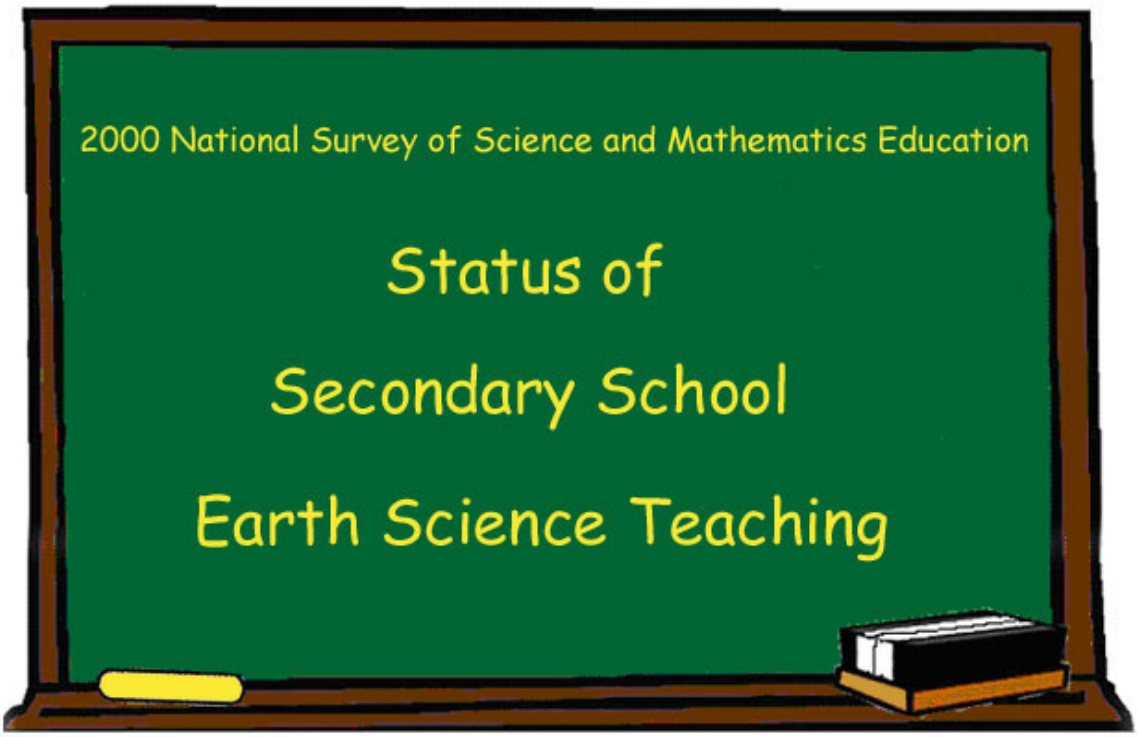

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Status of Secondary School Earth Science Teaching

Introduction

The 2000 National Survey of Science and Mathematics Education was designed to provide up-to-date information and to identify trends in the areas of teacher background and experience, curriculum and instruction, and the availability and use of instructional resources. A total of 5,728 science and mathematics teachers in schools across the United States participated in this survey, a response rate of 74 percent. Among the questions addressed by the survey:

- How well prepared are science and mathematics teachers in terms of both content and pedagogy?

- What are teachers trying to accomplish in their science and mathematics instruction, and what activities do they use to meet these objectives?

The 2000 National Survey is based on a national probability sample of schools and science and mathematics teachers in grades K–12 in the 50 states and the District of Columbia. The sample was designed to allow national estimates of science and mathematics course offerings and enrollment; teacher background preparation; textbook usage; instructional techniques; and availability and use of science and mathematics facilities and equipment. Every eligible school and teacher in the target population had a known, positive probability of being drawn into the sample.

This report describes the status of secondary (grades 6–12) earth science instruction based on the responses of 254 earth science teachers.[1] Technical detail on the survey sample design, as well as data collection and analysis procedures, is included in the *Report of the 2000 National Survey of Science and Mathematics Education* (Weiss, Banilower, McMahon, & Smith, 2001). The standard errors for the estimates presented in this report are included in parentheses in the tables. The narrative sections of the report generally point out only those differences which are substantial as well as statistically significant at the 0.05 level or beyond.

This status report of secondary earth science teaching is organized into major topical areas:

- Characteristics of the earth science teaching force in the United States;
- Professional development of earth science teachers, both needs and participation;
- Earth science classes offered;
- Earth science instruction, in terms of both objectives and class activities; and
- Resources available for earth science instruction.

[1] An earth science teacher is defined as someone who teaches at least one class of earth science in grades 6–8, or astronomy, geology, meteorology, oceanography/marine science, 1st year earth science, or advanced earth science in grades 9–12.

Characteristics of the Earth Science Teaching Force

General Demographics

Slightly more than half of all earth science teachers in the United States are female, 93 percent are white, and half have a master's degree, as shown in Table 1. Judging by the age of earth science teachers, it appears that as many as one-third may be nearing retirement in the next 10 years.

Table 1
Characteristics of the
Secondary Earth Science Teaching Force

	Percent of Teachers	
Sex		
Female	55	(5.7)
Male	45	(5.7)
Race		
White	93	(1.7)
Black or African-American	4	(1.2)
Hispanic or Latino	2	(0.6)
American Indian or Alaskan Native	1	(0.7)
Asian	1	(0.5)
Native Hawaiian or Other Pacific Islander	0	(0.0)
Age		
≤ 30 years	9	(1.7)
31–40 years	31	(5.4)
41–50 years	28	(4.4)
51+ years	33	(6.2)
Experience		
0–2 years	12	(2.9)
3–5 years	13	(3.2)
6–10 years	18	(4.0)
11–20 years	30	(5.9)
≥ 21 years	27	(4.0)
Master's Degree		
Yes	50	(5.3)
No	50	(5.3)

Content Preparedness

Relatively few secondary earth science teachers have extensive backgrounds in the earth sciences; only 34 percent have had six or more semesters of college coursework in the area, roughly the equivalent of a minor. Nine percent of secondary earth science teachers have had no college coursework in the area, and another 29 percent have had only 1–2 semesters. (See Table 2.) It is interesting to note that secondary earth science teachers tend to have more extensive background in the life sciences, with 44 percent having the equivalent of a minor in that field.

Table 2
Number of Semesters† Completed by Secondary Earth Science Teachers in Various Course Categories

	Percent of Teachers			
	Zero Semesters	1–2 Semesters	3–5 Semesters	6 or More Semesters
Earth/space science	9 (3.8)	29 (5.3)	27 (4.7)	34 (5.8)
Life science	3 (0.8)	32 (5.7)	21 (4.1)	44 (6.0)
Science education	21 (4.6)	34 (5.3)	18 (5.3)	26 (4.1)
Physics/physical science	16 (4.0)	40 (5.0)	29 (5.5)	15 (3.7)
Chemistry	17 (5.4)	40 (5.9)	30 (4.7)	14 (2.7)

† The highest number of courses a teacher could indicate for each of the four categories—life science, chemistry, physics/physical science, and earth/space science—was "> 8," and 9 was used as the number of courses in those cases. As a result, these figures underestimate the total for any teacher who completed more than eight courses in a particular category.

As can be seen in Table 3, teachers assigned to earth science classes are similar to the rest of the secondary science teaching force in preparation in science education, with the vast majority having completed a course in general methods of teaching, and 3 out of 4 having taken a methods course specific to science teaching. Not surprisingly, secondary earth science teachers are more likely to have completed college coursework in the earth sciences than are other secondary science teachers. Still, only about half of the secondary earth science teachers have completed courses in introductory earth science, astronomy, geology, and environmental science. Even fewer have taken courses in meteorology and in oceanography, topics that are commonly included in the middle/high school earth science curriculum.

Table 3
Secondary Earth Science Teachers Completing Various College Courses

	Percent of Teachers			
	Earth Science		All Other Sciences	
General methods of teaching	94	(2.6)	93	(1.2)
Methods of teaching science	76	(4.3)	76	(2.5)
Supervised student teaching in science	52	(5.6)	57	(2.9)
Instructional uses of computers/other technologies	48	(6.4)	50	(2.5)
Introductory earth science	55	(4.8)	44	(2.1)
Astronomy	53	(5.3)	30	(2.0)
Geology	52	(5.5)	41	(2.2)
Environmental science	49	(5.9)	34	(2.4)
Physical geography	34	(5.2)	21	(2.2)
Meteorology	31	(5.6)	15	(1.4)
Oceanography	28	(5.7)	14	(1.7)
Agriculture science	10	(2.4)	6	(0.7)

Earth science classes are more likely to be taught by out-of-field teachers than are other science classes. As can be seen in Table 4, only 39 percent of secondary earth science classes are taught by teachers who have had at least six semesters of college coursework in the earth sciences. (In contrast, 68 percent of secondary physics/physical science classes and 82 percent of secondary life science/biology classes are taught by teachers with six or more semesters in that field.) Another 21 percent of earth science classes are taught by teachers who have had in-depth coursework in another science discipline, while 40 percent of secondary earth science classes are taught by teachers who have had no in-depth preparation in any of the natural sciences.

Table 4
Secondary Earth Science Classes Taught by Teachers with Six or More College Courses in Field, in Another Science Field, and Lacking In-Depth Preparation in Any Science

	Percent of Classes					
	Six or More Courses In Field		Not In-Depth in Field, But Six or More in Another Science		Not In-Depth in Any Science	
Earth science	39	(7.0)	21	(3.6)	40	(7.1)
Life science/biology	82	(2.5)	3	(1.2)	14	(2.2)
Physical science/physics/chemistry	68	(3.2)	17	(2.0)	15	(2.8)

In addition to asking teachers about their course backgrounds, the survey asked them to rate how qualified they felt to teach a number of key topics in the various science disciplines. In the earth sciences these topics were:

- Earth's features and physical processes;
- The solar system and the universe; and
- Climate and weather.

Table 5 shows the percentage of secondary earth science teachers, and the percentage of all other secondary science teachers, reporting that they feel very well qualified, adequately qualified, and not well qualified to teach each of those three topics. Roughly half of the secondary earth science teachers responded that they felt "very well qualified" to teach each of the first two topics, and 1 in 3 that they felt "very well qualified" to teach about climate and weather. In each case, only a handful of earth science teachers indicated that they felt "not well qualified" to teach earth science topics.

Table 5
Secondary Earth Science Teachers' Perceptions of Their Qualifications to Teach Each of a Number of Earth Science Topics

	Percent of Teachers					
	Not Well Qualified		Adequately Qualified		Very Well Qualified	
Earth Science						
Earth's features and physical processes	6	(4.1)	43	(6.4)	51	(6.3)
The solar system and the universe	3	(0.8)	45	(6.2)	53	(6.3)
Climate and weather	7	(2.7)	57	(5.5)	36	(5.0)
All Other Sciences						
Earth's features and physical processes	22	(1.8)	51	(2.3)	27	(2.2)
The solar system and the universe	27	(2.0)	44	(2.3)	28	(2.2)
Climate and weather	26	(2.1)	50	(2.4)	24	(2.0)

Pedagogical Preparedness

The National Research Council's (NRC) *National Science Education Standards*, while not specific to earth science, provide a useful frame for interpreting data on earth science teachers' pedagogical preparedness. Responding to an item about the NRC *Standards*, 63 percent of secondary earth science teachers indicated they were at least somewhat familiar with the document, and of these, 60 percent said they agreed with them. (See Table 6.)

Table 6
Secondary Earth Science Teachers' Familiarity with, Agreement with, and Implementation of the NRC *Standards*

	Percent of Teachers			
	Earth Science		All Other Sciences	
Familiarity with NRC *Standards*				
Not at all familiar	37	(5.7)	37	(2.4)
Somewhat familiar	40	(5.2)	32	(2.3)
Fairly familiar	16	(3.7)	20	(1.8)
Very familiar	7	(1.8)	11	(1.8)
Extent of agreement with NRC *Standards*†				
Strongly Disagree	0	(0.3)	0	(0.1)
Disagree	2	(1.0)	7	(2.1)
No Opinion	37	(6.1)	21	(2.8)
Agree	53	(5.8)	64	(3.7)
Strongly Agree	7	(3.3)	8	(2.4)
Extent to which recommendations have been implemented†				
Not at all	1	(0.7)	5	(2.1)
To a minimal extent	28	(6.0)	21	(2.1)
To a moderate extent	64	(5.8)	57	(3.4)
To a great extent	7	(2.8)	17	(2.6)

† These analyses included only those teachers indicating they were at least somewhat familiar with the *Standards.*

The survey also asked teachers how well prepared they felt to use a number of instructional strategies in their teaching. Responses to these items were combined into several composite variables using factor analysis. (Definitions of all composite variables, descriptions of how they were created, and reliability information are included in the Appendix.) Each composite has a

minimum possible score of 0 and a maximum possible score of 100. Mean scores on these composites suggest that earth science teachers, like secondary science teachers generally, are least likely to feel prepared in technology-related areas. (See Table 7.)

Table 7
Composite Scores of Secondary Earth Science Teachers' Pedagogical Preparedness

	Mean Score			
	Earth Science		All Other Sciences	
Preparedness to Teach Students from Diverse Backgrounds	80	(1.9)	77	(0.9)
Preparedness to Use Standards Based Teaching Practices	76	(2.2)	76	(1.0)
Preparedness to Use Calculators/Computers	54	(3.8)	50	(1.7)
Preparedness to Use the Internet	53	(4.3)	48	(1.7)

In responding to individual items about a number of practices thought of as being closely aligned with the *Standards*, three-fourths or more of secondary earth science teachers rated themselves as being well prepared, e.g., to develop students' conceptual understanding of science; make connections between science and other disciplines; provide deeper coverage of fewer science concepts; lead a class of students using investigative strategies; and take students' prior understanding into account when planning curriculum and instruction. They were less likely to consider themselves well prepared to use technology in each of a number of ways, to involve parents in the education of their children, and, especially, to teach students who have limited English proficiency. (See Table 8.)

Table 8
Secondary Earth Science Teachers Considering Themselves Well Prepared† for Each of a Number of Tasks

	Percent of Teachers			
	Earth Science		All Other Sciences	
Encourage participation of females in science	97	(0.8)	94	(1.1)
Listen/ask questions as students work in order to gauge their understanding	96	(1.5)	93	(1.4)
Encourage students' interest in science	95	(1.9)	94	(1.3)
Encourage participation of minorities in science	94	(1.9)	88	(1.8)
Manage a class of students engaged in hands-on/project-based work	91	(3.3)	92	(1.2)
Develop students' conceptual understanding of science	88	(3.4)	88	(2.2)
Make connections between science and other disciplines	88	(4.2)	85	(2.4)
Have students work in cooperative learning groups	87	(2.6)	89	(1.4)
Provide deeper coverage of fewer science concepts	86	(4.7)	81	(1.8)
Use the textbook as a resource rather than the primary instructional tool	85	(4.9)	85	(1.8)
Teach groups that are heterogeneous in ability	82	(4.6)	83	(1.9)
Take students' prior understanding into account when planning curriculum and instruction	82	(3.2)	78	(1.7)
Lead a class of students using investigative strategies	77	(5.6)	81	(2.1)
Use the Internet in your science teaching for general reference	69	(5.8)	63	(2.9)
Use calculators/computers for drill and practice	69	(5.2)	61	(2.6)
Recognize and respond to student cultural diversity	67	(5.7)	65	(2.4)
Use calculators/computers to collect and/or analyze data	64	(5.7)	62	(2.6)
Use the Internet in your science teaching for data acquisition	61	(5.9)	53	(2.7)
Use calculators/computers for science learning games	54	(6.0)	48	(2.5)
Use computers to demonstrate scientific principles	52	(6.3)	47	(2.7)
Involve parents in the science education of their children	49	(6.3)	49	(2.4)
Use computers for laboratory simulations	40	(6.3)	37	(2.6)
Use the Internet in your science teaching for collaborative projects with classes/individuals in other schools	36	(6.5)	28	(2.4)
Teach students who have limited English proficiency	29	(6.3)	23	(2.1)

† Includes teachers responding "very well prepared" or "fairly well prepared" to each statement.

Teachers' ratings of their pedagogical preparedness are reflected in the areas they identify as needs for professional development. The survey asked about six different areas, shown in Table 9. Again, learning how to use technology in science instruction stands out, with 79 percent of the secondary earth science teachers indicating a moderate or substantial need in this area, compared to 60 percent or fewer for each of the other areas listed.

Table 9
Secondary Earth Science Teachers Reporting They Perceived a Moderate or Substantial Need for Professional Development in the Preceding Three Years

	Percent of Teachers			
	Earth Science		All Other Sciences	
Learning how to use technology in science instruction	79	(3.5)	72	(2.4)
Learning how to teach science in a class that includes students with special needs	60	(6.1)	58	(2.1)
Learning how to use inquiry/investigation-oriented teaching strategies	57	(5.5)	53	(2.1)
Deepening my own science content knowledge	56	(5.8)	46	(2.3)
Understanding student thinking in science	55	(5.4)	48	(2.1)
Learning how to assess student learning in science	46	(5.7)	44	(2.3)

Professional Development of Earth Science Teachers

Earth science teachers, like secondary science teachers generally, report low levels of participation in professional development specific to science teaching. Only a third of secondary earth science teachers have spent more than 35 hours in science-related professional development in the previous three years. (See Table 10.)

Table 10
Time Spent by Secondary Earth Science Teachers on Science-Related, In-Service Education in Science

	Percent of Teachers			
	Earth Science		All Other Sciences	
None	7	(3.0)	10	(1.6)
Less than 6 hours	10	(3.1)	8	(1.1)
6–15 hours	24	(6.1)	21	(2.4)
16–35 hours	25	(4.8)	24	(2.1)
More than 35 hours	33	(4.7)	37	(2.4)

As to how this time is spent, the workshop is by far the most common form of professional development (81 percent of secondary earth science teachers have attended one in the previous three years), followed by collaborating with teachers locally, either observing their classrooms (54 percent) or meeting regularly to discuss science teaching (51 percent). (See Table 11.) Forty-six percent of secondary earth science teachers reported attending a state or national science teachers meeting in the previous three years, and 34 percent have taken a college/university science course.

Table 11
Secondary Earth Science Teachers Participating in Various Professional Development Activities in the Preceding Three Years

	Percent of Teachers			
	Earth Science		All Other Sciences	
Attended a workshop on science teaching	81	(4.2)	72	(2.5)
Observed other teachers teaching science as part of your own professional development (formal or informal)	54	(6.1)	50	(2.8)
Met with a local group of teachers to study/discuss science teaching issues on a regular basis	51	(6.2)	49	(2.8)
Attended a national or state science teacher association meeting	46	(6.1)	38	(2.3)
Taken a formal college/university science course	34	(5.2)	36	(2.2)
Taken a formal college/university course in the teaching of science	26	(4.7)	27	(2.2)
Served as a mentor and/or peer coach in science teaching, as part of a formal arrangement that is recognized or supported by the school or district	18	(3.2)	19	(1.5)
Collaborated on science teaching issues with a group of teachers at a distance using telecommunications	14	(3.9)	14	(1.5)

Teachers were asked to consider their professional development as a whole and characterize it in terms of each of a number of potential emphases. As can be seen in Table 12, nearly half of all secondary earth science teachers indicated that their professional development experiences emphasized learning how to use technology in science instruction. Similarly, nearly half of all secondary earth science teachers indicated that their professional development emphasized learning to teach through inquiry/investigation, and 33–39 percent reported emphasis on assessing student learning, deepening their science content knowledge, and understanding student thinking.

In technology, there appears to be a good match between perceived need and emphasis in professional development opportunities; i.e., this area was mostly likely to be rated as a need and also most likely to be emphasized in professional development opportunities. (It is not clear if teachers are actively pursuing these types of opportunities or if they are simply what is being offered most often.) In contrast, there seems to be a very poor match between what teachers need and their opportunities in terms of learning to accommodate students with special needs; this was an area where 60 percent of the teachers noted they could use help, but only 15 percent indicated their professional development emphasized this topic.

Table 12
Secondary Earth Science Teachers Reporting that Their Professional Development Gave Heavy Emphasis to Various Areas†

	Percent of Teachers			
	Earth Science		All Other Sciences	
Learning how to use technology in science instruction	48	(6.5)	41	(2.5)
Learning how to use inquiry/investigation-oriented teaching strategies	48	(6.2)	34	(2.5)
Understanding student thinking in science	39	(5.9)	21	(2.0)
Deepening my own science content knowledge	37	(6.3)	26	(1.9)
Learning how to assess student learning in science	33	(6.1)	23	(2.0)
Learning how to teach science in a class that includes students with special needs	15	(3.8)	13	(1.8)

† Teachers responding with 4 or 5 on a five-point scale, where 1 was "Not at all" and 5 was "To a great extent."

Earth Science Classes Offered

A representative of each of the schools in the sample was asked about the science courses offered in the school. Just under half of the schools that include any of the grades 6–8 offer a course in "earth science" *per se*, as opposed to "general science" or "integrated science" in those grades. At the high school level (schools including grades 10, 11, and/or 12), 34 percent of schools in the United States offer at least one 1st year earth science course. In terms of specific earth science courses, astronomy is the most common, offered in 19 percent of schools. (See Table 13.)

Table 13
Availability of Earth Science Courses at the High School† Level

	Percent of High Schools Offering Course		Percent of Students with Access to Course	
Astronomy/Space Science	19	(2.8)	22	(2.3)
Oceanography/Marine Science	10	(1.9)	18	(2.5)
Geology	8	(2.0)	10	(1.4)
Meteorology	3	(1.2)	3	(0.8)
1st year	31	(3.0)	37	(2.3)
1st year, Applied	8	(3.2)	5	(1.0)
Any 1st year	34	(3.5)	38	(2.3)
2nd year, Advanced/Other	2	(0.8)	3	(0.8)

† A high school is defined as any school containing grades 10, 11, or 12.

In terms of the percentage of classes in the nation, earth science courses account for 14 percent of all grades 6–8 science classes, but only 7 percent of science classes in grades 9–12. (See Table 14.)

Table 14
Most Commonly Offered
Secondary Science Classes

	Percent of Classes	
Grades 6–8		
General Science	29	(2.8)
Integrated Science	22	(2.1)
Life Science	20	(2.4)
Physical Science	16	(2.5)
Earth Science	14	(2.3)
Grades 9–12		
1st Year Biology	30	(2.1)
Advanced Biology	6	(0.8)
1st Year Chemistry	19	(1.2)
Advanced Chemistry	3	(1.6)
1st Year Physics	10	(1.0)
Advanced Physics	2	(0.3)
Physical Science	7	(1.0)
Earth Science	7	(1.0)
General Science	3	(0.7)
Integrated/Coordinated Science	6	(0.8)
Other Science	8	(1.1)

Earth Science Instruction

Each teacher responding to the survey was asked to provide detailed information about a randomly selected class. Science teachers who were assigned to teach both earth science and other science classes may have been asked about any of those classes. Therefore, the number of earth science classes included in the analyses reported below (166) is less than the 254 responding teachers of earth science. The generally larger standard errors are a reflection of the reduced sample size.

The next two sections draw on teachers' descriptions of what transpires in earth science classrooms in the United States, in terms of both instructional objectives and class activities.

Instructional Objectives

Teachers were given a list of potential objectives and asked to rate each in terms of the emphasis it receives in the randomly selected class. As can be seen in Table 15, teachers in roughly three-fourths of secondary earth science classes reported giving a heavy emphasis to learning basic science concepts. Three other objectives each receive heavy emphasis in more than half of the secondary earth science classes: learning science process/inquiry skills, increasing student interest in science, and learning important terms and facts of science. It is interesting to note that learning to evaluate arguments based on science evidence is more likely to receive heavy emphasis in earth science classes than in other science classes at the secondary level. Objectives related to the history and nature of science, to applications of science concepts, and to test

preparation are not heavily emphasized in either secondary earth science classes or other secondary science classes.

Table 15
Secondary Earth Science Classes with Heavy Emphasis on Various Instructional Objectives

	Percent of Classes			
	Earth Science		All Other Sciences	
Learn basic science concepts	73	(4.7)	80	(1.5)
Learn science process/inquiry skills	58	(6.9)	67	(1.7)
Increase students' interest in science	58	(6.9)	51	(1.9)
Learn important terms and facts of science	57	(6.3)	48	(2.0)
Prepare for further study in science	44	(6.9)	48	(1.9)
Learn how to communicate ideas in science effectively	44	(6.7)	40	(1.8)
Learn to evaluate arguments based on scientific evidence	42	(7.8)	25	(1.8)
Learn about the relationship between science, technology, and society	33	(6.6)	29	(1.9)
Learn about the history and nature of science	22	(7.0)	12	(1.0)
Prepare for standardized tests	16	(3.1)	22	(1.4)
Learn about the applications of science in business and industry	15	(3.5)	18	(1.6)

Two composite variables were created from the list of objectives in Table 15: "Nature of Science" and "Science Content." The two composites are shown here with the objectives that comprise them:

Nature of Science

- 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
- Learn about the relationship between science, technology, and society

Science Content

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

As is the case with secondary science classes overall, science content objectives are much more likely than nature of science objectives to receive heavy emphasis in secondary earth science instruction. (See Table 16.)

Table 16
Mean Composite Scores Related to Secondary Earth Science Class Objectives

	Mean Score			
	Earth Science		All Other Sciences	
Science Content	84	(1.3)	85	(0.5)
Nature of Science	69	(2.4)	66	(0.7)

Class Activities

The 2000 National Survey of Science and Mathematics Education provides three sources of information about how secondary earth science is taught. One series of items listed various instructional strategies and asked teachers to indicate the frequency with which they used each in a randomly selected class. A second item listed a number of activities and asked teachers to indicate which occurred in the most recent lesson in their randomly selected class. Finally, a third item asked teachers to indicate the number of minutes devoted to each of several activities in their most recent lesson. Detailed data on the frequency of various class activities in secondary earth science instruction are presented in Table 17, while Tables 18–20 provide comparisons between earth science instruction and instruction in other science classes at the secondary level.

Each source paints the same picture of secondary earth science instruction; the predominant instructional strategies are lecture and discussion. While any given earth science lesson is more likely to involve students in doing textbook/worksheet problems than laboratory work (Table 19), the total time spent in working with hands-on, manipulative, or laboratory materials is roughly the same as that spent having students read textbooks, complete worksheets, etc. (Table 20).

Table 17
Secondary Earth Science Classes Where Teachers Report that Students Take Part in Various Instructional Activities

	Percent of Classes									
	Never		A few times A year		Once or twice a month		Once or twice a week		All or almost all lessons	
Listen and take notes during presentation by teacher	0	—[§]	4	(1.5)	25	(5.5)	51	(6.5)	20	(7.0)
Follow specific instructions in an activity or investigation	0	(0.5)	11	(6.6)	17	(3.8)	54	(7.1)	17	(7.1)
Answer textbook or worksheet questions	0	(0.4)	5	(2.0)	25	(6.7)	52	(6.7)	17	(5.6)
Do hands-on/laboratory science activities or investigations	0	(0.4)	14	(6.5)	27	(5.2)	45	(6.3)	14	(6.8)
Work in groups	0	—[§]	4	(3.2)	15	(3.1)	68	(5.1)	12	(3.2)
Watch a science demonstration	0	—[§]	14	(6.7)	45	(6.6)	31	(4.9)	10	(6.8)
Read from a science textbook in class	8	(2.6)	18	(4.0)	22	(4.1)	46	(7.1)	7	(3.6)
Record, represent, and/or analyze data	1	(0.6)	20	(6.8)	29	(5.5)	45	(6.8)	6	(2.3)
Write reflections	30	(6.6)	30	(5.6)	28	(6.6)	6	(2.2)	6	(2.6)
Use mathematics as a tool in problem-solving	6	(3.3)	15	(3.8)	39	(6.7)	38	(6.9)	3	(1.4)
Watch audiovisual presentations	0	(0.2)	11	(3.9)	60	(5.8)	26	(5.3)	3	(1.8)
Work on extended science investigations or projects	18	(6.6)	48	(7.1)	22	(4.6)	9	(3.9)	3	(1.9)
Use computers as a tool	31	(7.2)	20	(3.9)	40	(6.9)	7	(2.3)	3	(1.8)
Read other science-related materials in class	3	(1.2)	17	(4.9)	52	(7.1)	26	(5.5)	2	(1.7)
Design or implement their *own* investigation	4	(1.2)	44	(6.8)	31	(5.3)	19	(6.9)	2	(1.7)
Prepare written science reports	7	(2.3)	40	(6.7)	39	(6.4)	11	(3.9)	2	(1.8)
Make formal presentations to the rest of the class	12	(3.2)	51	(7.1)	25	(5.0)	11	(4.4)	2	(1.7)
Participate in field work	18	(4.8)	44	(6.6)	31	(7.2)	6	(2.1)	2	(1.7)
Take field trips	30	(5.2)	56	(6.0)	7	(1.9)	5	(3.5)	2	(1.7)

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

Table 18
Secondary Earth Science Classes Where Teachers Report That Students Take Part in Various Instructional Activities at Least Once a Week

	Percent of Classes			
	Earth Science		All Other Sciences	
Work in groups	80	(4.3)	80	(1.6)
Listen and take notes during presentation by teacher	71	(5.8)	76	(1.7)
Follow specific instructions in an activity or investigation	71	(7.0)	74	(1.8)
Answer textbook or worksheet questions	70	(6.5)	68	(1.7)
Do hands-on/laboratory science activities or investigations	59	(6.8)	71	(2.0)
Read from a science textbook in class	52	(6.4)	35	(1.9)
Record, represent, and/or analyze data	50	(6.9)	57	(1.9)
Watch a science demonstration	41	(6.6)	47	(1.8)
Use mathematics as a tool in problem-solving	40	(6.9)	46	(1.8)
Read other science-related materials in class	28	(5.8)	23	(1.8)
Watch audiovisual presentations	28	(5.3)	20	(1.4)
Design or implement their *own* investigation	21	(7.0)	12	(1.3)
Prepare written science reports	14	(4.2)	24	(1.9)
Write reflections	12	(3.5)	23	(1.6)
Work on extended science investigations or projects	12	(4.3)	9	(1.3)
Make formal presentations to the rest of the class	12	(4.7)	7	(1.2)
Use computers as a tool	10	(3.0)	15	(1.7)
Participate in field work	8	(2.7)	5	(1.0)
Take field trips	7	(3.9)	2	(0.8)

Table 19
Secondary Earth Science Classes Participating in Various Activities in Most Recent Lesson

	Percent of Classes			
	Earth Science		All Other Sciences	
Discussion	91	(2.2)	79	(1.6)
Lecture	74	(5.2)	65	(1.8)
Students completing textbook/worksheet problems	64	(5.6)	50	(2.2)
Students doing hands-on/laboratory activities	44	(6.5)	45	(1.7)
Students reading about science	42	(6.8)	30	(1.5)
Students working in small groups	41	(6.2)	53	(1.6)
Students using other technologies	14	(3.9)	9	(0.9)
Test or quiz	10	(2.3)	11	(1.0)
Students using computers	9	(3.0)	8	(0.9)
Students using calculators	8	(2.5)	21	(1.5)
None of the above	1	(0.7)	2	(0.4)

Table 20
Average Percentage of Secondary Earth Science
Class Time Spent on Different Types of Activities

	Average Percent			
	Earth Science		All Other Sciences	
Whole class lecture/discussion	39	(2.7)	33	(1.0)
Working with hands-on, manipulative, or laboratory materials	19	(2.8)	23	(1.0)
Individual students reading textbooks, completing worksheets, etc.	16	(1.5)	16	(0.8)
Daily routines, interruptions, and other non-instructional activities	12	(0.9)	11	(0.2)
Non-laboratory small group work	9	(1.9)	10	(0.9)
Other activities	4	(1.0)	6	(0.4)

Lecture/Discussion

Seventy-one percent of secondary earth science classes include having students listen and take notes at least weekly, with 20 percent doing so in all or almost all lessons. (See Table 17.) Teachers reported that 74 percent of the most recent earth science lessons included lecture, not significantly different from the 65 percent of other secondary science lessons. Ninety-one percent of earth science lessons included discussion, significantly higher than the 79 percent of lessons in the other sciences. (See Table 19.) On the average, 39 percent of secondary earth science instructional time is devoted to lecture/discussion. (See Table 20.)

Students Working in Groups

As can be seen in Table 18, 80 percent of secondary earth science classes include having students work in groups, in most cases about once or twice a week. When asked about their most recent science lesson, teachers reported that 41 percent of the lessons included students working in small groups.

Textbook/Worksheet Problems

Teachers report that 70 percent of secondary earth science classes answer textbook or worksheet problems at least weekly (See Table 18). As can be seen in Table 19, 64 percent of the classes completed textbook/worksheet problems in their most recent lesson, which is significantly higher than the 50 percent of most recent lessons in other secondary science classes.

Laboratory Activities

As can be seen in Table 18, 59 percent of secondary earth science classes do hands-on/laboratory science activities or investigations at least weekly. At the same time, 44 percent of earth science classes were doing laboratory work in their most recent lesson. (See Table 19.) Across all secondary earth science lessons, 19 percent of instructional time is spent working with hands-on, manipulative, or laboratory materials, a distant second to the 39 percent of class time spent on lecture/discussion. (See Table 20.)

Other Frequent Activities

From the three data sources described above, it is clear that some other activities are frequent in secondary earth science classes in addition to lecture/discussion, completing worksheets, and

laboratory activities. For example, 41 percent of secondary earth science classes watch demonstrations at least once a week, and another 45 percent do so once or twice a month. Students also spend class time reading about science; 53 percent of classes read from a science textbook in class at least once a week, and 28 percent read other science-related materials in class that often. (See Table 17.) In the most recent lesson, 42 percent of classes spent time reading about science. (See Table 19.)

It is also important to note that more than 10 percent of class time in secondary earth science classes (and in secondary science classes generally) is devoted to non-instructional activities. (See Table 20.) Over a year, this amounts to a loss of 3–4 weeks of instructional time.

As can be seen in Table 21, roughly one-third of secondary earth science classes are expected to do ½ hour or less of homework per week; 56 percent, 30–90 minutes per week; and 12 percent more than 1½ hours per week.

Table 21
Amount of Homework Assigned in
Secondary Earth Science Classes per Week

	Percent of Classes			
	Earth Science		All Other Sciences	
0–30 minutes	31	(8.1)	17	(1.3)
31–60 minutes	36	(6.5)	31	(1.8)
61–90 minutes	20	(5.1)	24	(1.7)
91–120 minutes	7	(2.2)	13	(1.4)
2–3 hours	4	(1.1)	10	(1.2)
More than 3 hours	1	(1.1)	5	(1.0)

Activities That Are Not Frequent

Survey data also point to some activities that are not very frequent, but might be expected to be. The NRC *Standards* call for a shift from "cookbook" labs to ones where students are involved in designing the question and the experimental procedure. Only about half of the secondary earth science classes have students design their own investigations at least once a month, compared to the nearly 90 percent of classes that follow specific instructions in investigations that often. (See Table 17.)

The frequency of computer use is surprisingly low. Although roughly 7 out of 10 secondary earth science classes use computers at least once during the year (Table 17), only about 1 in 10 most recent lessons incorporated computer use. (See Table 19.) Relatively common uses of computers include retrieving or exchanging data, playing science learning games, demonstrating scientific principles, and doing laboratory simulations. (See Table 22.)

Table 22
Secondary Earth Science Classes Where Teachers Report that Students Use Computers to do Particular Activities

	Percent of Classes									
	Never		A few times a year		Once or twice a month		Once or twice a week		All or almost all lessons	
Retrieve or exchange data	40	(7.7)	28	(5.6)	25	(6.8)	4	(1.5)	3	(2.0)
Play science learning games	49	(7.4)	31	(7.4)	17	(6.4)	2	(1.1)	0	(0.4)
Demonstrate scientific principles	53	(7.4)	27	(7.1)	14	(3.6)	4	(2.0)	1	(1.1)
Solve problems using simulations	59	(7.3)	29	(7.1)	8	(2.0)	2	(1.8)	2	(1.1)
Do laboratory simulations	62	(6.6)	22	(5.3)	11	(2.7)	5	(2.2)	0	(0.4)
Do drill and practice	63	(7.1)	24	(7.0)	11	(3.3)	1	(1.1)	0	(0.4)
Take a test or quiz	69	(7.4)	24	(7.3)	4	(1.7)	1	(1.1)	3	(1.8)
Collect data using sensors or probes	71	(5.7)	20	(4.4)	7	(2.1)	2	(1.2)	0	(0.4)

The infrequency of computer use is perplexing. One potential explanation is that teachers have not received the professional development they need in order to know how to integrate computers in their instruction. Data presented earlier in this report show that secondary earth science teachers identify instructional technology as an area where they are in particular need of professional development. (See Table 9.) While technology is a common emphasis in professional development activities, teacher participation is generally so low that the total amount of professional development time devoted to this area is quite small. (See Tables 10 and 12.) Another potential explanation is a lack of access to computers; however, teachers in only 3 percent of secondary earth science classes reported that computers were needed for instruction, but that they were not available. (See Table 23.)

Resources Available for Earth Science Instruction

Earth Science teachers' apparent access to computers is similar to that for other instructional resources. Given a list of equipment and facilities, in only four instances did teachers in more than 10 percent of secondary earth science classes report needing a particular resource and not having it. As can be seen in Table 23, these were:

- calculator/computer lab interfacing devices (12 percent reported needing, but not having interfacing devices);
- computers with internet connections (12 percent);
- gas for burners in labs/classrooms (11 percent) and
- hoods or air hoses in labs/classrooms (11 percent).

Table 23
Equipment Need, Availability, and Use in Secondary Earth Science Classes

	Percent of Classes					
	Not Needed		Needed, but Not Available		Used	
Overhead projector						
Earth Science	5	(3.0)	0	—[§]	95	(3.0)
All Other Sciences	10	(1.9)	0	(0.2)	89	(1.9)
Videotape player						
Earth Science	2	(1.2)	0	—[§]	98	(1.2)
All Other Sciences	6	(1.1)	0	(0.1)	93	(1.1)
Videodisc player						
Earth Science	26	(6.2)	8	(4.0)	67	(7.1)
All Other Sciences	39	(2.1)	7	(1.0)	53	(2.1)
CD-ROM player						
Earth Science	44	(7.7)	7	(3.9)	49	(7.3)
All Other Sciences	34	(2.0)	7	(1.0)	59	(2.2)
Four-function calculators						
Earth Science	39	(7.1)	3	(1.7)	59	(7.2)
All Other Sciences	35	(1.7)	4	(0.8)	61	(1.8)
Fraction calculators						
Earth Science	82	(5.4)	0	(0.0)	18	(5.4)
All Other Sciences	72	(2.5)	4	(1.1)	24	(2.2)
Graphing calculators						
Earth Science	82	(3.9)	2	(1.4)	16	(3.4)
All Other Sciences	65	(2.3)	7	(1.2)	28	(2.2)
Scientific calculators						
Earth Science	68	(6.0)	3	(1.4)	29	(5.8)
All Other Sciences	47	(2.1)	4	(0.8)	49	(2.0)
Computers						
Earth Science	14	(6.8)	3	(1.5)	83	(6.8)
All Other Sciences	7	(0.8)	5	(0.6)	88	(1.1)
Computers with Internet connection						
Earth Science	16	(6.8)	12	(4.9)	72	(7.5)
All Other Sciences	11	(1.1)	7	(0.8)	82	(0.8)
Calculator/computer lab interfacing devises						
Earth Science	64	(6.0)	12	(3.4)	25	(5.2)
All Other Sciences	44	(2.4)	18	(1.5)	38	(2.3)
Running water in labs/classrooms						
Earth Science	5	(2.2)	5	(3.7)	90	(4.4)
All Other Sciences	2	(0.4)	3	(0.6)	95	(0.7)
Electric outlets in labs/classrooms						
Earth Science	3	(1.3)	3	(2.1)	94	(2.5)
All Other Sciences	2	(0.5)	1	(0.2)	98	(0.5)
Gas for burners in labs/classrooms						
Earth Science	41	(7.1)	11	(3.8)	49	(7.7)
All Other Sciences	29	(1.6)	8	(1.1)	63	(1.8)
Hoods or air hoses in labs/classrooms						
Earth Science	64	(6.3)	11	(4.2)	25	(5.4)
All Other Sciences	41	(2.0)	13	(1.3)	46	(1.9)

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

Teachers in the vast majority of grade 6–8 earth science classes (97 percent) report using one or more textbooks/programs, with the most commonly used earth science texts being:

- *Earth Science* (McGraw-Hill/Merrill Co.);
- *Science Insights: Exploring Earth & Space* (Addison/Wesley Longman, Inc./Scott Foresman); and
- *Exploring Earth's Weather* (Prentice Hall, Inc.).

At the high school level (grades 9–12), the most commonly used textbook is *Earth Science* (Houghton Mifflin Company/McDougal Littell/D.C. Heath).

As can be seen in Table 24, teachers in 59 percent of earth science classes rated their textbook/program as good or better in quality. However, secondary earth science classes vary considerably in the extent to which they "cover" the entire textbook, with 27 percent covering less than half of their texts, and 13 percent covering 90 percent or more. (See Table 25.)

Table 24
Secondary Earth Science Teachers' Perceptions of Quality of Textbooks/Programs Used in Their Science Classes†

	Percent of Classes			
	Earth Science		All Other Sciences	
Very Poor	1	(0.7)	2	(0.5)
Poor	4	(1.9)	7	(1.1)
Fair	36	(6.9)	21	(1.5)
Good	32	(5.8)	36	(1.7)
Very Good	24	(5.7)	27	(1.8)
Excellent	3	(1.5)	7	(0.9)

† Only classes using published textbooks/programs were included in these analyses.

Table 25
Percentage of Secondary Earth Science Textbook/Program Covered During the Course†

	Percent of Classes			
	Earth Science		All Other Sciences	
Less than 25 percent	4	(2.0)	5	(0.7)
25–49 percent	23	(7.4)	18	(1.4)
50–74 percent	23	(3.9)	35	(1.7)
75–90 percent	37	(6.2)	33	(1.7)
More than 90 percent	13	(3.9)	9	(1.1)

† Only classes using published textbooks/programs were included in these analyses.

Summary

In general, secondary earth science classes are less likely than other secondary science classes to be taught by a teacher with in-depth preparation in their subject matter. Only about 4 in 10 earth science classes are taught by teachers with six or more courses in the field, compared to 6 in 10 physical science classes, and 8 in 10 life science classes that are taught by teachers who have in-depth preparation in their designated areas. Meteorology and oceanography stand out as areas of particular need, with fewer than a third of the secondary earth science teachers having completed college coursework in each of these areas, compared to about half for astronomy and geology. Similarly, when asked how well qualified they were to teach particular topics, only a third of secondary earth science teachers indicated they felt very well qualified to teach climate and weather, compared to roughly half for earth's features/ physical processes, and the solar system and the universe.

Earth science teachers expressed a need for help in a number of ways, especially in using instructional technology. They also called for help in accommodating students with special needs, in deepening their science content knowledge, and in pedagogy. At the same time, they spend very little time in professional development specific to science teaching, where they might receive such help; the typical secondary earth science teacher spent 16–35 hours on in-service education in science over the three-year period prior to completing the survey questionnaire.

Teachers reported that their earth science instruction emphasizes basic science concepts, with 73 percent of classes giving heavy emphasis in this area. More than half of secondary earth science teachers reported heavy emphasis on increasing student interest in science, having students learn science process skills, and learning important science terms and facts. Objectives related to the history and nature of science, to applications of science concepts, and to preparing students for standardized tests generally receive less attention.

The instructional strategies teachers use to help students achieve these goals are predominantly lecture and discussion. Students are involved in completing textbook/worksheet problems in roughly two-thirds of their earth science lessons. Hands-on/laboratory activities are fairly frequent (occurring in just under half of the most recent lessons), typically having students follow specific instructions as opposed to designing and implementing their own investigations. The frequency of computer use is surprisingly low, with only about 1 in 10 lessons incorporating their use. The explanation for this situation is far more likely lack of teacher preparedness than lack of computer equipment, given that 79 percent of secondary earth science teachers reported a moderate or substantial need for learning how to use technology in science instruction, while in only 3 percent of the classes did teachers report needing computers, but not having them available.

References

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Appendix

Description of Composite Variables

To facilitate the reporting of large amounts of survey data, and because individual questionnaire items are potentially unreliable, HRI used factor analysis to identify survey questions that could be combined into "composites." Each composite represents an important construct related to science education.

Each composite is calculated by summing the responses to the items associated with that composite and then dividing by the total points possible. In order for the composites to be on a 100-point scale, the lowest response option on each scale was set to 0 and the others were adjusted accordingly; so for instance, an item with a scale ranging from 1 to 4 was re-coded to have a scale of 0 to 3. By doing this, someone who marks the lowest point on every item in a composite receives a composite score of 0 rather than some positive number. It also assures that 50 is the true mid-point. The denominator for each composite is determined by computing the maximum possible sum of responses for a series of items and dividing by 100; e.g., a 9-item composite where each item is on a scale of 0–3 would have a denominator of 0.27.

Composite definitions for the science teacher questionnaire are presented below along with the item numbers. Reliability information is based on the entire sample of K–12 science teachers.

Table A-1
Science Teacher Content Preparedness*

	Biology/ Life Science	Chem-istry	Earth Science	Environ-mental Science	Integrated/ General Science	Physical Science	Physics
Earth's features and physical processes			Q15a1a	Q15a1a	Q15a1a	Q15a1a	
The solar system and the universe			Q15a1b		Q15a1b	Q15a1b	
Climate and weather			Q15a1c	Q15a1c	Q15a1c	Q15a1c	
Structure and function of human systems	Q15a2a				Q15a2a		
Plant biology	Q15a2b				Q15a2b		
Animal behavior	Q15a2c				Q15a2c		
Interactions of living things/ecology	Q15a2d			Q15a2d	Q15a2d		
Genetics and evolution	Q15a2e				Q15a2e		
Structure of matter and chemical bonding		Q15a3a			Q15a3a	Q15a3a	
Properties and states of matter		Q15a3b			Q15a3b	Q15a3b	
Chemical reactions		Q15a3c			Q15a3c	Q15a3c	
Energy and chemical change		Q15a3d			Q15a3d	Q15a3d	
Forces and motion					Q15a4a	Q15a4a	Q15a4a
Energy					Q15a4b	Q15a4b	Q15a4b
Light and sound					Q15a4c	Q15a4c	Q15a4c
Electricity and magnetism					Q15a4d	Q15a4d	Q15a4d
Modern physics (e.g., special relativity)					Q15a4e	Q15a4e	Q15a4e
Pollution, acid rain, global warming				Q15a5a	Q15a5a		
Population, food supply, and production				Q15a5b	Q15a5b		
Formulating hypothesis, drawing conclusions, making generalizations	Q15a6a	Q15a6a	Q15a6a	Q15a6a	Q15a6a	Q15a6a	Q15a6a
Experimental design	Q15a6b	Q15a6b	Q15a6b	Q15a6b	Q15a6b	Q15a6b	Q15a6b
Describing, graphing, and interpreting data	Q15a6c	Q15a6c	Q15a6c	Q15a6c	Q15a6c	Q15a6c	Q15a6c
Number of Items in Composite	**8**	**7**	**6**	**8**	**22**	**15**	**8**
Reliability (Cronbach's Coefficient Alpha)	**0.87**	**0.87**	**0.76**	**0.79**	**0.87**	**0.89**	**0.88**

* Questions comprising these composites were asked of only those teachers in non-self-contained settings.

Table A-2
Science Teacher Preparedness to Use Standards-Based Teaching Practices

Take students' prior understanding into account when planning curriculum and instruction.	Q3a
Develop students' conceptual understanding of science	Q3b
Provide deeper coverage of fewer science concepts	Q3c
Make connections between science and other disciplines	Q3d
Lead a class of students using investigative strategies	Q3e
Manage a class of students engaged in hands-on/project-based work	Q3f
Have students work in cooperative learning groups	Q3g
Listen/ask questions as students work in order to gauge their understanding	Q3h
Use the textbook as a resource rather than the primary instructional tool	Q3i
Teach groups that are heterogeneous in ability	Q3j
Number of Items in Composite	**10**
Reliability (Cronbach's Coefficient Alpha)	**0.88**

Table A-3
Science Teacher Preparedness to Teach Students from Diverse Backgrounds

Recognize and respond to student cultural diversity	Q3l
Encourage students' interest in science	Q3m
Encourage participation of females in science	Q3n
Encourage participation of minorities in science	Q3o
Number of Items in Composite	**4**
Reliability (Cronbach's Coefficient Alpha)	**0.81**

Table A-4
Science Teacher Preparedness to Use Calculators/Computers

Use calculators/computers for drill and practice	Q3q
Use calculators/computers for science learning games	Q3r
Use calculators/computers to collect and/or analyze data	Q3s
Use computers to demonstrate scientific principles	Q3t
Use computers for laboratory simulations	Q3u
Number of Items in Composite	**5**
Reliability (Cronbach's Coefficient Alpha)	**0.89**

Table A-5
Science Teacher Preparedness to Use the Internet

Use the Internet in your science teaching for general reference	Q3v
Use the Internet in your science teaching for data acquisition	Q3w
Use the Internet in your science teaching for collaborative projects with classes/individuals in other schools	Q3x
Number of Items in Composite	**3**
Reliability (Cronbach's Coefficient Alpha)	**0.86**

Table A-6
Nature of Science Objectives

Learn to evaluate arguments based on scientific evidence	Q23f
Learn about the history and nature of science	Q23j
Learn how to communicate ideas in science effectively	Q23g
Learn about the applications of science in business and industry	Q23h
Learn about the relationship between science, technology, and society	Q23i
Number of Items in Composite	**5**
Reliability (Cronbach's Coefficient Alpha)	**0.84**

Table A-7
Science Content Objectives

Learn basic science concepts	Q23b
Learn important terms and facts of science	Q23c
Learn science process/inquiry skills	Q23d
Prepare for further study in science	Q23e
Number of Items in Composite	**4**
Reliability (Cronbach's Coefficient Alpha)	**0.60**