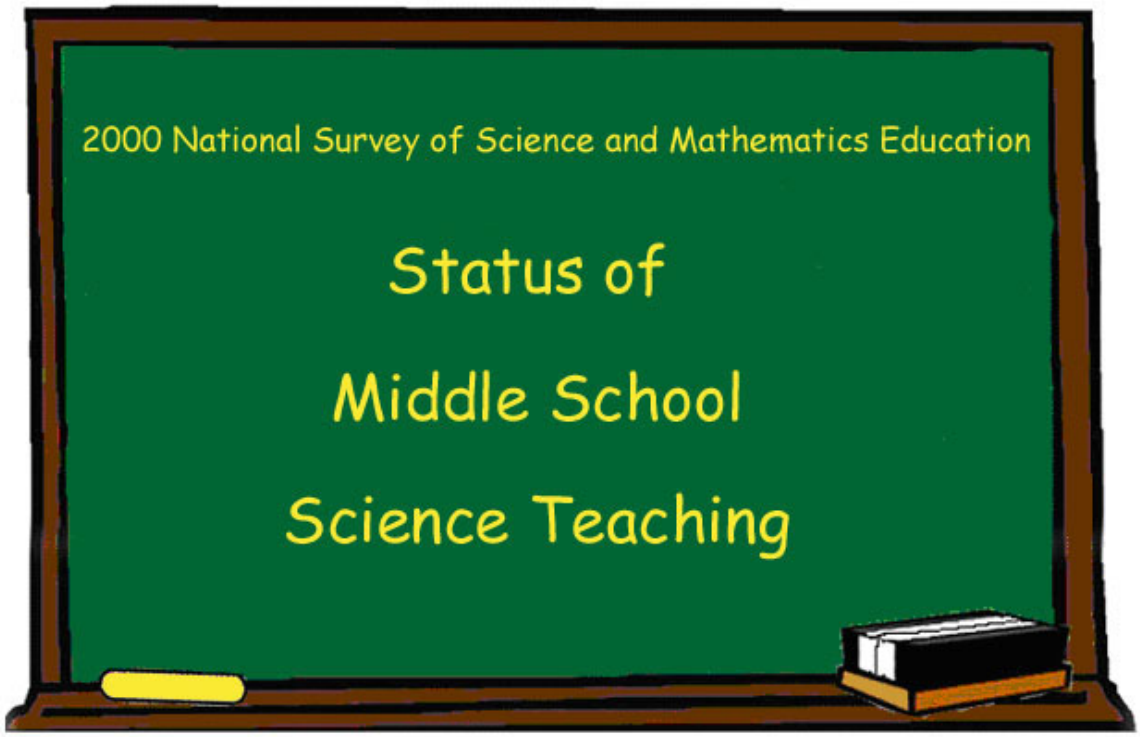

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Horizon Research, Inc.
326 Cloister Court
Chapel Hill, NC. 27514

Sherri L. Fulp

www.horizon-research.com

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Status of Middle School 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 middle school (grades 6–8) science instruction based on the responses of 529 middle school science teachers. 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, 2000). 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 that are substantial as well as statistically significant at the 0.05 level or beyond.

This status report of middle school science teaching is organized into major topical areas:

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

Characteristics of the Middle School Science Teaching Force

General Demographics

Nearly three-quarters of all middle school science teachers in the United States are female, and 89 percent are white, as shown in Table 1. Nearly half have a Master's degree. While the age of middle school science teachers is fairly evenly distributed among each of the age groups, roughly 1 in 4 is over the age of 50, suggesting that many teachers may be nearing retirement in the next 10 years.

Table 1
Characteristics of the
Middle School Science Teaching Force

	Percent of Teachers	
Sex		
Female	74	(2.8)
Male	26	(2.8)
Race		
White	89	(2.0)
Black or African-American	6	(1.2)
Hispanic or Latino	3	(1.5)
Asian	1	(0.3)
American Indian or Alaskan Native	1	(0.3)
Native Hawaiian or Other Pacific Islander	0	(0.4)
Age		
≤ 30 years	20	(2.5)
31–40 years	26	(3.1)
41–50 years	27	(3.0)
51+ years	27	(4.2)
Experience		
0–2 years	19	(3.2)
3–5 years	15	(2.2)
6–10 years	16	(2.1)
11–20 years	26	(3.6)
≥ 21 years	24	(3.6)
Master's Degree		
Yes	45	(3.7)
No	55	(3.7)

Content Preparedness

Since it would be extremely difficult to gauge the extent to which a large national sample of teachers understands science concepts (and know how to help their students learn these concepts), proxy measures, such as major or college courses taken in the field, are typically used. Approximately, two-thirds of middle school science teachers received their undergraduate degrees in areas other than science or science education; 53 percent have majors in education. (See Table 2.)

Table 2
Undergraduate Majors of
Middle School Science Teachers†

	Percent of Teachers	
Science	26	(2.9)
Science Education	9	(1.7)
Other Education	53	(4.3)
Other Fields	13	(2.7)

† These data should be interpreted with caution. When asked to specify the subject(s) of their degrees, approximately 10 percent of the teachers indicated they had undergraduate majors in three or more fields. These teachers were excluded from these analyses.

Middle school science teachers are generally better prepared in life science than in other science disciplines, with one-third of them having taken at least six courses in the subject, the equivalent of a minor. (See Table 3.) Preparation in other science disciplines is less extensive, with most teachers having two semesters or less of coursework in physics/physical science (74 percent), chemistry (68 percent), and earth/space science (55 percent). These findings are supported by a recent report from the National Center for Education Statistics based on data from the 1999–2000 Schools and Staffing Survey. That study found that 40 percent of grade 5–8 students enrolled in physical science (and 29 percent enrolled in biology/life science) nationwide are taught by teachers who lacks either a major, minor, or certification in the subject.[1]

Table 3
Number of Semesters† Completed
by Middle School Science Teachers

	Percent of Teachers							
	Zero Semesters		1–2 Semesters		3–5 Semesters		6 or More Semesters	
Life science	6	(1.2)	35	(4.3)	24	(3.1)	35	(3.8)
Earth/space science	15	(3.0)	40	(3.6)	30	(3.6)	15	(2.5)
Science education	24	(3.2)	38	(3.8)	24	(3.3)	15	(2.2)
Chemistry	28	(4.1)	40	(3.9)	22	(2.5)	10	(1.7)
Physics/physical science	24	(3.7)	50	(3.8)	19	(2.6)	7	(1.3)

† 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.

[1] U.S. Department of Education, National Center for Education Statistics. *Qualifications of the Public School Teacher Workforce: Prevalence of Out-of-Field Teaching,1987–88 to 1999–2000*, NCES 2002-603, by Marilyn McMillen, Seastrom, Kerry J. Gruber, Robin Henke, Daniel J. McGrath, and Benjamin A. Cohen. Washington, DC: 2002.

Further evidence of middle school teachers' lack of content preparedness is provided in Table 4. Nearly half of all middle school life, earth, and physical science classes are taught by teachers who lack in-depth preparation in any science.

Table 4
Middle School 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	
Life science/biology	52	(6.1)	4	(2.1)	44	(6.4)
Physical science	42	(9.3)	10	(3.8)	48	(10.5)
Earth science	28	(10.5)	27	(7.6)	45	(9.5)

In terms of the specific courses taken by middle school science teachers, the majority of teachers have had college coursework in general methods of teaching (96 percent) and methods of teaching science (76 percent). (See Table 5.) A closer look at the disciplinary courses taken shows that most are basic and introductory in nature, with the largest numbers of teachers completing courses in introductory biology/life science (85 percent), general/introductory chemistry (69 percent), introductory earth science (56 percent), general/introductory physics (50 percent), and physical science (47 percent). After the completion of introductory courses, college coursework in the sciences drops off considerably.

Table 5
Middle School Science Teachers
Completing Various College Courses

	Percent of Teachers	
General methods of teaching	96	(1.2)
Methods of teaching science	76	(3.3)
Instructional uses of computers/other technologies	52	(3.6)
Supervised student teaching in science	45	(3.8)
General/introductory chemistry	69	(4.0)
Analytical chemistry	11	(1.9)
Organic chemistry	27	(2.8)
Physical chemistry	12	(2.4)
Quantum chemistry	1	(0.4)
Biochemistry	13	(2.0)
Other chemistry	9	(1.5)
Introductory earth science	56	(3.3)
Astronomy	32	(3.7)
Geology	39	(3.3)
Meteorology	16	(2.6)
Oceanography	15	(3.3)
Physical geography	30	(3.6)
Environmental science	33	(3.4)
Agricultural science	6	(1.2)
Introductory biology/life science	85	(2.5)
Botany, plant physiology	34	(3.2)
Cell biology	27	(3.1)
Ecology	28	(3.2)
Entomology	12	(3.3)
Genetics, evolution	23	(2.6)
Microbiology	27	(3.7)
Anatomy/Physiology	35	(3.6)
Zoology, animal behavior	33	(3.2)
Other life science	28	(3.1)
Physical science	47	(3.7)
General/introductory physics	50	(4.2)
Electricity and magnetism	11	(2.5)
Heat and thermodynamics	11	(2.6)
Mechanics	5	(1.1)
Modern or quantum physics	2	(0.6)
Nuclear physics	1	(0.5)
Optics	2	(0.6)
Solid state physics	5	(2.3)
Other physics	5	(1.0)
History of science	11	(2.9)
Philosophy of science	6	(1.3)
Science and society	8	(1.5)
Electronics	1	(0.5)
Engineering (any)	3	(0.8)
Integrated science	10	(2.5)
Computer programming	16	(2.1)
Other computer science	21	(3.2)

The National Science Teachers Association (NSTA) has recommended that in preparing middle school science teachers in addition to coursework in science education, "conceptual content should be balanced among life, earth/space, physical, and environmental science, including natural resources" (National Science Teachers Association, 1998). Using completion of a college course as an indicator, Table 6 shows that 63 percent of middle school science teachers meet those standards, while another 13 percent meet the science coursework standard, but lack a course in science education.

Table 6
Middle School Science Teachers Meeting
NSTA Course-Background *Standards*

	Percent of Teachers	
Coursework in each science discipline plus science education	63	(3.3)
Lack science education only	13	(2.5)
Lack one science discipline	14	(2.1)
Lack two science disciplines	8	(2.9)
Lack three science disciplines	1	(0.5)

The lack of depth in science coursework is reflected in middle school science teachers' ratings of their content preparedness. The survey asked them to rate how qualified they felt to teach a number of fundamental science topics in earth science, biology, chemistry, physics, environmental and resource issues, as well as science process/inquiry skills. As can be seen in Table 7, middle school science teachers feel the most prepared to teach science process/inquiry skills, with many reporting that they were "very well qualified" to teach formulating hypotheses, drawing conclusions, and making generalizations (62 percent) and describing, graphing, and interpreting data (61 percent).

Table 7
Middle School Science Teachers' Perceptions of Their Qualifications to Teach Each of a Number of Topics

	Percent of Teachers					
	Not Qualified		Adequately Qualified		Very Well Qualified	
Earth science						
Earth's features and physical processes	10	(2.4)	51	(3.8)	39	(4.0)
The solar system and the universe	11	(2.0)	49	(4.0)	40	(4.0)
Climate and weather	13	(3.7)	55	(4.5)	32	(3.6)
Biology						
Structure and function of human systems	7	(2.0)	40	(4.1)	53	(4.0)
Plant biology	13	(3.2)	43	(4.4)	44	(3.6)
Animal behavior	11	(2.1)	47	(4.1)	42	(3.6)
Interactions of living things/ecology	5	(1.5)	41	(3.7)	54	(3.8)
Genetics and evolution	19	(3.1)	45	(3.5)	36	(3.2)
Chemistry						
Structure of matter and chemical bonding	23	(3.5)	42	(4.0)	35	(3.8)
Properties and states of matter	17	(3.6)	35	(4.0)	49	(3.9)
Chemical reactions	25	(3.6)	46	(3.9)	30	(3.6)
Energy and chemical change	26	(3.9)	44	(3.9)	31	(3.4)
Physics						
Forces and motion	21	(3.4)	50	(3.8)	29	(3.6)
Energy	20	(3.4)	53	(4.0)	27	(3.6)
Light and sound	28	(3.7)	49	(3.7)	23	(3.4)
Electricity and magnetism	33	(3.6)	45	(3.5)	22	(3.2)
Modern physics (e.g., special relativity)	58	(4.1)	33	(3.5)	10	(2.8)
Environmental and resource issues						
Pollution, acid rain, global warming	8	(1.8)	50	(3.9)	42	(3.6)
Population, food supply and production	14	(3.6)	47	(3.8)	38	(3.6)
Science process/inquiry skills						
Formulating hypotheses, drawing conclusions, making generalizations	4	(2.0)	34	(4.1)	62	(4.3)
Experimental design	13	(3.8)	38	(3.4)	49	(4.0)
Describing, graphing, and interpreting data	4	(2.0)	35	(4.0)	61	(4.0)

Composite variables were created from the individual topics. (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.

Table 8 shows the mean composite scores for all middle school science teachers. Note that teachers are more confident in teaching life and earth science than in teaching physical science.

Table 8
Content Preparedness Composite Scores of Middle School Science Teachers

	Mean Score	
Biology/Life Science	70	(1.9)
Earth Science	69	(2.1)
Physical Science	58	(2.3)
Integrated/General Science	61	(2.1)

The overall picture of middle school science teachers is that they are relatively ill prepared in the sciences. Considering that almost 50 percent of middle school science teachers are teaching general or integrated science (see Table 18), there is a need to increase the content knowledge of in-service middle school science teachers in all science disciplines and to provide more in-depth content training for pre-service teachers of grades 6–8.

Pedagogical Preparedness

The National Research Council (NRC) *National Science Education Standards* provide a useful framework for interpreting data on middle school science teachers' pedagogical preparedness. Responding to an item about the NRC *Standards*, two-thirds of middle school science teachers indicated they were at least somewhat familiar with the document, and of these, 69 percent said they agreed with the *Standards*. (See Table 9.) In addition, over three-fourths of the teachers familiar with the national standards indicate that they are implementing their recommendations at least to a moderate extent.

Table 9
Middle School Science Teachers' Familiarity with, Agreement with, and Implementation of the NRC *Standards*

	Percent of Teachers	
Familiarity with NRC *Standards*		
Not at all familiar	33	(3.4)
Somewhat familiar	33	(3.2)
Fairly familiar	23	(3.0)
Very familiar	10	(2.8)
Extent of agreement with NRC *Standards*†		
Strongly Disagree	0	—§
Disagree	5	(3.5)
No Opinion	25	(3.9)
Agree	58	(5.6)
Strongly Agree	11	(4.5)
Extent to which recommendations have been implemented†		
Not at all	4	(3.5)
To a minimal extent	16	(2.9)
To a moderate extent	61	(5.5)
To a great extent	18	(4.4)

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

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

The survey asked teachers how well prepared they felt to use each of a number of instructional strategies in their teaching. Composite variables were created from these individual strategies using factor analysis. Mean scores on these composites suggest that middle school science teachers are least likely to feel prepared in technology-related areas. (See Table 10.) In particular, relatively few middle school science teachers indicated they felt well prepared to use

computers for laboratory simulations (31 percent) or to use the Internet for collaborative projects across classes or schools (30 percent). (See Table 11.)

Table 10
Composite Scores of Middle School Science Teachers' Pedagogical Preparedness

	Mean Score	
Preparedness to Teach Students from Diverse Backgrounds	79	(1.4)
Preparedness to Use Standards Based Teaching Practices	77	(1.4)
Preparedness to Use Calculators/Computers	49	(2.8)
Preparedness to Use the Internet	48	(3.0)

Table 11
Middle School Science Teachers Considering Themselves Well Prepared† for Each of a Number of Tasks

	Percent of Teachers	
Encourage students' interest in science	95	(1.2)
Encourage participation of females in science	95	(1.0)
Listen/ask questions as students work in order to gauge their understanding	94	(1.3)
Manage a class of students engaged in hands-on/project-based work	92	(1.9)
Have students work in cooperative learning groups	91	(1.9)
Encourage participation of minorities in science	89	(2.6)
Develop students' conceptual understanding of science	88	(2.9)
Use the textbook as a resource rather than the primary instructional tool	86	(2.9)
Teach groups that are heterogeneous in ability	86	(3.2)
Make connections between science and other disciplines	85	(3.6)
Take students' prior understanding into account when planning curriculum and instruction	83	(2.3)
Provide deeper coverage of fewer science concepts	81	(2.8)
Lead a class of students using investigative strategies	80	(3.4)
Recognize and respond to student cultural diversity	67	(3.7)
Use the Internet in your science teaching for general reference	64	(4.6)
Use calculators/computers for drill and practice	61	(4.4)
Use calculators/computers to collect and/or analyze data	60	(4.2)
Involve parents in the science education of their children	56	(4.2)
Use the Internet in your science teaching for data acquisition	53	(4.7)
Use calculators/computers for science learning games	52	(4.5)
Use computers to demonstrate scientific principles	47	(4.4)
Use computers for laboratory simulations	31	(4.0)
Use the Internet in your science teaching for collaborative projects with classes/individuals in other schools	30	(4.2)
Teach students who have limited English proficiency	26	(3.3)

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

As shown in Table 11, middle school science teachers appear well prepared in more general pedagogical practices, with over 90 percent reporting themselves as being well prepared to:

- Listen/ask questions as students work in order to gauge their understanding;

- Manage a class of students engaged in hands-on/project-based work; and
- Have students work in cooperative learning groups.

This is consistent with data from Table 2 presented earlier that showed a majority of middle school science teachers majored in education. High percentages of teachers also report feeling well prepared to encourage females and minorities in science. With one exception (recognize and respond to student cultural diversity), 80 percent or more rated themselves as being well prepared to implement a number of practices thought of as being closely aligned with the *Standards* (Table 11). For example:

- Take students' prior understanding into account when planning curriculum and instruction;
- Develop students' conceptual understanding of science;
- Provide deeper coverage of fewer science concepts;
- Make connections between science and other disciplines; and
- Lead a class of students using investigative strategies.

Teachers' perceptions of their pedagogical preparedness are also reflected in the areas they identify as needs for professional development. The survey asked about six different areas, shown in Table 12. Learning how to use technology in science instruction was identified by 75 percent of middle school science teachers as a moderate or substantial need. Fifty-six percent of middle school science teachers reported a moderate or substantial need to deepen their science content knowledge, providing further evidence of weak content preparation among these teachers. (See Table 12.)

It is interesting to note that while most middle school science teachers indicated they felt well prepared in various pedagogical areas, over 50 percent also rated themselves as having at least a moderate need for professional development in learning how to use inquiry/investigation-oriented teaching strategies and understanding student thinking in science. In addition, more than half of middle school science teachers perceived a need for help in teaching science in a class that includes students with special needs. Clearly, a majority of teachers of middle school science perceive a need for professional development that includes both content and pedagogical emphases.

Table 12
Middle School Science Teachers Reporting They Perceived a Moderate or Substantial Need for Professional Development in the Preceding Three Years

	Percent of Teachers	
Learning how to use technology in science instruction	75	(3.6)
Learning how to teach science in a class that includes students with special needs	58	(3.7)
Deepening my own science content knowledge	56	(3.9)
Learning how to use inquiry/investigation-oriented teaching strategies	55	(3.7)
Understanding student thinking in science	52	(3.9)
Learning how to assess student learning in science	46	(4.1)

Professional Development of Middle School Science Teachers

Middle school science teachers, like other science teachers generally (Weiss et al, 2001), reported low levels of participation in professional development specific to science teaching. Fewer than a third of middle school science teachers have spent more than 35 hours in science-related professional development in the previous three years. (See Table 13.)

Table 13
Time Middle School Science Teachers Spent on In-Service Education in Science in the Preceding Three Years

	Percent of Teachers	
None	10	(2.5)
Less than 6 hours	10	(1.9)
6–15 hours	25	(4.2)
16–35 hours	25	(3.3)
More than 35 hours	30	(2.2)

As to how this time is spent, the workshop is by far the most common form of professional development (76 percent of teachers have attended one in the previous three years), followed by collaborating with teachers locally, either observing their classrooms (49 percent) or meeting regularly to discuss science teaching (49 percent). (See Table 14.) Thirty-seven percent report attending a state or national science teachers meeting in the previous three years, and approximately a third have taken a college/university science course.

Table 14
Middle School Science Teachers Participating in Various Professional Development Activities in the Preceding Three Years

	Percent of Teachers	
Attended a workshop on science teaching	76	(3.4)
Observed other teachers teaching science as part of your own professional development (formal or informal)	49	(4.1)
Met with a local group of teachers to study/discuss science teaching issues on a regular basis	49	(4.4)
Attended a national or state science teacher association meeting	37	(4.0)
Taken a formal college/university science course	35	(3.6)
Taken a formal college/university course in the teaching of science	26	(3.3)
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	15	(1.6)
Collaborated on science teaching issues with a group of teachers at a distance using telecommunications	11	(2.1)

As can be seen in Table 15, roughly a third of middle school science teachers have not taken a college/university science course since 1990. Twenty percent of middle school science teachers

have had no college coursework in science education, and another 23 percent have not taken a course on how to teach science since 1990.

Table 15
Middle School Science Teachers'
Most Recent College Coursework in Field

	Percent of Teachers	
Science		
1996–2000	42	(3.9)
1990–1995	26	(2.9)
Prior to 1990	31	(3.6)
The Teaching of Science		
1996–2000	35	(3.3)
1990–1995	23	(3.6)
Prior to 1990	23	(3.0)
Never	20	(3.0)
Science or the Teaching of Science		
1996–2000	52	(3.9)
1990–1995	21	(2.8)
Prior to 1990	27	(3.5)

Teachers were asked to consider their professional development as a whole and characterize it in terms of different potential emphases. (See Table 16.) Forty-two percent of all middle school science teachers indicated that their professional development experiences emphasized learning how to use technology in science instruction, where 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 these are simply what are being offered most often or if teachers are actively pursuing these types of opportunities. Other areas of high need, including learning to accommodate students with special needs, were less frequently emphasized in professional development.

Table 16
Middle School Science Teachers Reporting That Their
Professional Development Gave Heavy Emphasis[†] to Various Areas

	Percent of Teachers	
Learning how to use technology in science instruction	42	(4.1)
Learning how to use inquiry/investigation-oriented teaching strategies	40	(4.2)
Deepening my own science content knowledge	31	(3.2)
Understanding student thinking in science	28	(3.8)
Learning how to assess learning in science	28	(3.6)
Learning how to teach science in a class that includes students with special needs	14	(2.0)

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

Middle School Science Classes Offered

Two-thirds of schools that contain grades 7–8 offer some form of general, coordinated, or integrated science. Sixty-three percent of these schools offer life science; 48 percent offer earth science; and 43 percent offer physical science (Table 17). Again, the high number of middle schools offering general, coordinated, or integrated science points to the necessity for science teachers in these schools to possess a broad background in science content.

Table 17
Middle Schools Offering
Various Science Courses, Grades 7 or 8†

	Percent of Schools	
Life Science	63	(4.2)
Earth Science	48	(4.2)
Physical Science	43	(4.3)
General Science	44	(4.4)
Integrated Science	27	(3.7)
General, Coordinated, or Integrated Science	65	(4.3)

† Only schools containing grades 7 and/or 8 were included in these analyses.

In terms of the percentage of science classes offered in the nation, general science and integrated science account for just over half of all middle school science classes. (See Table 18.)

Table 18
Most Commonly Offered
Middle School Science Courses

	Percent of Classes	
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)

The typical middle school science class has approximately 23 students, with roughly equal percentages of male and female students. Non-Asian minorities make up approximately a quarter of the typical middle school science classroom.

Regarding the ability level of middle school science students, teachers in over half of middle school science classes describe their students as heterogeneous, 24 percent as homogenous and average, and 13 percent as homogenous and high in ability. Only 9 percent of middle school science classes were categorized as "low ability." (See Table 19.)

Table 19
Ability Grouping in
Middle School Science Classes

	Percent of Classes	
Fairly homogenous and low in ability	9	(1.7)
Fairly homogenous and average in ability	24	(3.0)
Fairly homogenous and high in ability	13	(2.2)
Heterogeneous, with a mixture of two or more ability levels	55	(3.4)

Middle School Science Instruction

The next two sections draw on teachers' descriptions of what transpires in middle school science classrooms in the United States, in terms of both instructional objectives and class activities. Each teacher responding to the survey was asked to provide detailed information about a randomly selected class.

Instructional Objectives

Teachers were given a list of potential objectives and asked to rate each in terms of the emphasis it received in the randomly selected class. As can be seen in Table 20, 78 percent of middle school science teachers report placing a heavy emphasis on learning basic science concepts, followed by learning science process/inquiry skills (69 percent). In fewer than half of middle school science classes, teachers reported a strong focus on learning facts and terms of science. Twenty percent of classes included a heavy focus on preparing students for standardized tests.

Table 20
Middle School Science Classes with
Heavy Emphasis on Various Instructional Objectives

	Percent of Classes	
Learn basic science concepts	78	(2.4)
Learn science process/inquiry skills	69	(3.1)
Increase students' interest in science	60	(3.6)
Prepare for further study in science	46	(3.1)
Learn important terms and facts of science	45	(3.2)
Learn how to communicate ideas in science effectively	42	(3.3)
Learn about the relationship between science, technology, and society	28	(3.3)
Learn to evaluate arguments based on scientific evidence	26	(3.4)
Prepare for standardized tests	20	(2.1)
Learn about the history and nature of science	15	(2.7)
Learn about the applications of science in business and industry	13	(1.8)

Given the reports of emphasis on process/inquiry skills in middle school science classes, it is somewhat surprising that other objectives commonly thought of as being aligned with the *Standards* are heavily emphasized in fewer than half the nation's middle school science classes. These include:

- Learning how to communicate ideas in science effectively;
- Learning about the relationship between science, technology, and society; and
- Learning to evaluate arguments based on scientific evidence.

This contrast is captured again in two composite variables created from the list of objectives in Table 20. 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 shown in Table 21, Science Content objectives are much more likely than Nature of Science objectives to be emphasized in middle school science instruction.

Table 21
Mean Composite Scores Related to
Middle School Science Class Objectives

	Mean Score	
Science Content	85	(0.8)
Nature of Science	66	(1.2)

Class Activities

The 2000 National Survey of Science and Mathematics Education provides three sources of information about how science is taught at the middle school level. One series of items listed various instructional strategies and asked middle school science 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. The data from these three items are presented in Tables 22–24.

Table 22
Middle School 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	
Work in groups	0	(0.1)	2	(1.1)	18	(2.2)	58	(3.4)	22	(2.9)
Do hands-on/laboratory science activities or investigations	0	(0.1)	7	(2.2)	27	(2.9)	48	(3.1)	19	(3.0)
Follow specific instructions in an activity or investigation	0	(0.1)	4	(2.2)	20	(2.3)	60	(3.1)	16	(2.8)
Listen and take notes during presentation by teacher	1	(0.6)	6	(1.4)	28	(2.8)	52	(3.3)	12	(2.6)
Answer textbook or worksheet questions	1	(0.5)	8	(1.6)	29	(2.8)	52	(3.0)	11	(2.2)
Record, represent, and/or analyze data	0	—[§]	9	(2.4)	35	(2.7)	45	(3.1)	11	(2.0)
Read from a science textbook in class	3	(0.7)	19	(2.2)	31	(2.6)	39	(3.2)	8	(1.5)
Write reflections	17	(2.8)	27	(3.0)	26	(2.8)	21	(2.7)	8	(1.5)
Watch a science demonstration	0	(0.4)	9	(2.6)	43	(3.3)	42	(3.5)	6	(2.4)
Use mathematics as a tool in problem-solving	2	(1.1)	16	(1.9)	43	(3.3)	34	(3.2)	5	(1.3)
Prepare written science reports	4	(1.2)	33	(3.0)	45	(2.9)	15	(2.0)	3	(1.0)
Read other science-related materials in class	2	(0.6)	21	(2.8)	51	(3.2)	25	(2.6)	2	(0.7)
Watch audiovisual presentations	2	(0.7)	16	(2.3)	63	(3.0)	16	(2.5)	2	(0.8)
Design or implement their *own* investigation	3	(0.7)	39	(2.9)	42	(3.1)	15	(3.1)	2	(0.6)
Work on extended science investigations or projects	9	(2.3)	53	(3.5)	30	(2.6)	8	(1.2)	2	(0.7)
Use computers as a tool	20	(3.3)	34	(2.5)	35	(3.3)	9	(1.8)	1	(0.8)
Make formal presentations to the rest of the class	5	(1.3)	48	(3.4)	39	(3.1)	7	(1.3)	1	(0.5)
Participate in field work	21	(2.5)	46	(3.7)	27	(3.2)	5	(1.1)	1	(0.5)
Take field trips	24	(2.8)	65	(3.2)	8	(1.5)	2	(1.2)	0	(0.1)

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

Table 23
Middle School Science Classes Participating in Various Activities in Most Recent Lesson

	Percent of Classes	
Discussion	81	(2.6)
Lecture	62	(2.9)
Students completing textbook/worksheet problems	53	(3.9)
Students working in small groups	52	(2.9)
Students doing hands-on/laboratory activities	49	(3.7)
Students reading about science	37	(3.1)
Students using calculators	10	(1.9)
Students using other technologies	9	(1.6)
Students using computers	8	(1.5)
Test or quiz	8	(1.4)
None of the above	2	(0.8)

Table 24
Average Percentage of Middle School Science Class Time Spent on Different Types of Activities

	Average Percent	
Whole class lecture/discussion	31	(1.6)
Working with hands-on, manipulative, or laboratory materials	24	(2.1)
Individual students reading textbooks, completing worksheets, etc.	18	(1.1)
Daily routines, interruptions, and other non-instructional activities	12	(0.5)
Non-laboratory small group work	10	(1.5)
Other activities	5	(0.6)

Lecture/Discussion

Nearly two-thirds of middle school science classes involve students listening and taking notes during a presentation by the teachers at least once a week. (See Table 22.) When teachers reported on activities occurring in the most recent science class, 81 percent of classes included discussion and 62 percent included lecture. (See Table 23.) On the average, 31 percent of instructional time is devoted to lecture/discussion. (See Table 24.)

Students Working In Groups

In 80 percent of middle school science classes, teachers report students working in groups at least once a week (Table 22), and 52 percent of the most recent science lessons included students working in small groups (Table 23). The fact that non-laboratory small group work averaged only 10 percent of science class time suggests that a lot of small group work takes place in labs and/or hands-on tasks.

Students Working Problems

Nearly two-thirds of middle school science classes have students answer textbook or worksheet problems at least weekly. (See Table 22.) Similarly, over one-half of the middle school science classes included having students complete textbook/worksheet problems in their most recent lesson. (See Table 23.)

Activities and Investigations

In two-thirds of middle school science classes, teachers report students doing a hands-on/ laboratory science activity or investigation at least weekly (Table 22). Students are much more likely to be asked to follow specific instructions in completing an activity or investigation (76 percent of classes do so weekly) than to design or implement their own investigations (17 percent).

In 49 percent of middle school science classes, indicated that students worked on hands-on/laboratory activities in the most recent lesson, compared to 53 percent for completing textbook/worksheet problems. (See Table 23.) Across all middle school science lessons, 24 percent of instructional time is spent working with hands-on/manipulative materials. (See Table 24.)

Other Frequent Activities

From the three data sources described above, it is clear that some other activities are frequent in addition to lecture/discussion, working in groups, completing textbook/worksheet questions, and doing hands-on/laboratory science activities or investigations. Table 22 shows that close to half of middle school science teachers have their students watch a science demonstration once a week or more. Students reading from a science textbook in class is also quite frequent (Tables 22 and 23), which may be related to students working problems or using the textbook as a source of directions for an activity. Student use of mathematics as a tool in problem-solving is also fairly common.

It is important to note that 12 percent of the time in middle school science classes is devoted to non-instructional activities. (See Table 24.) Over a year, this amounts to a loss of 3–4 weeks of instructional time.

As can be seen in Table 25, there is wide variation in the amount of homework assigned to middle school science students, with 26 percent of middle school science classes assigned less than ½ hour of homework per week, and 14 percent assigned more than 1½ hours of homework per week.

Table 25
Amount of Homework Assigned in Middle School Science Classes per Week

	Percent of Classes	
0–30 minutes	26	(3.3)
31–60 minutes	36	(3.0)
61–90 minutes	24	(3.0)
91–120 minutes	10	(2.3)
2–3 hours	3	(0.9)
More than 3 hours	1	(0.3)

Activities That Are Not Frequent

Most middle school science students take field trips or work on extended science investigations or projects no more than a few times a year, according to their teachers. In addition, middle school science teachers report that their classes rarely write science reports or make formal presentations. (See Table 22.)

Most surprising is the low frequency of computer use in middle school science classes. Only 10 percent of classes include using computers as a tool at least once a week, and 1 in 5 science classes *never* use computers as a tool. (See Table 22.) The most common uses of computers are for retrieving or exchanging data, for demonstrations, and for playing science learning games. (See Table 26.)

Table 26
Middle School 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	42	(3.6)	30	(3.2)	20	(3.2)	7	(1.5)	1	(0.4)
Demonstrate scientific principles	44	(3.6)	35	(3.2)	18	(2.7)	3	(0.8)	0	(0.3)
Play science learning games	47	(3.3)	29	(3.3)	21	(3.1)	3	(0.8)	0	(0.2)
Do laboratory simulations	56	(3.5)	26	(2.8)	13	(2.2)	4	(1.2)	0	(0.2)
Solve problems using simulations	57	(3.5)	31	(3.3)	10	(1.8)	2	(0.6)	1	(0.4)
Do drill and practice	61	(3.6)	27	(3.2)	10	(1.6)	2	(0.7)	0	—§
Take a test or quiz	65	(3.2)	20	(2.8)	11	(2.1)	4	(0.9)	1	(0.5)
Collect data using sensors or probes	68	(3.2)	20	(2.6)	11	(2.4)	1	(0.4)	0	—§

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

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, since data presented earlier in this report show that middle school science teachers identify instructional technology as an area where they are in particular need of professional development. (See Table 12.) At the same time, other survey data show that teachers participate in very little professional development that is focused on science instruction, so even though many of those experiences emphasized technology use, the total amount of professional development time devoted to this area was relatively low. (See Tables 13 and 16.)

Resources Available for Middle School Science Instruction

A potential explanation for the infrequent use of computers is lack of access; however, teachers in only 4 percent of middle school science classes reported that computers were needed for instruction, but that they were not available. (See Table 27.) The vast majority of middle school science classes use computers at least once during the year; frequency of use, however, is clearly very low.

Middle school science teachers' access to computers is similar to that for other instructional resources. Given a list of equipment and facilities, in only three instances did teachers in more than 10 percent of middle school science classes report needing a particular resource and not having it. One of these was calculator/computer lab interfacing devices (18 percent reported needing, but not having), and the other two were hoods or air hoses (16 percent) and gas for burners (12 percent).

Table 27
Middle School Science Classes Where Various Equipment is Needed and/or Used

	Percent of Classes					
	Not Needed		Needed, but Not Available		Used	
Overhead projector	8	(2.4)	0	(0.0)	92	(2.4)
Videotape player	6	(2.0)	0	—[§]	94	(2.0)
Videodisc player	35	(3.7)	9	(1.9)	55	(3.8)
CD-ROM player	35	(4.3)	7	(2.0)	58	(4.1)
Four-function calculators	34	(3.4)	4	(1.2)	62	(3.5)
Fraction calculators	79	(3.4)	4	(1.3)	18	(3.1)
Graphing calculators	78	(2.9)	8	(2.1)	14	(2.5)
Scientific calculators	63	(3.7)	4	(1.1)	33	(3.8)
Computers	6	(2.6)	4	(1.1)	90	(2.8)
Calculator/computer lab interfacing devises	55	(4.2)	18	(2.4)	26	(3.4)
Computers with Internet connection	8	(3.1)	7	(2.1)	85	(3.6)
Running water in labs/classrooms	2	(0.6)	6	(1.6)	92	(1.6)
Electric outlets in labs/classrooms	2	(0.8)	1	(0.3)	97	(0.9)
Gas for burners in labs/classrooms	41	(3.5)	12	(2.4)	47	(3.6)
Hoods or air hoses in labs/classrooms	56	(3.7)	16	(2.3)	28	(3.5)

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

Ninety percent of middle school science classes report using one or more textbooks, with two publishers accounting for 61 percent of the textbooks used. The most commonly used middle school science textbooks are shown in Table 28 by course type.

Table 28
Most Commonly Used Middle School Science Textbooks, by Course

	Publisher	Title
Life Science	McGraw-Hill/Merrill Co.	*Life Science*
	Prentice Hall, Inc.	*Prentice Hall Science*
	Prentice Hall, Inc.	*Exploring Life Science*
Earth Science	McGraw-Hill/Merrill Co.	*Earth Science*
	Addison Wesley Longman, Inc./Scott Foresman	*Science Insights: Exploring Earth & Space*
	Prentice Hall, Inc.	*Exploring Earth's Weather*
Physical Science	Prentice Hall, Inc.	*Physical Science*
	Prentice Hall, Inc.	*Exploring Physical Science*
	McGraw-Hill/Merrill Co.	*Physical Science*
General/Integrated Science	McGraw-Hill/Merrill Co.	*Glencoe Science Interactions*

As can be seen in Table 29, fewer than two-thirds of the teachers in middle school science classes rated their textbooks as good or better in quality, implying that 1 in every 3 middle school science classes are using textbook materials that the teachers perceive as substandard.

Table 29
Middle School Science Teachers' Perceptions of Quality of Textbooks/Programs Used in Science Classes

	Percent of Classes	
Very poor	4	(1.1)
Poor	10	(2.3)
Fair	28	(3.1)
Good	33	(3.2)
Very good	22	(2.8)
Excellent	5	(1.5)

Another issue concerns the amount of material in middle school science textbooks. Only 41 percent of middle school science classes address more than three-fourths of their textbook, possibly a reflection of publishers' efforts to meet as many state and district textbook selection criteria as possible by including all of the content anyone might seek. (See Table 30.)

Table 30
Percentage of Middle School Science Textbooks/Programs Covered During the Course

	Percent of Classes	
Less than 25 percent	7	(1.5)
25–49 percent	27	(3.2)
50–74 percent	25	(2.7)
75–90 percent	30	(2.6)
More than 90 percent	11	(2.1)

Summary

The middle school science teacher workforce is predominantly female and predominantly white; based on the age distribution, nearly one-quarter of them may be retiring within the next ten years.

Considering that a majority of middle school science classes are either general science or integrated science, teachers need to possess a broad array of science content knowledge. However, many middle school science teachers have gaps in science content preparation. It is not surprising, therefore, that relatively few middle school science teachers report feeling well qualified to teach specific science concepts, and more than half perceive a substantial need for professional development to deepen their own science content knowledge.

In contrast, middle school science teachers reported a high degree of pedagogical preparedness, consistent with the high percentage who possess a degree in education. High percentages of teachers reported feeling well prepared to listen and ask questions of their students, engage their students in hands-on work and cooperative groups, and develop their students' conceptual understanding of science. Approximately one-third of the teachers reported being at least fairly

familiar with the NRC *Standards*, and over two-thirds of those agreed with the *Standards'* vision and indicated that they were implementing the *Standards* in their classrooms. Teachers were less likely to report being well prepared in the use of technology, in particular the use of computers for laboratory simulations and the use of the Internet for collaborative projects.

Middle school science teachers spend very little time in professional development specific to science or science teaching. Data indicate that roughly one-fourth of middle school science teachers have not taken a course in science or the teaching of science since 1990. Middle school science teachers also called for help in accommodating students with special needs. However, it appears that very little of the professional development they do participate in is focused on this area.

Most middle school science lessons include "traditional" strategies as whole class discussion (81 percent), lecture (62 percent) and solving worksheet or textbook problems (53 percent). At the same time, many middle school science lessons include such "reform-oriented" strategies as having students work in groups (52 percent) and doing hands-on science activities or investigations (49 percent). Data also show that middle school science teachers rarely provide opportunities for students to use computers, which appears to be due more to lack of knowledge about integrating technology in science instruction than to lack of access to computers.

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**