	(2.5)	58	(2.9)	45	(2.5)
Learn important terms and facts of science	42	(2.8)	43	(2.9)	52	(2.5)
Learn science process/inquiry skills	37	(2.9)	64	(2.7)	65	(2.2)
Prepare for further study in science	25	(2.2)	39	(2.3)	48	(2.4)
Learn how to communicate ideas in science effectively	21	(2.0)	39	(2.6)	39	(2.3)
Prepare for standardized tests	21	(2.2)	23	(2.1)	21	(1.5)
Learn about the relationship between science, technology, and society	10	(1.6)	24	(2.3)	29	(2.0)
Learn to evaluate arguments based on scientific evidence	8	(1.3)	21	(2.4)	29	(1.9)
Learn about the history and nature of science	7	(1.3)	11	(1.7)	11	(0.9)
Learn about the applications of science in business and industry	4	(1.1)	11	(1.4)	20	(2.2)

Differences between types of objectives and among grade ranges are captured in the mean scores on two composite variables—Science Content and Nature of Science—as shown in Table 5.2. (See Appendix E for definitions of all composite variables, descriptions of how they were created, and reliability information.) The composite related to Science Content objectives included the following items:

- Learn basic science concepts;
- Learn important terms and facts of science;
- Learn science process/inquiry skills; and
- Prepare for further study in science.

The Nature of Science composite included the following:

- Learn to evaluate arguments based on scientific evidence;
- Learn about the history and nature of science;
- Learn how to communicate ideas in science effectively;
- Learn about the applications of science in business and industry; and
- Learn about the relationship between science, technology, and society.

Of the two types of objectives, science content is emphasized more frequently and fairly uniformly across grade ranges. Nature of science objectives receive heavy emphasis less frequently and are quite a bit more likely to be stressed in grade 5–12 classes than in classes at the lower grades.

Table 5.2
Mean Composite Scores Related to Science Class Objectives, by Grade Range

	Mean Score					
	Grades K–4		Grades 5–8		Grades 9–12	
Science Content	76	(1.1)	83	(0.7)	85	(0.6)
Nature of Science	46	(1.1)	63	(1.2)	66	(0.8)

Instructional objectives in mathematics classes are more similar among the grade levels. (See Table 5.3.) Learning mathematical concepts, learning how to solve problems, and learning how to reason mathematically are emphasized heavily in 66–88 percent of the grade K–4, 5–8, and 9–12 mathematics classes. Other objectives that have similar emphasis across grade ranges include, in decreasing order of emphasis: learning how mathematical ideas connect with one another (55–59 percent); learning to explain ideas in mathematics effectively (32–42 percent); preparing for standardized tests (28–38 percent); learning how to apply mathematics in business and industry (10–18 percent); and learning about the history and nature of mathematics (3 percent).

In general, teachers reported that their mathematics classes emphasize conceptual mastery (85–88 percent) more frequently than development of what might be thought of as basic skills: computational skills (37–64 percent); mathematical algorithms/procedures (41–57 percent); and performing computations with speed and accuracy (20–39 percent).

Table 5.3
Mathematics Classes with Heavy Emphasis on Various Instructional Objectives, by Grade Range

	Percent of Classes					
	Grades K–4		Grades 5–8		Grades 9–12	
Learn mathematical concepts	88	(1.4)	88	(1.9)	85	(1.4)
Learn how to solve problems	80	(1.8)	82	(2.2)	74	(1.7)
Learn to reason mathematically	66	(2.2)	72	(2.6)	72	(1.8)
Develop students' computational skills	64	(2.3)	61	(2.4)	37	(1.9)
Learn how mathematics ideas connect with one another	57	(2.3)	59	(2.3)	55	(1.8)
Increase students' interest in mathematics	53	(2.5)	43	(2.4)	29	(1.8)
Prepare for further study in mathematics	44	(2.4)	50	(2.2)	61	(1.9)
Learn mathematical algorithms/procedures	41	(2.1)	55	(2.7)	57	(1.9)
Learn to perform computations with speed and accuracy	39	(2.3)	35	(2.6)	20	(1.6)
Prepare for standardized tests	36	(2.5)	38	(2.6)	28	(1.9)
Learn to explain ideas in mathematics effectively	34	(2.1)	42	(2.5)	32	(2.0)
Understand the logical structure of mathematics	27	(2.3)	33	(2.3)	38	(1.6)
Learn how to apply mathematics in business and industry	10	(1.4)	18	(1.9)	16	(1.4)
Learn about the history and nature of mathematics	3	(0.7)	3	(0.7)	3	(0.5)

Several objectives are treated differently depending on grade range. Elementary and middle grades mathematics classes are much more likely than high school mathematics classes to emphasize increasing interest in mathematics, developing students' computational skills, and learning to perform computations with speed and accuracy.

Comparing science and mathematics classes, two objectives are more likely to be emphasized heavily across grade ranges in mathematics: preparing for further study in the discipline and preparing for standardized tests.

Table 5.4 presents means for the composite variables related to objectives for mathematics classes. Across grade ranges, the greatest emphasis appears to be on objectives related to mathematics reasoning—learning mathematical concepts, learning how to solve problems, learning to reason mathematically, and learning how mathematics ideas connect with one another. Basic mathematics skills (e.g., developing computational skills, preparing for standardized tests) are the next most emphasized objectives followed by helping students learn about the nature of mathematics (e.g., learning about the logical structure, history, and nature of mathematics).

Table 5.4
Mean Composite Scores Related to
Mathematics Class Objectives, by Grade Range

	Mean Score					
	Grades K–4		Grades 5–8		Grades 9–12	
Mathematics Reasoning	90	(0.7)	91	(0.6)	90	(0.5)
Basic Mathematics Skills	75	(0.9)	75	(1.2)	64	(1.0)
Nature of Mathematics	51	(1.0)	61	(0.8)	60	(0.7)

C. Class Activities

Teachers were given a list of activities and asked how often they did each in the randomly selected class; response options were: never, a few times a year, once or twice a month, once or twice a week, and all or almost all science/mathematics lessons. Results for science instruction are presented first, followed by mathematics instruction.

Science Instruction

Table 5.5 shows the percentage of classes in which the teacher reported doing the activity on a daily basis. As the grade range increases, science classes are less likely to incorporate whole class discussion; almost 6 in 10 grade K–4 classes use this strategy, compared to 4 in 10 and 3 in 10 for grade 5–8 and 9–12 classes, respectively. Classes in grades K–4 are also somewhat more likely than those in grades 9–12 to incorporate open-ended questioning and to allow students to work at their own pace. High school classes, in contrast, were more likely than those in grades K–4 to introduce content through formal presentations. Of the activities listed in Table 5.5, the one most likely to occur on a daily basis in grades 9–12 was assigning homework (39 percent). Science classes in grades K–8 were less likely to assign homework that frequently.

Table 5.5
Science Classes Where Teachers Report Using Various Strategies on a Daily Basis, by Grade Range

	Percent of Classes					
	Grades K–4		Grades 5–8		Grades 9–12	
Engage the whole class in discussions	57	(2.4)	43	(3.0)	31	(2.3)
Pose open-ended questions	36	(2.2)	33	(3.0)	27	(1.9)
Allow students to work at their own pace	24	(2.0)	19	(2.1)	14	(2.1)
Help students see connections between science and other disciplines	20	(1.8)	27	(2.2)	19	(1.5)
Require students to supply evidence to support their claims	16	(1.9)	27	(2.4)	20	(1.5)
Ask students to explain concepts to one another	14	(1.5)	15	(2.0)	14	(1.3)
Introduce content through formal presentations	12	(1.6)	16	(2.0)	22	(1.3)
Ask students to consider alternative explanations	10	(1.3)	14	(1.8)	9	(0.9)
Read and comment on the reflections students have written, e.g., in their journals	5	(1.1)	7	(1.5)	6	(1.1)
Assign science homework	4	(1.0)	17	(2.0)	39	(2.3)

Table 5.6 shows the percentage of grades K–4, 5–8, and 9–12 science classes participating in various instructional activities at least once a week. Three instructional activities occur at least once a week in many science classes across the grade levels: working in groups (64–80 percent); doing hands-on/laboratory science activities or investigations (50–71 percent); and following specific instructions in an activity or investigation (46–71 percent). (In grade 9–12 classes, students listening and taking notes during a presentation by the teacher and answering textbook or worksheet questions were also frequent activities.) The least frequent activities were also strikingly similar across grade ranges. These involved students:

- Working on extended science investigations or projects;
- Designing their own investigations;
- Using computers as a tool;
- Participating in field work;
- Taking field trips; and
- Making formal presentations to the rest of the class.

The fact that science is often taught on a less-than-daily basis in elementary schools is reflected in the finding that only one activity (working in groups) was reported by more than half of the grade K–4 teachers as happening at least weekly. This stands in sharp contrast to the six or seven activities occurring weekly in more than 50 percent of the classes in grades 5–12, where science is typically taught daily.

With only a few exceptions, class activities in grades 5–8 and 9–12 science classes are very similar. In grades 5–8, science classes are much more likely to include reading and reflective writing. In contrast, grade 9–12 science classes are much more likely to include answering textbook or worksheet questions and using mathematics as a tool in problem-solving.

Table 5.6
Science Classes Where Teachers Report that Students Take Part in Various Instructional Activities at Least Once a Week, by Grade Range

	Percent of Classes					
	Grades K–4		Grades 5–8		Grades 9–12	
Work in groups	64	(2.6)	80	(2.0)	80	(2.0)
Do hands-on/laboratory science activities or investigations	50	(3.0)	65	(2.7)	71	(2.5)
Follow specific instructions in an activity or investigation	46	(2.6)	70	(2.9)	71	(2.5)
Read other (non-textbook) science-related materials in class	44	(2.6)	32	(2.5)	20	(2.3)
Read from a science textbook in class	31	(2.3)	46	(3.2)	28	(2.2)
Watch a science demonstration	30	(2.8)	42	(3.3)	43	(2.0)
Record, represent, and/or analyze data	29	(2.6)	51	(2.5)	54	(2.5)
Answer textbook or worksheet questions	28	(2.2)	56	(2.5)	72	(2.0)
Use mathematics as a tool in problem-solving	24	(2.3)	36	(2.6)	52	(2.1)
Write reflections (e.g., in a journal)	22	(2.3)	32	(2.7)	15	(1.5)
Watch audiovisual presentations (e.g., videotapes, CD-ROMs, videodiscs, television programs, films, or filmstrips)	18	(2.3)	19	(2.3)	21	(1.6)
Listen and take notes during presentation by teacher	15	(1.5)	54	(2.6)	86	(1.4)
Work on extended science investigations or projects (a week or more in duration)	9	(1.4)	10	(1.5)	7	(1.1)
Design or implement their *own* investigation	8	(1.6)	13	(1.8)	9	(1.1)
Use computers as a tool (e.g., spreadsheets, data analysis)	6	(1.1)	11	(1.7)	16	(2.2)
Participate in field work	5	(1.0)	7	(1.3)	4	(0.8)
Take field trips	5	(1.0)	3	(1.0)	2	(0.5)
Prepare written science reports	4	(0.8)	16	(2.0)	24	(2.1)
Make formal presentations to the rest of the class	3	(0.8)	9	(1.4)	6	(0.9)

Table 5.7 shows the percentage of science classes which never participate in particular instructional activities. At the high school level, students in 50 percent of the science classes never take field trips; those in 39 percent of the classes never write reflections; and in a third of the high school science classes, students never participate in field work. Using computers as a tool is very rare in grades K–4, with two-thirds of the science classes reporting no use.

Table 5.7
Science Classes Where Teachers Report that Students Never Take Part in Particular Instructional Activities, by Grade Range

	Percent of Classes					
	Grades K–4		Grades 5–8		Grades 9–12	
Use computers as a tool (e.g., spreadsheets, data analysis)	64	(2.4)	24	(2.4)	21	(1.6)
Listen and take notes during presentation by teacher	47	(2.2)	2	(0.7)	0	(0.1)
Participate in field work	41	(2.4)	21	(2.8)	32	(2.1)
Prepare written science reports	41	(2.4)	5	(1.4)	7	(1.2)
Make formal presentations to the rest of the class	40	(2.4)	5	(1.2)	17	(1.5)
Read from a science textbook in class	32	(2.2)	7	(1.6)	15	(1.4)
Work on extended science investigations or projects (a week or more in duration)	30	(2.4)	7	(1.4)	17	(1.4)
Design and implement their *own* investigation	25	(2.1)	3	(0.8)	8	(0.9)
Write reflections (e.g., in a journal)	23	(2.2)	16	(2.1)	39	(2.5)
Answer textbook or worksheet questions	21	(2.1)	3	(1.2)	1	(0.3)
Take field trips	17	(2.1)	21	(2.3)	50	(2.4)
Use mathematics as a tool in problem-solving	15	(1.6)	3	(1.0)	5	(0.9)
Record, represent, and/or analyze data	9	(1.3)	1	(0.3)	1	(0.4)
Read other (non-textbook) science-related material in class	8	(1.8)	2	(0.6)	10	(1.2)
Watch audiovisual presentations (e.g., videotapes, CD-ROMs, videodiscs, television programs, films, or filmstrips)	6	(1.2)	2	(0.8)	3	(0.5)
Do hands-on/laboratory science activities or investigations	3	(0.8)	0	(0.1)	1	(0.2)
Follow specific instructions in an activity or investigation	3	(0.8)	0	(0.1)	0	(0.2)
Watch a science demonstration	2	(0.6)	0	(0.3)	1	(0.2)
Work in groups	1	(0.8)	0	(0.2)	0	(0.1)

Another question asked teachers about the ways they use computers in their science instruction. Table 5.8 shows the percentage of classes in which teachers report *never* using computers in various ways. The data make it clear that computers are not used in half of science classes in grades K–4 and in more than 40 percent of classes in grades 5–12. Beyond this general finding, a number of specific differences between grade ranges are apparent. In grade K–4 science classes, computers are used most for science learning games and to do drill and practice. In grades 5–8, computers are most likely to be used for learning games, to retrieve or exchange data, and to demonstrate scientific principles. In high school, the most frequent uses of computers are to retrieve or exchange data, to demonstrate scientific principles, and to do laboratory simulations.

In the early grades, computer use does not seem to have progressed beyond the notion of the "teaching machine" envisioned by B. F. Skinner decades ago. In later grades, the power of computing is more likely to be utilized, but the general picture is still one of limited use that falls well short of the role for computers visualized in the National Educational Technology Standards for Students (International Society for Technology in Education, 2000)

Table 5.8
Science Classes Where Teachers Report that Students Never Use Computers to do Particular Activities, by Grade Range

	Percent of Classes					
	Grades K–4		Grades 5–8		Grades 9–12	
Collect data using sensors or probes	84	(1.7)	69	(2.7)	55	(2.3)
Do laboratory simulations	79	(1.6)	56	(3.0)	45	(2.2)
Take a test or quiz	77	(2.2)	61	(2.9)	69	(2.5)
Solve problems using simulations	76	(2.1)	55	(3.2)	54	(2.3)
Retrieve or exchange data	73	(2.1)	44	(2.6)	43	(2.3)
Demonstrate scientific principles	70	(2.2)	45	(3.1)	43	(2.2)
Do drill and practice	57	(2.6)	57	(2.7)	56	(2.2)
Play science learning games	48	(2.4)	46	(2.6)	59	(2.5)

A summary of the data on teaching practice is provided by the composite variables listed in Table 5.9. (See Appendix E for definitions of all composite variables, descriptions of how they were created, and reliability information.) A score of 100 is attained if an individual indicated s/he used each strategy in the composite in every science lesson. Similarly a score of 0 indicates that none of the strategies in the composite were ever used. The data suggest that traditional practices (e.g., students listening and taking notes during a lecture, doing textbook or worksheet questions, reviewing homework) are more common in grades 5–12 than in grade K–4 science classes, as is the use of projects and extended investigations. Computer use is quite infrequent across all grades.

Table 5.9
Class Mean Scores for Science Teaching Practice Composite Variables, by Grade Range

	Mean Score					
	Grades K–4		Grades 5–8		Grades 9–12	
Use of Strategies to Develop Students' Abilities to Communicate Ideas	68	(0.8)	73	(0.9)	69	(0.6)
Use of Laboratory Activities	60	(1.1)	69	(1.0)	69	(0.7)
Use of Traditional Teaching Practices	48	(0.7)	66	(0.6)	69	(0.4)
Use of Projects/Extended Investigations	25	(0.8)	39	(0.9)	35	(0.7)
Use of Computers	12	(0.8)	19	(0.9)	20	(1.1)

In addition to asking about class activities in the course as a whole, the 2000 National Survey of Science and Mathematics Education gave teachers a list of possible class activities and asked teachers to indicate those that took place during their most recent lesson in the randomly selected class. As can be seen in Table 5.10, 86–90 percent of the science lessons in each grade range included discussion, and 59–71 percent included lecture. In addition, more than 50 percent of the science lessons in each grade range included group work.

Approximately 6 in 10 science lessons in grades K–4 involved students doing hands-on/laboratory activities, compared to 5 in 10 in grades 5–8 and 4 in 10 in grades 9–12. In grades

K–8, 41 percent of the lessons included students reading about science, compared to 26 percent of the lessons at the high school level. Use of calculators was much more common in high school science classes (27 percent) than in elementary and middle school science classes (1 percent and 8 percent, respectively). Only 4–10 percent of the science lessons in any grade range involved computer use.

Table 5.10
Science Classes Participating in Various Activities in Most Recent Lesson, by Grade Range

	Percent of Classes					
	Grades K–4		Grades 5–8		Grades 9–12	
Discussion	90	(2.0)	83	(2.6)	81	(1.4)
Students doing hands-on/laboratory activities	62	(2.6)	50	(3.2)	42	(2.2)
Lecture	59	(2.7)	62	(3.1)	71	(2.1)
Students working in small groups	55	(2.9)	56	(2.9)	52	(1.9)
Students completing textbook/worksheet problems	43	(2.5)	50	(3.0)	52	(2.3)
Students reading about science	41	(2.6)	41	(2.6)	26	(2.2)
Test or quiz	7	(1.4)	11	(1.6)	12	(1.2)
Student using computers	4	(0.8)	10	(1.6)	7	(1.0)
Students using other technologies	4	(0.9)	9	(1.4)	9	(1.2)
Students using calculators	1	(0.5)	8	(1.4)	27	(1.9)

The survey also asked science teachers to estimate the time spent on each of a number of kinds of activities in their most recent lesson in the randomly selected class. These results are shown in Table 5.11. Note that on the average, science lessons appear to be relatively similar in instructional arrangements in the various grade ranges, with roughly 33–37 percent of the class time spent on whole class lecture/discussion; 22–30 percent of the time on hands-on activities; and 14–18 percent of the time with students working individually reading textbooks and completing worksheets. Approximately 10 percent of class time was spent on non-instructional activities, including daily routines and interruptions.

Table 5.11
Average Percentage of Science Class Time Spent on Different Types of Activities, by Grade Range

	Percent of Class Time					
	Grades K–4		Grades 5–8		Grades 9–12	
Daily routines, interruptions, and other non-instructional activities	9	(0.5)	11	(0.5)	11	(0.3)
Whole class lecture/discussion	33	(1.0)	30	(1.2)	37	(1.1)
Individual students reading textbooks, completing worksheets, etc.	16	(1.0)	18	(1.0)	14	(0.9)
Working with hands-on, manipulative, or laboratory materials	30	(1.6)	24	(1.6)	22	(1.2)
Non-laboratory small group work	8	(0.8)	11	(1.1)	10	(0.8)
Other activities	4	(0.8)	5	(1.1)	7	(0.6)

Mathematics Instruction

Table 5.12 shows the percentage of mathematics classes in which teachers do various activities. The frequency of group discussion on a daily basis appears largely dependent on grade range, decreasing from 60 percent of the grade K–4 classes to 35 percent of the grade 9–12 classes. A similar trend is evident for allowing students to work at their own pace. In contrast, assigning of homework occurs on a daily basis much more frequently in grade 5–12 mathematics classes (about 8 in 10), compared to grade K–4 classes (about 4 in 10).

In roughly half of all classes, teachers report requiring students to supply evidence to support their claims on a daily basis, a practice consistent with the recommendations of the NCTM *Standards*. Other standards-based practices—e.g., considering alternative methods for solutions, asking students to explain concepts to one another, and asking students to use multiple representations—occur on a daily basis in fewer mathematics classes, ranging from 10 to 28 percent in the various grade range categories.

Table 5.12
Mathematics Classes Where Teachers Report Using Various Strategies on a Daily Basis, by Grade Range

	Percent of Classes					
	Grades K–4		Grades 5–8		Grades 9–12	
Engage the whole class in discussions	60	(2.5)	45	(2.5)	35	(1.9)
Require students to explain their reasoning when giving an answer	52	(2.3)	56	(2.8)	46	(2.3)
Allow students to work at their own pace	50	(2.5)	30	(3.0)	16	(1.1)
Assign mathematics homework	43	(2.4)	75	(2.4)	80	(1.9)
Introduce content through formal presentations	37	(2.5)	43	(2.4)	49	(1.9)
Pose open-ended questions	33	(2.5)	32	(2.2)	29	(1.7)
Ask students to consider alternative methods for solutions	23	(1.9)	28	(2.0)	17	(1.4)
Help students see connections between mathematics and other disciplines	23	(1.9)	17	(2.0)	12	(1.1)
Ask students to explain concepts to one another	20	(2.1)	24	(1.9)	20	(1.4)
Ask students to use multiple representations (e.g., numeric, graphic, geometric, etc.)	14	(1.5)	10	(1.1)	13	(1.0)
Read and comment on the reflections students have written (e.g., in their journals)	7	(1.1)	6	(1.5)	2	(0.3)

Tables 5.13 and 5.14 present results on the frequency of student activities in mathematics classes. Note that students doing problems from textbooks or worksheets is a very frequent activity in mathematics classes, especially in the higher grades. Ninety-four percent of the grade 9–12 classes participate in this activity at least weekly, with 65 percent doing so on a daily basis; comparable figures for grades 5–8 are 89 percent weekly, and 55 percent daily; and for grades K–4, 82 percent weekly and 47 percent daily. Seventy-five percent or more of the mathematics classes across grade levels focus on practicing routine computations and algorithms at least once a week; 30 percent or more do this on a daily basis. Reviewing homework/worksheet assignments is also quite prevalent, especially in grades 5–12 where more than two-thirds of the classes take part in the activity on a daily basis.

Table 5.13
Mathematics Classes Where Teachers Report that Students Take Part in Various Instructional Activities at Least Once a Week, by Grade Range

	Percent of Classes					
	Grades K–4		Grades 5–8		Grades 9–12	
Engage in mathematical activities using concrete materials	85	(1.9)	48	(2.8)	25	(1.5)
Answer textbook or worksheet questions	82	(1.9)	89	(1.5)	94	(1.0)
Practice routine computations/algorithms	77	(1.8)	80	(1.9)	75	(1.4)
Follow specific instructions in an activity or investigation	73	(2.0)	78	(2.0)	72	(1.8)
Work in groups	71	(2.4)	65	(2.4)	62	(2.1)
Review homework/worksheet assignments	71	(2.5)	93	(1.3)	93	(1.2)
Use mathematical concepts to interpret and solve applied problems	62	(2.1)	71	(2.3)	70	(1.8)
Record, represent, and/or analyze data	46	(2.5)	49	(3.1)	33	(1.8)
Read from a mathematics textbook in class	40	(2.5)	49	(2.8)	34	(1.9)
Use calculators or computers for learning or practicing skills	27	(2.3)	54	(2.9)	82	(1.6)
Read other (non-textbook) mathematics-related materials in class	26	(2.2)	17	(1.9)	6	(0.9)
Use calculators or computers to develop conceptual understanding	22	(2.2)	44	(2.3)	61	(2.0)
Write reflections (e.g., in a journal)	21	(1.8)	16	(1.9)	6	(0.9)
Listen and take notes during presentation by teacher	20	(2.2)	69	(3.1)	93	(1.2)
Design their *own* activity or investigation	15	(1.7)	11	(1.4)	6	(1.0)
Make formal presentations to the rest of the class	9	(1.3)	11	(2.0)	7	(1.0)
Use calculators or computers as a tool (e.g., spreadsheet, data analysis)	9	(1.4)	26	(2.5)	36	(2.0)
Work on extended mathematics investigations or projects (a week or more in duration)	6	(1.0)	7	(1.2)	4	(0.7)

The use of concrete materials (or manipulatives) and the use of calculators or computers for learning or practicing skills follow exactly opposite trends as grade range increases, with manipulative use most frequent in grades K–4 and calculator/computer use most frequent in grades 9–12. Computer/calculator use in general is quite low in grades K–4, with only about 1 in 4 classes participating in each activity on at least a weekly basis. The use of lecture (students listening and taking notes during a presentation by the teacher) increases sharply with grade range; the percentage of classes having lectures at least once a week increases from 20 percent in grades K–4 to 69 percent in grades 5–8 to 93 percent in grades 9–12.

Table 5.14
Mathematics Classes Where Teachers Report that Students Take Part in Various Instructional Activities on a Daily Basis, by Grade Range

	Percent of Classes					
	Grades K–4		Grades 5–8		Grades 9–12	
Answer textbook or worksheet questions	47	(2.6)	55	(2.5)	65	(1.9)
Engage in mathematical activities using concrete materials	42	(2.4)	9	(1.8)	5	(0.5)
Practice routine computations/algorithms	36	(2.3)	36	(2.4)	30	(1.9)
Review homework/worksheet assignments	36	(2.3)	67	(2.7)	70	(1.9)
Follow specific instructions in an activity or investigation	30	(2.3)	32	(2.3)	28	(1.9)
Work in groups	17	(1.6)	18	(1.9)	19	(1.6)
Use mathematical concepts to interpret and solve applied problems	17	(1.7)	24	(2.5)	21	(1.5)
Read from a mathematics textbook in class	16	(1.9)	17	(2.2)	10	(1.4)
Listen and take notes during presentation by teacher	10	(1.5)	34	(2.4)	59	(1.7)
Record, represent, and/or analyze data	10	(1.4)	9	(1.7)	7	(0.9)
Read other (non-textbook) mathematics-related materials in class	5	(1.1)	3	(0.7)	1	(0.4)
Write reflections (e.g., in a journal)	5	(1.0)	4	(0.9)	1	(0.5)
Use calculators or computers for learning or practicing skills	3	(0.8)	16	(1.6)	49	(1.9)
Design their *own* activity or investigation	2	(0.6)	1	(0.6)	2	(0.8)
Work on extended mathematics investigations or projects (a week or more in duration)	2	(0.7)	1	(0.3)	1	(0.2)
Use calculators or computers to develop conceptual understanding	2	(0.6)	12	(1.4)	29	(1.8)
Make formal presentations to the rest of the class	1	(0.6)	2	(1.1)	1	(0.2)
Use calculators or computers as a tool (e.g., spreadsheets, data analysis)	1	(0.4)	6	(1.1)	16	(1.5)

Table 5.15 shows the percentage of mathematics classes that *never* take part in various instructional activities. Note particularly that 30–55 percent of the classes never write reflections about their mathematics work, and that 24–46 percent never work on extended mathematics investigations or projects.

Table 5.15
Mathematics Classes Where Teachers Report that Students Never Take Part in Particular Instructional Activities, by Grade Range

	Percent of Classes					
	Grades K–4		Grades 5–8		Grades 9–12	
Listen and take notes during presentation by teacher	49	(2.6)	4	(1.3)	0	(0.1)
Use calculators or computers as a tool (e.g., spreadsheets, data analysis)	49	(2.8)	21	(2.1)	19	(1.6)
Work on extended mathematics investigations or projects (a week or more in duration)	46	(2.7)	24	(2.5)	37	(2.2)
Make formal presentations to the rest of the class	34	(2.2)	19	(1.9)	30	(1.9)
Read from a mathematics textbook in class	33	(2.3)	7	(1.4)	11	(1.2)
Write reflections (e.g., in a journal)	30	(2.4)	32	(2.3)	55	(2.1)
Use calculators or computers to develop conceptual understanding	17	(2.3)	6	(1.3)	4	(0.6)
Design their *own* activity or investigation	16	(2.0)	11	(1.4)	25	(1.9)
Read other (non-textbook) mathematics-related materials in class	15	(1.8)	14	(1.7)	28	(1.7)
Use calculators or computers for learning or practicing skills	14	(1.9)	4	(1.0)	3	(0.6)
Review homework/worksheet assignments	8	(1.1)	0	(0.1)	0	(0.1)
Practice routine computations/algorithms	6	(1.2)	1	(0.4)	1	(0.3)
Answer textbook or worksheet questions	5	(1.0)	0	(0.3)	0	(0.1)
Use mathematical concepts to interpret and solve applied problems	4	(0.9)	0	(0.2)	1	(0.3)
Record, represent, and/or analyze data	4	(1.1)	1	(0.2)	4	(0.6)
Work in groups	0	(0.2)	0	(0.1)	1	(0.3)
Engage in mathematical activities using concrete materials	0	(0.2)	1	(0.3)	4	(0.7)
Follow specific instructions in an activity or investigation	0	(0.3)	0	(0.1)	1	(0.2)

Teachers were asked to provide more detailed information about the use of calculators/computers in their mathematics instruction. Table 5.16 presents the percentage of classes in which calculators/computers are used in various ways on at least a weekly basis. There are sharp differences in use between grade levels. Teachers report that the most frequent use in grades K–4 is to play mathematics learning games, followed by drill and practice, which may well be similar activities at that grade level. At the high school level, the most frequent use of calculators/computers is for taking a test or quiz, followed closely by doing drill and practice. In roughly half of the high school mathematics classes, calculators/computers are used to demonstrate mathematics principles on at least a weekly basis.

Table 5.16
Mathematics Classes Where Teachers Report that Students Use Calculators/ Computers for Various Activities at Least Once a Week, by Grade Range

	Percent of Classes					
	Grades K–4		Grades 5–8		Grades 9–12	
Play mathematics learning games	47	(2.2)	20	(2.1)	6	(0.9)
Do drill and practice	32	(2.3)	38	(3.1)	62	(1.9)
Demonstrate mathematics principles	18	(1.8)	37	(2.4)	51	(2.0)
Take a test or quiz	11	(1.7)	32	(2.8)	68	(2.2)
Do simulations	10	(1.2)	9	(1.4)	11	(1.2)
Solve problems using simulations	9	(1.3)	14	(1.6)	14	(1.5)
Retrieve or exchange data	5	(1.0)	8	(1.5)	9	(1.1)
Collect data using sensors or probes	3	(0.6)	3	(0.7)	4	(0.6)

Table 5.17 shows the percentage of "most recent lessons" in grades K–4, 5–8, and 9–12 mathematics classes that included various instructional activities. Discussion is the most frequently reported activity, occurring in 9 out of 10 mathematics classes at each grade range. Again, the preponderance of having students do textbook/worksheet problems is clear, with more than 75 percent of the mathematics lessons in each grade range involving these activities. Most mathematics lessons also include lecture, ranging from 68 percent in grades K–4 to 88 percent in grades 9–12. As is the case in science, use of small groups is essentially the same across grade levels, with about half of all classes including the activity in the most recent lesson. While computer use is generally low (ranging from 3 percent of the lessons in grades 9–12 to 7 percent in grades K–4), calculator use is fairly common, especially in the high school grades, where 80 percent of the lessons involved their use.

Table 5.17
Mathematics Classes Participating in Various Activities in Most Recent Lesson, by Grade Range

	Percent of Classes					
	Grades K–4		Grades 5–8		Grades 9–12	
Discussion	89	(1.7)	91	(1.5)	90	(1.0)
Students completing textbook/worksheet problems	77	(2.2)	80	(1.8)	81	(1.6)
Students doing hands-on/manipulative activities	75	(2.2)	36	(2.9)	19	(1.5)
Lecture	68	(2.4)	80	(2.0)	88	(1.1)
Students working in small groups	52	(2.7)	52	(2.3)	55	(1.8)
Student reading about mathematics	17	(1.6)	26	(2.0)	17	(1.6)
Test or quiz	13	(1.7)	15	(1.8)	15	(1.3)
Students using computers	7	(1.1)	5	(1.0)	3	(0.7)
Students using calculators	5	(0.9)	39	(2.1)	80	(1.5)
Students using other technologies	2	(0.6)	4	(0.9)	1	(0.2)

Table 5.18 presents the means for composite variables related to mathematics teaching practice. To achieve a score of 100, a class would have to do each of the activities in a composite in every mathematics lesson. A score of 0 would indicate that none of the activities in a composite are ever done.

Table 5.18
Class Mean Scores for Mathematics Teaching Practice Composite Variables, by Grade Range

	Mean Score					
	Grades K–4		Grades 5–8		Grades 9–12	
Use of Strategies to Develop Students' Abilities to Communicate Ideas	74	(0.8)	73	(0.8)	69	(0.7)
Use of Traditional Teaching Practices	66	(0.9)	81	(0.7)	82	(0.5)
Use of Calculators/Computers for Developing Concepts and Skills	34	(1.0)	49	(1.1)	68	(0.8)
Use of Calculators/Computers for Investigation	24	(0.9)	34	(1.1)	31	(0.8)

Teachers at all grade levels report using techniques aimed at helping students learn to communicate mathematics ideas; e.g., posing open-ended questions, asking students to explain their reasoning and to explain concepts to one another, asking students to use multiple representations. Traditional teaching practices—lecture, doing textbook/worksheet problems, and practicing routine computations—are also very clearly in evidence, particularly in grade 5–12 mathematics classes, where they dominate instruction. Activities involving the use of calculators/computers for developing concepts and skills show a steady increase from grades K–4 to grades 9–12.

As noted earlier, teachers were asked to estimate the time spent on each of a number of kinds of activities in their most recent lesson in the randomly selected class. The results for mathematics lessons are shown in Table 5.19. While the proportion of time spent on various instructional arrangements in science lessons was similar across the grades, mathematics classes vary considerably more by grade range. On average, more time is spent in whole class lecture/discussion in the higher grades, ranging from 27 percent in grades K–4 to 42 percent in grades 9–12; and more time is spent working with manipulative materials in the lower grades, ranging from 27 percent of class time in grades K–4 to 5 percent in grades 9–12. In mathematics classes, 21–25 percent of class time is spent reading textbooks and completing worksheets; and about 10 percent is spent on non-instructional activities.

Table 5.19
Average Percentage of Mathematics Class Time Spent on Different Types of Activities, by Grade Range

	Percent of Class Time					
	Grades K–4		Grades 5–8		Grades 9–12	
Daily routines, interruptions, and other non-instructional activities	10	(0.4)	12	(0.4)	12	(0.3)
Whole class lecture/discussion	27	(0.7)	36	(0.9)	42	(0.9)
Individual students reading textbooks, completing worksheets, etc.	24	(1.1)	25	(1.1)	21	(0.8)
Working with hands-on or manipulative materials	27	(1.2)	11	(1.0)	5	(0.4)
Non-manipulative small group work	8	(0.7)	10	(0.8)	15	(0.8)
Other activities	4	(0.6)	5	(0.6)	6	(0.4)

D. Homework and Assessment Practices

Science and mathematics teachers were asked about the amount of homework assigned per week in a randomly selected class. As can be seen in Table 5.20, teachers in only about 1 in 10 grade K–4 science classes and about 1 in 2 grade K–4 mathematics classes expect their students to do more than 30 minutes of homework in these subjects per week. Students in the higher grades are typically expected to spend more time on homework, especially in mathematics, with a median of 31–60 minutes in grades 5–8 science, 61–90 minutes in grades 5–8 mathematics and grades 9–12 science, and 91–120 minutes in grades 9–12 mathematics.

Table 5.20
Amount of Homework Assigned in Science and Mathematics Classes per Week, by Grade Range

	Percent of Classes					
	Grades K–4		Grades 5–8		Grades 9–12	
Science						
0–30 minutes	89	(1.5)	37	(2.8)	11	(1.2)
31–60 minutes	8	(1.1)	35	(2.3)	27	(1.7)
61–90 minutes	2	(0.8)	19	(2.2)	25	(1.7)
91–120 minutes	1	(0.4)	6	(1.5)	16	(1.4)
2–3 hours	0	--*	3	(0.7)	14	(1.8)
More than 3 hours	0	(0.2)	0	(0.2)	7	(1.6)
Mathematics						
0–30 minutes	48	(2.3)	8	(1.3)	6	(0.9)
31–60 minutes	27	(2.3)	21	(2.2)	14	(1.3)
61–90 minutes	13	(1.8)	26	(2.5)	23	(2.0)
91–120 minutes	8	(1.3)	24	(2.4)	23	(1.6)
2–3 hours	3	(0.9)	17	(1.8)	23	(1.7)
More than 3 hours	1	(0.4)	5	(1.6)	11	(1.2)

* No teachers in the sample selected this response option. Thus, it is not possible to calculate the standard error of this estimate.

Teachers were also given a list of ways that they might assess student progress and asked to describe the frequency with which they did each in the randomly selected class. The percentages of classes in which teachers report using the various assessment strategies at least once a month are presented in Tables 5.21 and 5.22. In both science and mathematics, teachers report that five strategies for assessing student progress are by far the most common. These are:

- Asking students questions during large group discussions;
- Using assessments embedded in class activities to see if students are "getting it";
- Observing students and asking questions as they work individually;
- Observing students and asking question as they work in small groups; and
- Reviewing student homework.

These methods are especially prevalent in grades 5–12 where they occur in more than 90 percent of the science and mathematics classes on at least a monthly basis. Formal tests occur somewhat less frequently, especially in science in grades K–4. In contrast, some of the less traditional forms of assessing student progress, such as reviewing student portfolios, are used more frequently in the lower grades (K–8).

Table 5.21
Science Classes Where Teachers Report Assessing Students' Progress Using Various Methods at Least Monthly, by Grade Range

	Percent of Classes					
	Grades K–4		Grades 5–8		Grades 9–12	
Ask students questions during large group discussions	97	(0.8)	98	(0.7)	98	(0.5)
Observe students and ask questions as they work in small groups	90	(1.6)	96	(1.2)	96	(0.9)
Use assessments embedded in class activities to see if students are "getting it"	89	(2.1)	96	(1.0)	93	(1.3)
Observe students and ask questions as they work individually	88	(1.8)	95	(1.3)	95	(1.0)
Review student homework	59	(2.1)	93	(1.5)	94	(0.9)
Review student notebooks/journals	57	(2.9)	70	(2.6)	51	(2.7)
Conduct a pre-assessment to determine what students already know	54	(2.9)	57	(2.9)	46	(2.5)
Give predominantly short-answer tests (e.g., multiple choice, true/false, fill in the blank)	49	(2.5)	81	(2.5)	79	(1.8)
Have students present their work to the class	48	(2.3)	55	(3.3)	44	(2.2)
Give tests requiring open-ended responses (e.g., descriptions, explanations)	47	(2.6)	84	(1.7)	83	(1.8)
Review student portfolios	41	(2.6)	42	(2.9)	23	(2.2)
Grade student work on open-ended and/or laboratory tasks using defined criteria (e.g., a scoring rubric)	41	(2.2)	76	(2.5)	79	(1.7)
Have students assess each other (peer evaluation)	19	(2.0)	36	(2.3)	27	(2.1)
Have students do long-term science projects	17	(1.8)	31	(2.5)	25	(2.6)

Table 5.22
Mathematics Classes Where Teachers Report Assessing Students' Progress Using Various Methods at Least Monthly, by Grade Range

	Percent of Classes					
	Grades K–4		Grades 5–8		Grades 9–12	
Ask students questions during large group discussions	100	(0.0)	100	(0.2)	97	(0.8)
Observe students and ask questions as they work individually	98	(0.6)	99	(0.3)	96	(1.3)
Use assessments embedded in class activities to see if students are "getting it"	98	(0.7)	98	(0.4)	93	(0.9)
Observe students and ask questions as they work in small groups	96	(1.0)	92	(1.5)	90	(1.6)
Review student homework	86	(1.6)	99	(0.3)	98	(0.7)
Conduct a pre-assessment to determine what students already know	69	(2.2)	59	(2.4)	45	(1.8)
Give predominantly short-answer tests (e.g., multiple choice, true/false, fill in the blank)	61	(2.5)	62	(2.8)	46	(2.0)
Review student notebooks/journals	53	(2.5)	59	(2.4)	44	(1.8)
Give tests requiring open-ended responses (e.g., descriptions, explanations)	49	(2.6)	71	(2.3)	75	(1.8)
Have students present their work to the class	48	(2.8)	57	(2.5)	53	(2.4)
Review student portfolios	45	(2.6)	30	(2.0)	17	(1.6)
Grade student work on open-ended and/or laboratory tasks using defined criteria (e.g., a scoring rubric)	35	(2.2)	50	(2.7)	46	(2.1)
Have students assess each other (peer evaluation)	29	(2.5)	37	(2.3)	23	(1.9)
Have students do long-term mathematics projects	14	(1.8)	26	(2.0)	16	(1.5)

These findings are summarized in the composite variables related to assessment practices; mean scores are presented in Table 5.23. The use of informal assessment strategies is much more frequent than the use of journals/portfolios, and use is quite similar across grade ranges and across subjects. The use of journals and portfolios is more common in grades K–4 and 5–8 classes than in high school classes.

Table 5.23
Class Mean Scores for Assessment Practice Composite Variables, by Grade Range

	Mean Score					
	Grades K–4		Grades 5–8		Grades 9–12	
Science Classes						
Use of Informal Assessment	70	(1.1)	75	(1.0)	74	(0.6)
Use of Journals/Portfolios	39	(1.4)	43	(1.6)	31	(1.3)
Mathematics Classes						
Use of Informal Assessment	83	(0.8)	81	(0.7)	78	(0.5)
Use of Journals/Portfolios	37	(1.3)	34	(1.1)	22	(0.8)

E. Summary

Data from the 2000 National Survey indicate clear patterns of emphasis in teachers' objectives for their classes and in the instructional activities they use. Across grade ranges, science classes are more likely to emphasize learning basic concepts than other objectives. At the secondary level, learning science process and inquiry skills also receives heavy emphasis. Mathematics classes emphasize the same three objectives regardless of grade level: learning mathematical concepts, learning how to solve problems, and learning how to reason mathematically. Mathematics teachers generally report that their classes emphasize conceptual mastery over what might be thought of as basic skills—e.g., computational skills and mathematical algorithms/procedures. Mathematics classes are more likely than science classes to stress preparing for further study in the discipline and preparing for standardized tests.

In terms of instructional activities, class discussion and lecture dominate science teaching. Teacher reports of their most recent lesson indicate that more than 80 percent of the science lessons in grades K–12 include discussion, and 59–71 percent of the lessons include lecture. Group work is included in more than half of all science lessons. Use of hands-on/laboratory activities varies by grade range; approximately 6 in 10 science lessons in grades K–4 involve students doing hands-on/laboratory activities, compared to 5 in 10 in grades 5–8 and 4 in 10 in grades 9–12. Computer use is quite infrequent across grade ranges, but varies by type of use. In the elementary grades, computers are used mostly for drill and practice, compared to the high school level where teachers use them primarily for laboratory simulations.

Discussion and lecture are also very prominent in mathematics instruction, as is the use of textbook/worksheet problems. Ninety percent or more of mathematics lessons include discussion; more than 75 percent, textbook/worksheet problems; and 70 percent or more, lecture. The use of small groups is essentially the same across grade levels, with about half of all classes including the activity in the most recent lesson. While computer use is generally infrequent (ranging from 3 percent of the lessons in grades 9–12 to 7 percent in grades K–4), calculator use is fairly common, especially in the high school grades, where 80 percent of the lessons involve their use. The use of hands-on/manipulative activities decreases sharply from 75 percent of mathematics lessons in grades K–4 to 19 percent in grades 9–12.

In both science and mathematics, informal means of assessment—e.g., asking students questions during large group discussions—are the most common ways of tracking student progress. Checking student homework is also quite common. Formal tests occur less frequently, especially in grade K–4 science. The use of journals and portfolios is more common in grades K–4 and 5–8 classes than in high school classes.